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K-12 SCIENCE AND MATHEMATICS TEACHERS' BELIEFS ABOUT AND USE OF INQUIRY IN THE CLASSROOM

Received: 16 May 2007; Accepted: 24 December 2007

ABSTRACT. A survey instrument was developed and administered to 1,222 K-12 mathematics and science teachers to measure their beliefs about and use of inquiry in the classroom. Four variables (grade level taught, content area taught, level of support received, and self-efficacy for teaching inquiry) were significantly correlated to two dependent variables, percentage of time that students are engaged in inquiry during a typical lesson and the perceived ideal percentage of instructional time that should be devoted to inquiry. Specifically, elementary school teachers reported using inquiry-based practices more than either middle-school or high-school teachers; similarly, elementary-school teachers believed such practices should be used more often. All groups, however, reported believing in an ideal percentage of time devoted to inquiry instruction that was significantly greater than their reported percentage of time actually spent on inquiry instruction. A disordinal effect was found between grade level taught and content area taught; at the elementary level, science teachers reported both an ideal and actual percentage of time on inquiry higher than those reported by the math teachers, while at the high school level math teachers reported both an ideal and actual percentage of time on inquiry higher than those reported by the science teachers. No correlations were found between typical and ideal percentage of time devoted to inquiry and subject matter content knowledge training, gender, years of teaching experience, or maximum degree earned.

KEY WORDS: inquiry instruction, inquiry learning, inquiry teaching, mathematics education, science education, self-efficacy, teacher training

INTRODUCTION

The goal of providing high-quality science and mathematics instruction in the K-12 classroom remains elusive. Student performance on standardized tests, ranging from state achievement tests to the Third International Math and Science Study (Schmidt, McNight & Raizen, 2002), suggests that the goals of Science for All Americans—Project 2061 (American Association for the Advancement of Science, AAAS, 1993), the inquiry standards from the *National Science Education Standards, NSES* (National Research Council, NRC, 1996), and the *Principles and Standards for Teaching Mathematics* (National Council of Teachers of Mathematics, NCTM, 2000) are not being realized.

International Journal of Science and Mathematics Education (2009) 7: 575–596

Perhaps insight into this discrepancy between educational goals and student learning outcomes can be explained by surveying teachers' beliefs and practices. Because a single survey could not possibly identify all the aspects involved in productive teacher behavior, a narrower focus becomes critical. As such, the behaviors, beliefs, and motivations of mathematics and science teachers to implement inquiry-based learning situations are central to this study.

Inquiry-based instruction is the focus for this study because promoting positive conceptual change requires that student prior knowledge and preconceptions be engaged early and throughout the learning process (Bransford, Brown & Cocking, 1999; Bybee, Taylor, Gardner, Scotter, Powell, Westbrook & Landes, 2006; Donovan & Bransford, 2005; Willingham, 2003). Such active engagement promoted by constructivist learning theorists such as Vygotsky requires that students go beyond learning facts, rules, algorithms, and procedures in order to become critical thinkers and problem-solvers. The researchers for this study chose to survey factors related to one specific instructional strategy, inquiry instruction, in an effort to answer the following research question: Are teachers' behaviors, beliefs, and motivation regarding inquiry instruction related?

In the pages that follow, we provide a rationale for investigating inquiry instruction; we elaborate on the factors related to inquiry instruction we identified to investigate; and we discuss results obtained from a survey administered to all of the math and science teachers in a large school district.

Inquiry Instruction

Why should we focus this survey project on inquiry instruction? Inquiry instructional practices have been lauded as central tenets for mathematics and science learning for over two decades by the *NSES* (1996). Further, numerous research studies and commissions report that K-12 science, technology, engineering, and mathematics (STEM) education can be improved through the use of inquiry instruction (Bransford et al., 1999; Bybee et al., 2006; Donovan & Bransford, 2005; Llewellyn, 2002; National Commission on Excellence in Education, 1983; National Commission on Mathematics and Science Teaching, 2000; NCTM, 2000). Nonetheless, teachers may or may not implement inquiry instruction in actual learning environments. This avoidance may be due to any number of factors. One such reason is the complexity of inquiry instruction; in order to fully engage students in the inquiry process, teachers must help students navigate several simultaneous tasks, from brainstorming initial ideas, to gathering and applying information, to ultimately explaining results (Puntambekar, Stylianou & Goldstein, 2007). Similarly, teachers' reluctance to engage in inquiry instruction might be related to a lack of knowledge of or experience with non-traditional teaching methods (Borko & Putman, 1996), which could pose a barrier between teachers' desire to provide sound instruction and their motivation to implement a sound, yet unfamiliar strategy. Thus, the present study sought to investigate the reported behaviors, beliefs, and motivation for inquiry instruction of teachers.

For the purpose of this study, we adopted a definition of inquiry-based instruction that unites insights from multiple educational theories and philosophers (Bransford et al., 1999; Dewey, 1938; NCTM, 1998; NRC, 1996):

> A student-centered pedagogy that uses purposeful, extended investigations set in the context of real-life problems as both a means for increasing student capacities and as a feedback loop for increasing teachers' insights into student thought processes (Supovitz, Mayer & Kahle, 2000, p. 332).

Admittedly, this definition encompasses a great many variants of inquiry instruction that differ considerably in terms of effectiveness (Puntambekar et al., 2007). Nonetheless, based on this definition, we identified and then measured several independent variables that have the potential to influence inquiry instruction, seven of which are reported on in this paper: (1) the grade level taught by teachers, (2) content area (math or science) taught, (3) teachers' perceived support for inquiry instruction, (4) teachers' self-efficacy for inquiry instruction, (5) teachers' gender, (6) teachers' content knowledge training, and (7) teachers' experience. Each independent measure was compared to the following dependent variables: (1) the percentage of time mathematics teachers and science teachers believe that inquiry should be used in the classroom and (2) the percentage of time they report actually engaging students in inquiry learning experiences.

Potential Factors Related to Inquiry Instruction

Several factors may be related to the typical amount of time teachers spend on inquiry in the classroom and the ideal amount of time they believe should be spent on inquiry in the classroom. Prior to the survey, we identified several of these, four of which are discussed below.

Grade Level Taught. A teacher's instructional grade level might influence the amount of inquiry-based teaching that occurs. For example, Keys & Kang (2000) found that secondary teachers who have an interest in inquiry-based teaching possess both a personal and cultural belief structure regarding inquiry forms of learning. Conversely, Tobin & McRobbie (1996) suggest cultural beliefs that permeate the secondary education setting, such as transmission, efficiency, rigor, and exam preparation, might be related to high-school teachers' avoidance of inquiry-based forms of teaching. This limited research does not address middle-school or elementary-school phenomena, however. More research is needed before generalizations can be made about trends in inquiry instruction across grade levels.

Support for Inquiry Instruction. The reasons vary considerably, but a teacher's perceived sense of institutional support for inquiry instruction might also affect its implementation. Spillane & Thompson (1997) believe that a shift in instructional expectations stemming from true administrative support (or even mandate) might facilitate change, but a shift in policy alone would be insufficient for meaningful reform. Other scholars view teachers as more important catalysts in the change process than administrators or policy. For example, Hawley and Rosenholtz assume a *Lone Ranger* viewpoint (Hawley & Rosenholtz, 1984), suggesting that teachers prove to have greater impact on student achievement than do programs. Similarly, even when programs are well developed and have student success centrally configured, teachers' active engagement within the program is critical to student achievement (DuFour, DuFour, Eaker & Karhanek, 2004). Thus, in this study, we investigate teachers' perceptions of administrative, peer, and curricular support for inquiry.

Self-efficacy for Inquiry Instruction. Self-efficacy refers to one's confidence in performing a specific task correctly (Bandura, 1997). Research on the motivational construct of self-efficacy has demonstrated the link between a person's confidence and subsequent behavior (Woolfolk, 2004). For example, teachers who are more efficacious are more likely to try new strategies and adjust current strategies, and they are more resilient when confronted with classroom challenges (Hoy & Woolfolk, 1993; Tschannen-Moran & Hoy, 2001; Woolfolk & Hoy, 1990). Consequently, teachers who have a higher sense of self-efficacy for inquiry instruction might be more motivated to engage and persist in inquiry instruction. Teachers with a lower sense of self-efficacy might be less motivated to try inquiry instruction. Fortunately, self-efficacy is malleable, and improving teacher efficacy can be achieved with various experiences related to teacher development (Woolfolk, 2004). Because such a change in beliefs is critical to changes in practice (Jones & Carter, 2007), surveying teachers' self-efficacy for inquiry instruction might provide evidence of varying teacher motivation. This measurement might provide justification for conducting interventions designed to boost teachers' self-efficacy, increase motivation for inquiry, and change instructional practices.

Subject Matter Content Knowledge Training. The amount of subject matter knowledge (SMK) needed for teachers to lead inquiry learning has been a topic of debate for quite some time. Some researchers (Corcoran, 1995; Kennedy, 1998) suggest that professional development experiences focusing on SMK have larger positive effects on learning than experiences focusing on teaching behaviors. Lee (1995) suggests that the quality of classroom interactions increases with teacher SMK, whereas teachers' reliance on textbooks decreases. However, Garet, Porter, Desimone, Birman & Yoon (2001) argue for a more balanced approach to teacher preparation that necessitates inclusion of pedagogical training, and Lloyd, Smith, Ray, Khang, Kam Wah & Sai (1998) suggest that SMK and pedagogical content knowledge (PCK) are not directly related. A practical resolution to this conflict is perhaps best summed up by Shulman: "Mere content knowledge is likely to be as useless pedagogically as content-free skill" (Shulman, 1986, p. 8). Thus, there are conflicting views as to whether SMK is sufficient to promote quality inquiry-based teaching. Perhaps, PCK is more critical, as PCK entails the knowledge that makes the discipline comprehensible and understandable to others. But PCK can be seen as the confluence of SMK, pedagogical knowledge, and knowledge of context (student, school, and community) (Abell, 2007). Again, more investigation addressing the relationships between these forms of knowledge and teacher behavior is needed. In our study, because we had no direct way to measure teachers' actual subject matter content knowledge, we asked participants to report prior educational training and work experiences.

The purpose of this survey study was to examine the relationships among teachers' inquiry behaviors, beliefs, and motivation and the factors previously described. We also considered whether gender is associated with beliefs about and use of inquiry—little has been reported in this area. Behaviors related to inquiry instruction were gathered through a self-report of typical percentage of class time devoted to inquiry. Beliefs regarding inquiry instruction were gathered through various self-report and Likert-type items. Motivation was measured through a researcher-developed self-efficacy scale. Demographic information gathered included the teachers' highest degree earned, grade levels taught, years experience in the field of teaching, and so on. The next section of this paper reports the method of study.

Method

Participants

An entire population of K-12 mathematics and science teachers from one of the largest school districts (67,383 students enrolled—49% are on free or reduced lunch) in the southeastern United States was surveyed for this study. The district has 4,784 teachers, with 55.9% holding a master's degree or higher. However, only those that teach mathematics, science, or both were included in this study. There were 1,222 complete responses to the survey, which represents approximately 64% of the total district population of teachers who teach mathematics, science, or both (70.2% of all middle/secondary mathematics teachers and 57.4% of all middle/ secondary science teachers).

It is impossible to determine with certainty the response rate for the entire survey since elementary teaching assignments are not differentiated by content area (e.g., mathematics and/or science) on school websites. Of the 1,222 responses, 173 are from secondary teachers (grades 9–12), 199 from middle school teachers (grades 6–8), and 850 from elementary teachers (grades K-5). Collectively, 236 of the teachers teach science, 283 teach mathematics, and 703 teach both. The participants are representative of the entire district teacher population in regard to average years of teaching experience (12.8 years for survey participants vs. 12.1 for the district overall) and highest degree earned (55.6% with master's or higher for survey participants vs. 55.9% for district overall), based on data reported on the district website. The high response rate is likely attributable to two factors: (1) encouragement from the district's associate superintendent and the district's curriculum coordinators, and (2) eight $50 gift cards that were awarded through a random drawing of those who completed the survey. However, since the demographics of the respondents seem to match the district population, the encouragement and incentives did not appear to skew the results.

Dependent Measures

A 58-item survey instrument was developed as part of a larger study. Specifically, 43 of the 58 items directly relate to this study and include the following: (1) 16 demographic questions (e.g., schedule type, educational background, science and math training), (2) 17 Likert-scaled items measuring beliefs about inquiry instruction, content standards, and support structures, and (3) ten items measuring how often teachers engage in inquiry and frequency that career connections are made with the curriculum. Portions of the instrument relevant to the present research questions are now described. Two dependent measures were used for this study.

Teacher behaviors related to inquiry instruction. The amount of instructional time devoted to inquiry was measured with a self-report item in which teachers provided the typical percentage of instructional time devoted inquiry practices. The item was worded as follows: *Which value best represents the percentage of instructional time your students are engaged in inquiry during a typical lesson?* Participants selected from a scale relative to percentage of time devoted to inquiry (TypInq%) which ranged from 0 to 100%.

Teacher beliefs regarding inquiry instruction. A separate item measured teachers' beliefs regarding the ideal amount of instructional time that should be spent on inquiry practices (IdealInq%). This construct was measured in the same way as the percentage of time devoted to inquiry during a typical lesson and was stated as follows: *Ideally, what percentage of instructional time should be devoted to inquiry?*

Predictor Variables

Two of the predictor variables, self-efficacy for inquiry instruction and perceived support for inquiry instruction were part of the survey.

Self-efficacy for inquiry instruction. Efficacy was measured with a four-item subscale component of a larger scale. The items were constructed to be analogous to other instruments of teacher-efficacy (e.g., Woolfolk & Hoy, 1990). That is, teacher-efficacy scales typically present the participant with statements related to classroom phenomena, followed by a Likert-type opportunity to rate one's confidence for success-fully participating in the phenomena. To that end, the researchers created four items that first presented the participants with a statement, such as, *During inquiry, I can manage my students' behavior*, and *I can effectively lead students in inquiry*. After these statements, participants selected from a Likert-type scale (1=*completely disagree*, 2=*strongly disagree*, 3=*somewhat disagree*, 4=*somewhat agree*, 5=*strongly agree*, and 6=*completely agree*). Total scores then were created by summing these four items, resulting in scores that could range from four to 24. Reliability was assessed with Cronbach's alpha (.87). Validity was checked with a principal components factor analysis using varimax rotation, which suggested that these four items were measuring a construct distinct from the other items on the larger scale.

Support for inquiry instruction. Three factors (administrative, faculty, and curricular) concerning the level of support provided for inquiry teaching were targeted for measurement. A factor analysis indicated that administrative support and faculty support collectively account for 76.1% of the noted variance for the support structures surveyed. Specifically, the two items (Cronbach's alpha=.87) read as follows: *My school's administration is supportive of inquiry instruction,* and *The faculty at my school is supportive of inquiry instruction*. Participants rated each item with the same Likert-type scale as the self-efficacy items (where 1 through 6 corresponded to *completely disagree* to *completely agree*, respectively). Total scores were generated by summing responses to these two items (minimum possible = 2 and maximum possible = 12). The third item concerning curricular support was measured using the same Likert-type scale (rated from 1–6) and read as follows: *The curriculum I use supports inquiry instruction.* Curricular support was kept separate from the administrative and faculty support because this appears to be a different domain within the support structures for teachers regarding promoting inquiry instruction.

Data Collection

The 58-item survey was administered electronically over a 10-day period during February, 2007. This period was selected because it represented a point in the school year where few impediments to completion of the survey occur (e.g., not during the beginning or the end of a term, not during or near implementation of state achievement tests). Five versions of the survey were administered, with adjustments made according to grade level or content differences. After identifying the grade level and subject(s) taught, teachers were routed to the appropriate version of the survey. These versions included (1) middle/high science, (2) middle/high mathematics, (3) elementary science, (4) elementary mathematics, and (5) elementary mathematics and science.

RESULTS

For the entire sample, the mean percentage of time that teachers reported devoting to inquiry (TypInq%) was 38.7% (SD=18.9%). The mean percentage of time that teachers reported that they should ideally devote to inquiry (IdealInq%) was 57.3% (SD=19.5%). These measures, along with a look at other variables, are discussed in the paragraphs below.

Grade Level Taught

For this study, level taught refers to the grade level (elementary, middle, or high) taught by the teacher, not the ability level of the students. A one-way analysis of variance (ANOVA) was conducted to evaluate the relationship between teachers' grade level and their self-reported behaviors related to inquiry instruction. The ANOVA indicated a significant main effect, $F(2,1219)=20.7$, $p<.001$ (see Figure 1). Group sizes were quite different, so the Hochberg procedure was used in follow-up procedures. This post hoc test showed the mean percentage of instruction time reported by elementary teachers 41% (SD=20.1) was significantly higher than both middle school teachers 34.4% (SD=19.0) and high school teachers 32.1%

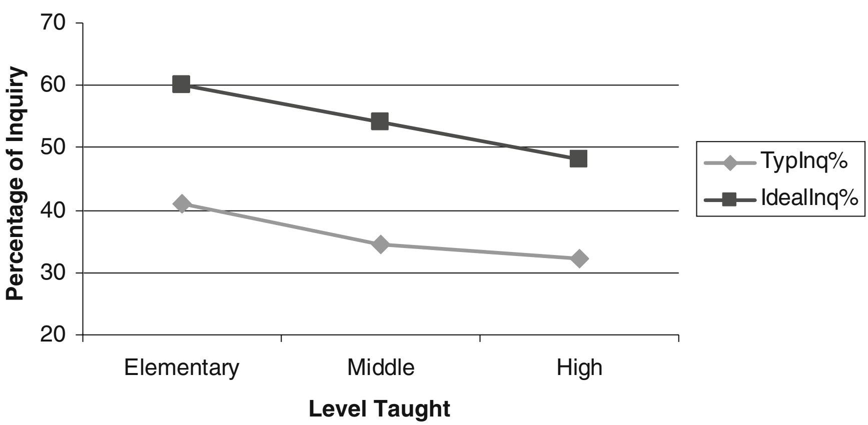

Figure 1. Percentage of inquiry (typical and ideal) used in the classroom vs. level taught

(*SD*=17.1). However, the strength of the relationship between grade level taught and percentage of time spent on inquiry instruction was small as assessed by $\eta 2$, with level taught accounting for only 3.3% of the variance in percentage reported.

An ANOVA performed on grade level taught and teacher beliefs about the ideal percentage of instructional time that should be devoted to inquiry was also significant, $F(2,1219)=30.9$, $p<.001$ (see Figure 1). Again, Hochberg was selected as the follow-up procedure, and it indicated that elementary teachers (*M*=60.0%, *SD*=19.0) supported a higher percentage of inquiry instruction was ideal than middle school teachers (*M*=54.0%, *SD*=19.4), and middle school teachers supported a higher percentage of time than high school teachers (*M*=48.2%, *SD*=18.9). The strength of the relationship between grade level taught and belief in the ideal percentage of time spent on inquiry instruction was small as assessed by $\eta 2$, with level taught accounting for 4.8% of the variance in percentage reported. During this testing, however, it was noted that equal variances could not be assumed based on Levene's test of homogeneity of variances, $F(2,1219)=3.11$, $p=.045$, so the Game-Howell post hoc also was performed, and it confirmed the significance of the previous tests ($p\leq.01$) for all three comparisons: elementary–middle, middle–high school, and elementary–high school.

Content Area

Science teachers reported a higher percentage of time devoted to inquiry during a typical lesson (*M*=37.3%, *SD*=20.7) than mathematics teachers (*M*=34.0%, *SD*=17.7), $t(465)=1.93$, $p=.05$. Further, science teachers reported a higher ideal percentage of instructional time that should be devoted to inquiry (*M*=55.4%, *SD*=20.4) than mathematics teachers (*M*=51.5%, *SD*=19.1), $t(517)=2.25$, $p=.025$. Though this main effect was not unexpected, blocking on grade level uncovered some surprising findings. At the elementary level, the typical and ideal percentages of time allocated to inquiry instruction were significantly higher for science teachers than for math teachers. However, these differences disappeared for middle school teachers, with no significant difference existing between the groups. For the high school teachers, both the typical and ideal percentages of time allocated to inquiry instruction were significantly higher for mathematics teachers than they were for science teachers. Also of note was that, as grade level increased from elementary to middle to high, both the typical and ideal percentages of time allocated to inquiry decreased dramatically for the science teachers, but remained approximately the same for the mathematics teachers. See Figure 2 and Table I for a summary of these results.

Support for Inquiry Instruction

Table II contains the correlations between the support scale and both the percentage of time devoted to inquiry during a typical lesson and ideal percentage of instructional time that should be devoted to inquiry reported by teachers. The M_{tot}=9.74 (SD=1.54), out of a maximum of 12, for the support scale indicated the high positive value placed on support for inquiry. Significance was found in six out of the eight comparisons at p<.01. A Pearson's correlation value of.257 (p<.001) was noted for the support scale total vs. the percentage of time devoted to inquiry during a typical lesson and approaches what Cohen (1988) referred to as medium significance (.30–.49). The highest correlation was noted among the elementary teachers, suggesting that support of colleagues and administration plays a more important role in the amount of inquiry that occurs in elementary classrooms than for middle and high school teachers.

Table II also contains the correlations between the role that curriculum support plays and the percentage of time devoted to inquiry during a typical lesson or ideal percentage of instructional time that should be devoted to inquiry. All eight correlations were significant at p<.01. Curriculum support was more highly correlated to the percentage of time devoted to inquiry during a typical lesson than to ideal percentage of instructional time that should be devoted to inquiry. For all correlations

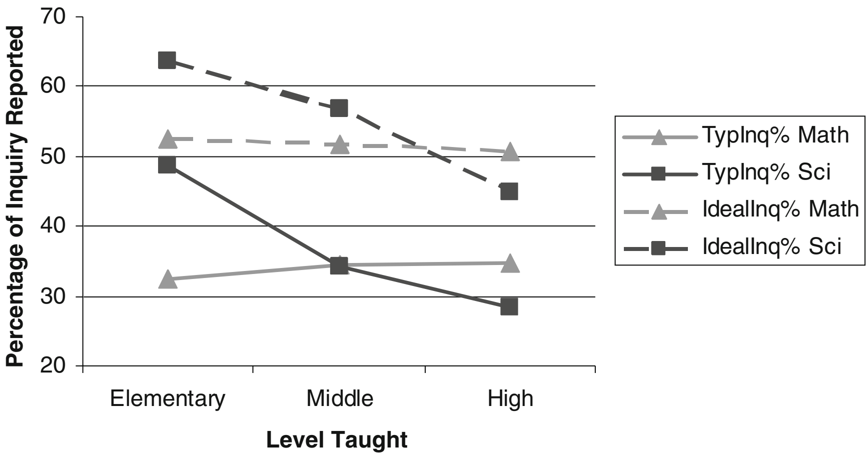

Figure 2. Percentage of inquiry in science and mathematics classrooms vs. level taught

TABLE I

Percentage of inquiry reported for mathematics and science teachers at various levels

	TypInq%			IdealInq%		
	Math	Science	Comparison	Math	Science	Comparison
Elementary	M=32.3% SD=15.0%	M=48.8% SD=22.1%	$t(134)=5.35^{***}$	M=52.6% SD=18.7%	M=63.6% SD=19.7%	$t(145)=3.45^{***}$
Middle	M=34.4% SD=19.3%	M=34.3% SD=18.7%	*t(197)=−0.035 (NS)*	M=51.7% SD=20.8%	M=56.8% SD=17.1%	$t(197)=1.90$ (NS)
High School	M=34.7% SD=17.8	M=28.5% SD=15.4%	$t(171)=-2.40^{*}$	M=50.6% SD=17.5%	M=44.8% SD=20.4%	$t(171)=-2.00^{*}$

NS indicates $p>0.05$, $^{*}p<0.05$, $^{***}p<0.001$.

TABLE II

Correlation of various support structures with TypInq% and IdealInq%

	Mean (SD)[i] for Ind. Var.	Pearson's r for TypInq% [M (SD)]	Pearson's r for IdealInq% [M (SD)]
Support Scale (total)[ii]	9.74% (1.54%)	.257*** [38.7% (19.8%)]	.200*** [57.3% (19.6%)]
Support Scale (elem)	9.90% (1.54%)	.255*** [41.0% (20.1%)]	.171*** [59.9% (19.0%)]
Support Scale (ms)	9.53% (1.53%)	.229** [34.4% (19.0%)]	.210** [54.0% (19.4%)]
Support Scale (hs)	9.21% (1.41%)	.117 (NS) [32.1% (17.1%)]	.115 (NS) [48.2% (18.9%)]
Curriculum Support (total)[ii]	4.44% (.994%)	.355*** [38.7% (19.8%)]	.202*** [57.3% (19.6%)]
Curriculum Support (elem)	4.52% (.978%)	.366*** [41.0% (20.1%)]	.171*** [59.9% (19.0%)]
Curriculum Support (ms)	4.19% (1.04%)	.299*** [34.4% (19.0%)]	.246*** [54.0% (19.4%)]
Curriculum Support (hs)	4.33% (.965%)	.271*** [32.1% (17.1%)]	.182** [48.2% (18.9%)]

NS indicates $p>.05$, $^{**}p<.01$, $^{***}p<.001$

[i] $N_{tot}=1222$, $N_{elem}=850$, $N_{ms}=199$, $N_{hs}=173$

[ii] Support Scale Maximum = 12 and Curriculum Support Maximum = 6

between curriculum support and percentage of time devoted to inquiry during a typical lesson, Pearson's r approached or exceeded the Cohen standard for a medium level effect ($\geq .30$). These findings suggest that the curriculum available that promotes inquiry instruction plays an important role in the amount of inquiry occurring in the classroom. Remember that this research addresses the role and frequency of inquiry in the classrooms of the teachers surveyed—not the quality or depth of the inquiry. Further studies are planned to investigate the quality of the inquiry being implemented. No significant differences were observed between the correlations for math teachers and those for science teachers.

Self-Efficacy for Teaching Inquiry

The mean self-efficacy score was 18.9 on a range from 4 to 24 ($SD = 2.53$). Correlational results suggest that teachers who possess a higher self-efficacy for teaching inquiry show a higher percentage of time devoted to inquiry during a typical lesson, $r(1219)=.323$, $p<.001$. This correlation drops only slightly when controlling for level and content area taught $r(1219)=.318$, $p<.001$. Similarly, those who report a higher self-efficacy for teaching inquiry show a higher ideal percentage of instructional time that should be devoted to inquiry, $r(1219)=.181$, $p<.001$. When grade level and content area taught are controlled for, the correlation drops slightly to.173 ($p<.001$).

Gender

Female teachers reported higher percentage of time devoted to inquiry during a typical lesson (M=39.18%, SD=19.93) than male teachers (M= 34.17%, SD 18.59), $t(150.4)=2.79$, $p=.006$. Likewise, female teachers reported a higher ideal percentage of instructional time that should be devoted to inquiry (M=57.99%, SD 19.38) than male teachers (M=51.17%, SD=19.88), $t(144.7)=3.58$, $p<.001$. For both tests, equal variances were assumed based on Levene's Test ($p=.916$ and $p=.135$, respectively). However, when controlling for the grade level taught, males did not have a significantly different percentage of time devoted to inquiry during a typical lesson, $p=.876$, or ideal percentage of instructional time that should be devoted to inquiry, $p=.543$, than females. In other words, the differences in gender for the percentage of time devoted to inquiry during a typical lesson appear to be due to the higher percentage of males teaching in the secondary schools, whose teachers tend to use and believe in a lower percentage of inquiry in the classroom.

Subject Matter Content Knowledge Training

The breadth of general SMK training in both mathematics and science (M=4.15, SD=1.35) was slightly lower for those reporting higher percentage of time devoted to inquiry during a typical lesson (M=38.7%, SD=19.8), r(1222)=-.057, p=.045. Significance was not noted when comparing breadth of SMK training in science and mathematics (M=4.15, SD=1.35) and the ideal percentage of instructional time that should be devoted to inquiry (M=57.3%, SD=19.5), r(1222)=-.049, p=.086. The measure of SMK training was determined by summation of the following college courses taken: college algebra, pre-calculus, calculus, statistics, physics, chemistry, biology, and earth science. If students took calculus in college, they were also given credit for having mastery of college algebra and pre-calc. In fact, when three college courses (pre-calc, calculus, and physics) where analyzed (M=1.16, SD=1.12) as a composite, there was no significance noted when compared to the percentage of time devoted to inquiry during a typical lesson (M=38.7, SD=19.8), r(1222)=-.010, p=.719 and to the ideal percentage of instructional time that should be devoted to inquiry (M=57.3, SD=19.5), r(1222)=.038, p=.181 (controlling for grade level taught).

Teacher Experience

Years of teaching experience. Even with the continued push in pre-service programs to encourage more inquiry and constructivist forms of teaching and learning (NRC, 1996), no significance was seen for the correlation between the number of years taught (M=12.8, SD=10.0) and the percentage of time devoted to inquiry during a typical lesson (M=38.7, SD=19.8), r(1222), p=.132. When controlling for the various levels taught, the correlation still lacked significance for all levels (p>.25) in all cases. However, without longitudinal data, we do not know whether professional development for in-service teachers has increased the use of inquiry to the same degree it has for pre-service teachers, or if there has not been a change at all.

Maximum Degree Earned. No significant difference was noted between the maximum degree held by the teacher and the percentage of time devoted to inquiry during a typical lesson F(2,1219)=.793, p=.453. Nor was a significant difference noted when the dependent variable changes to the ideal percentage of instructional time that should be devoted to inquiry F (2,1219)=.539, p=.584.

Prior STEM Career. Those who have had a STEM career prior to teaching (M=35.3%, SD=19.8, N=123) had a lower percentage of time devoted to inquiry during a typical lesson than those not having had a prior STEM career (M=39.1%, SD=19.8), $t(151)=2.01$, $p=.047$. Note that equal variances were not assumed. Likewise, those who have had a STEM career prior to teaching (M=52.2%, SD=19.4) reported a lower ideal percentage of instructional time that should be devoted to inquiry than those not having a prior STEM career (M=57.9%, SD=19.5), $t(151)=3.08$, $p=.002$. At this point, we can only speculate as to the reasons for this difference.

Discussion

In terms of typical percentage of time allocated and ideal percentage of time that should be allocated, inquiry-based teaching and learning have assumed a prominent role in science and mathematics classrooms at all levels for the district surveyed. Yet current implementation of inquiry does not come close to matching the desired amount of inquiry. Teachers at all grade levels in the present study consistently report an ideal percentage of instructional time that should be devoted to inquiry about one standard deviation above their current percentage of time devoted to inquiry during a typical lesson (see Figure 1). More specifically, these teachers reported believing the ideal percentage of instructional time that students should be engaged in inquiry is 18–20% higher than the actual percentage of time they report for a typical class. This disjunct provides a great opportunity for future research.

Further, the typical and ideal percentages of time allocated for inquiry decreases significantly for science teachers as the grade level increases (see Figure 2). This trend is not true for mathematics teachers who show relatively static percentages of reported typical inquiry and ideal inquiry. Perhaps mathematics teachers perceive appropriate instructional practice in similar ways throughout K-12 education whereas science teachers do not. For this district, one conjecture entails that the state achievement tests in science place a heavy emphasis on the process or inquiry standards whereas mathematics achievement tests tend to measure more procedural competency. This may explain why higher inquiry is found in elementary science when compared to elementary mathematics. However, by middle school there is no significant difference between math and science teachers, but the state tests in science still emphasize both the content and the process standards. So, the argument used for elementary teachers no longer holds true for middle school teachers. At the high school level, significance is noted but now in the opposite direction—math teachers now report higher percentage of time devoted to inquiry during a typical lesson and ideal percentage of instructional time that should be devoted to inquiry. The disordinal effect that was noticed between content area taught and grade level taught is a curious phenomenon where more research is needed. Perhaps high school science teachers lack the pedagogical knowledge to implement inquiry effectively at this level. However, why would high school science teachers have less pedagogical knowledge for inquiry than mathematics teachers do?

Though a definition of inquiry was provided on the survey *(inquiry refers to the development of understanding through investigation, i.e., asking questions, determining appropriate methods, gathering data, thinking critically about relationships between evidence and explanations, and formulating and communicating logical arguments—adapted from the National Science Education Standards, 1996, p. 105*), it is possible that there remain large differences between mathematics and science teachers' understanding not only of what inquiry is, but what it looks like in the classroom. In other words, though the definition for mathematics and science teachers may be the same, science teachers may have a very different worldview than mathematics teachers in how inquiry is best implemented in the classroom.

Of the factors studied, self-efficacy for inquiry teaching, level taught, and support structure were three areas identified that relate significantly to the percentage of time devoted to inquiry during a typical lesson and the ideal percentage of instructional time that should be devoted to inquiry. These differences are interesting because teachers' efficacy for teaching inquiry apparently does not differ significantly among grade levels or content area taught. These results suggest that self-efficacy is important but not individually sufficient to make the necessary transformation to more inquiry-based teaching (Ernest, 1989; Lerman, 1997). Further, the importance seen in the survey results regarding the need for strong support structures for teachers aligns with the current research (DuFour et al., 2004).

Possibly surprising to some (Corcoran, 1995; Kennedy, 1998; Lee, 1995) and not to others (Abell, 2007; Garet et al., 2001; Lloyd et al., 1998; Shulman, 1986), prior educational and work experiences were not significantly correlated to the percentage of time devoted to inquiry during a typical lesson and ideal percentage of instructional time that should be devoted to inquiry. This lack of correlation brings into question whether professional development experiences are critical for effective teaching if devoid of specific pedagogical instruction (Shulman, 1987).

Further research may be able to determine what a more effective balance between content knowledge and pedagogical knowledge is and if and how they can be better integrated. Again, however, it must be noted that SMK was not measured in this survey; at best, the measure was indirect, determined by number of courses taken and highest degree earned.

Those with prior STEM careers before entering teaching typically bring considerable SMK expertise because of their prior major and experience, but may have minimal PCK training. Perhaps this is the reason that those with prior STEM careers actually have lower percentage of time devoted to inquiry during a typical lesson and lower ideal percentage of instructional time that should be devoted to inquiry than their peers in mathematics and science education. Without the necessary content-specific pedagogical understandings, teachers cannot facilitate inquiry experiences that embed critical concepts within the learning experiences (Reynolds, 1995).

SMK and PCK training is not sufficient if the self-efficacy or belief structure is not also directly addressed in the process. Self-efficacy may lead to potential changes in teacher practice, but teachers also need practice in designing and teaching inquiry lessons in a supportive environment so that lasting change occurs (Jones & Carter, 2007).

This study is based on results from a survey administered to K-12 math and science teachers. Although differences were significant among level taught and content area taught, dissimilarities are also likely to exist within disciplines for each content area. Through observations, professional development opportunities, and discussions, future research in this area can also prove valuable.

Implications

Based on our survey results, we believe that the grade level taught, the content area taught, the support structures available, and the level of self-efficacy to teach inquiry are all significant factors that relate to the percentage of time teachers typically devote to inquiry (TypInq%) and the percentage of time they believe they should ideally devote to inquiry (IdealInq%). Numerous implications result from these findings. First, professional training programs that lack a long-term sustained commitment to change are not likely to significantly affect teacher practice and thus student learning (Supovitz & Turner, 2000). Since no correlation between the number of years taught and the percentage of time devoted to inquiry during a typical lesson was noted, several explanations are possible: (1) pre-service teacher training programs have been unsuccessful in recent years at increasing beliefs in or implementation of more inquiry, (2) pre-service and in-service teachers are growing, either positively or negatively, at an equal level toward their views and abilities to implement inquiry, or (3) a combination of both (1) and (2). For pre-service and in-service programs to grow to a point where equivalent views are noted seems unlikely. We hope that this study will help, at least partially, to guide the success of future professional development programs.

Other factors such as the degree held are not significant in determining the percentage of time devoted to inquiry during a typical lesson and the ideal percentage of instructional time that should be devoted to inquiry. This may suggest that graduate programs are not emphasizing inquiry instruction or are largely ineffective in doing so. Even if inquiry-based instruction is addressed in graduate programs, the efforts seem insufficient to promote significant change in practice. Further, the reason for the difference noted in percentage of time devoted to inquiry during a typical lesson found between mathematics and science teachers is difficult to determine until one better understands what inquiry looks like in a science class as compared with a mathematics class. So, further research into the quality of inquiry being implemented in each of these settings is needed. But *caeteris paribus*, elementary science teachers report using inquiry to a greater extent and believe a greater percentage of time should be devoted to inquiry than elementary mathematics teachers do; middle grade mathematics and science teachers do not show a significant difference from one another for either variable; and high school mathematics teachers report significantly higher than science teachers on both variables.

This study and current research (DuFour et al., 2004) shows that administrative, teacher, and curricular support structures are highly valued for all levels of teachers and should thus be integral to teacher training programs. Even though the quality of inquiry being imparted in the classroom was not measured as part of this study, the data suggest that elementary teachers collectively use and value inquiry teaching at a greater level than middle or high school teachers. Pragmatically, this shows a perception among teachers that inquiry is more important for lower grade levels or less feasible for higher grade level. We expected this to hold true for both mathematics and science teachers, though we had prior evidence of this only in science (Tobin & McRobbie, 1996); we found no studies in mathematics that addressed this issue. However, whether inquiry for the elementary grades is used to build deeper understanding of important scientific and mathematical concepts or to simply engage students in enjoyable activities without significant conceptual development is a matter for future study. Further, teachers in the upper grades may feel a greater need to impart learning in less inquiry-based formats, perhaps opting for what they view as greater efficiency, rigor, test preparation, and transmission. The reasons high school science teachers actually use and believe they should employ inquiry-based strategies less than elementary teachers is worthy of future exploration. Researchers in mathematics education are provided a very different problem—explain the relatively static reporting from all levels of mathematics teachers regarding the use and belief of how much inquiry-based teaching should be employed.

An argument often espoused by teachers for less inquiry teaching is that there is little time for it with all the content that must be "covered." If we are going to make significant strides in transforming how science and math are learned in school, particularly in the upper grades, then we first need to combat the dichotomization of content and inquiry where teachers feel that one is achieved only at the expense of the other. Perhaps one path to addressing this is to engage teachers in meaningful discussions as to what science and mathematics actually are and why students should study them. Certainly the standards in both disciplines suggest that the processes inherent in science and mathematics are critical, that students should master the scientific processes and learn to reason logically. Subsequently, we might then direct efforts toward helping teachers to become more proficient at explicitly integrating key content (conceptual ideas) into inquiry learning situations. If teaching practice is to match teacher beliefs, the efforts must be sustained and provide the long-term support for teachers to practice and refine newly assimilated inquiry-based learning approaches (Jones & Carter, 2007; Supovitz et al., 2000). The resulting product increases both teacher self-efficacy for teaching inquiry and the percentage of time devoted to inquiry during a typical lesson and the ideal percentage of instructional time that should be devoted to inquiry in the classroom. Further studies need to address the quality of the inquiry learning that is transpiring in the classroom as well as how content and inquiry can be unified from a practitioner's perspective.

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