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Inquiry-based Instruction: Does School Environmental Context Matter?

Abstract

In a larger study on teachers' beliefs about science teaching, one component looks at how school environmental context factors influence inquiry-based science instruction. Research shows that three broad categories of school environmental factors (human, sociocultural, design) impact inquiry-based teaching in some way. A mixed-method, sequential, explanatory design uncovers how school environmental context factors impact middle school science teachers' use of inquiry-based science instruction in the county where the study takes place. Ninety-one middle school science teachers participate in the study. Results show that few school environmental context factors impact teachers' ability to teach science using inquiry-based methods.

Background

Since the mid 1990s, there has been concern about whether or not school environmental context factors interfere with inquiry-based teaching. As part of a larger study, this article discusses an explanatory study that investigated the impact of school environmental context factors on middle school science teachers' (MSST) ability to teach science using inquiry-based instruction. Examining the impact of school environmental context factors using MSST provides an intriguing perspective about the teaching of science at the middle school level.

Research conducted by Ford (1992) and Bandura (1997) broadly classified context factors as aspects of the human environment (e.g. students, teachers, peers, principals, parents, and other stakeholders), sociocultural environment (e.g. culture, diversity, policy), or design environment (e.g. facilities, materials, and equipment). Of the three broad categories, this article focuses on the human and sociocultural environments. The following questions guided this component of the larger study:

- Do MSST enabling beliefs differ significantly from likelihood beliefs about science teaching?
- Are different patterns of context factors likely to enable MSST to effectively teach science?
- How do context factors influence MSST behavior in the classroom?

Research by Lumpe, Haney, and Czerniak (2000) on *Assessing Teachers' Beliefs about their Science Teaching Context* was used to help frame this study. These researchers used 262, K-12 teachers with varying degrees of experience in science to examine how context beliefs influenced science teaching. Their study revealed significant differences between what context factors the teachers believed would help them teach better (termed enabling factors) and those that would likely be available over the next school year (termed likelihood factors). The survey instrument from Lumpe, Haney, and Czerniak's research was modified and piloted for use in this component of the larger study.

Methodology. A mixed-methods, sequential, explanatory design with a multi-case research approach was used to conduct this study (Creswell, 2003). A survey of MSST was followed by case studies of three teachers from the survey pool (two females and one male).

Study site. The research took place in a large urban/suburban public school district (in the northeastern part of the United States) with a population of approximately 170,000 students enrolled in 240 schools. The student population consists mostly of White, Hispanic, African-American, and Asian students.

Participant selection. The participants for this study included all of the seventh and eighth grade science teachers in the district. Of the 150 surveys disseminated, 98 were returned, resulting in a 65% response rate. Seven survey responses were eliminated due to missing data. A stratified random sampling technique was used to select three teachers for the case studies.

Data Collection and Analysis

Quantitative methods: Data collection and analysis. An open-ended Likert-style survey was used to collect quantitative data. The survey included a section for demographics information and individual variables that included gender, years of teaching science, degree, certification in subject taught, and semester credits in science. The survey data were prepared for computation. Then, descriptive statistics, a paired t-test, and analysis of variance (ANOVA) were used to compute the survey data. The outcomes were analyzed and interpreted to build a cross-case report.

Qualitative methods: Data collection and analysis. Interviews and observations were used to collect qualitative data. Protocols were developed for each of these methods. Each teacher was interviewed before, during, and after being observed using a semi-structured approach. An exit interview was also conducted at the end of the observation

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sessions. The interviews lasted 30-60 minutes.

Each teacher was observed six to seven times. Short intermittent interviews, of 5-10 minutes, were held as needed during classroom observations to clarify issues that surfaced during the sessions.

Analysis of the interviews and observations data resulted in themes that were placed in cells of matrices to help identify school environmental context factors specific to each teacher. The themes were re-coded into smaller lists of terms and phrases to further determine if the data collected were responsive to the research questions.

Excerpts from the interviews and observations guided the logic of the analysis and explored how teachers differed in their beliefs about the influence of school environmental context factors on their ability to teach science using inquiry methods. These excerpts helped outline salient points from the interviews and observation that were later used to build interpretative summaries and initiate the development of research results and findings across the cases.

A comparison theme analysis grid of all of the cases revealed different kinds of information portraying theme patterns linking grid cells, empty grid cells, and the detailed content of each grid cell. Furthermore, distinguishable patterns and other features of teachers' beliefs about school environmental context factors became more evident as the data was analyzed and interpreted. This multidimensional approach to the analysis of data produced recurring patterns of themes and categories about school environmental context factors, which led to rich interpretation of the data (Creswell, 2003; Maxwell, 1996; Miles & Huberman, 1994; Yin, 2003a; 2003b). These procedures included:

- Coding and recoding data
- Placing data into different arrays
- Creating a matrix of categories in which to place respondent beliefs
- Creating flowcharts and other graphics for examining the data
- Identifying and conducting theme analysis and making comparisons across theme analysis grids for each teacher
- Organizing data in chronological order or other temporal schemes
- Composing cross-case report about how school environmental context factors influence teachers' classroom behavior.

Study Results and Findings

Quantitative results and findings. Results and findings from the survey are presented based on teachers' enabling and likelihood beliefs regarding school environmental context factors using the following variables:

- Years of teaching science
- Certification in the subject taught
- Semesters of college credit
- Degree
- Gender

Demographics results. Demographic data showed that 65 percent of the MSST were White and female, 92 percent held valid state teaching licenses and 74 percent were certified in the subject assigned to teach. Additionally, 92 percent had more than six semesters of credit in science, 62 percent held master's degrees, and 70 percent had less than 10 years of teaching experience. When compared to national statistics, the gender/race/ethnicity of these teachers is significantly lower than the national teaching population, which is 83 percent White and female. In all other categories, teachers in this study were more highly qualified than those comprising the national population as a whole (Ingersoll, 2011; Feistritzer, 2011).

Enabling beliefs about school environmental context factors. For the enabling factor, the mean scores were ranked from highest to lowest on a five-point scale to show whether teachers strongly disagree, disagree, undecided, agree, or strongly agree that particular items would enable them to be more effective teachers. Data in Table 1 show results for the enabling factor for the human environment.

As Table 1 shows, in the human environment, MSST ranked student motivation to learn as most critical to their effectiveness using inquiry, and ranked involvement of colleges and universities as the least critical to their effectiveness using inquiry. In response to items in the sociocultural environment (e.g. policy, cultural, diversity) that enabled them to be effective teachers, the mean scores showed that teachers ranked team planning as the most critical item followed by policies that supported science teaching (see Table 2). They did not place much value on decreasing the course teaching load, extending class time, or reducing the amount of content to teach as important to their effectiveness in using inquiry practices.

Likelihood beliefs about school environmental factors. In contrast to factors MSST believed would enable them to be effective using inquiry, the survey also asked them to indicate the likelihood that these items would occur

Table 1. *Items From the Human Environment That MSST Believed Would Help Them to Be More Effective Science Teachers.*

Enabling: Human Environment	*M*	*SD*
Students motivated to learn	4.8	.52
Support from peers/lead teachers	4.7	.65
Students who take control of own learning	4.7	.72
Support from principal/science supervisor	4.6	.64
Support from mentor/model teachers	4.6	.63
Students who can work well together	4.6	.60
Parental involvement in student learning	4.6	.73
Support from superintendent/board for rewards	3.8	1.11
Students looking for right answers	3.7	1.00
Involvement of colleges/universities	3.4	1.00

Table 2. *Items for the Sociocultural Environment That MSST Identified As Important to Their Effectiveness as Science Teachers*

Enabling: Sociocultural Environment	*M*	*SD*
Team planning time with other teachers	4.7	.58
Policies that support science teaching	4.5	.67
Reduced class size	4.5	.83
Increased planning time	4.5	.77
Tutoring and after-school support for students	4.4	.77
State and national guidelines	4.1	.82
Special programs and PD to address diversity	4.0	1.02
Community involvement	4.0	.81
Decreased course teaching load	3.7	1.22
Extended class time (block scheduling)	3.7	1.26
Reduced amount of content to teach	3.5	1.30

Table 3. *Items for the Human Environment MSST Believed Would Likely Be Available During the Next School Year*

Likelihood: Human Environment	*M*	*SD*
Support from peers, lead teachers, department chairs	4.7	.67
Support from mentors or model teachers	4.5	.85
Support from principals and science supervisors	4.4	.83
Students who work well together	4.0	.94
Students motivated to learn	3.8	1.05
Students looking for the right answers	3.8	.83
Parental involvement in student learning	3.5	1.06
Students who take control of their own learning	3.4	1.04
Support from superintendent and the board for rewards	3.0	1.05
Involvement of colleges and universities	2.6	1.01

Table 4. *Items for the Sociocultural Environment That MSST Believed Would Likely Be Available During the Next School Year*

Likelihood: Sociocultural Environment	*M*	*SD*
State and national guidelines	4.3	.87
Team planning time with other teachers	4.0	1.20
Tutoring and after school support for students	3.8	1.11
Policies that support science teaching	3.8	1.06
Community involvement	3.3	1.04
Extended class time (block scheduling)	3.2	1.49
Increased planning time	2.3	1.26
Reduced amount of content to teach	1.8	.90
Decreased course teaching load	1.8	.96
Reduction in class size	1.8	1.12

Table 5. *Paired Sample Statistics for Enabling and Likelihood Factors*

	M	*N*	*SD*	*SD* Error Mean
Pair Enabling beliefs	168.9	91	16.9	1.8
1 Likelihood beliefs	138.9	91	17.6	1.8

or be available to them during the next school year. The resultant information for factors in the human environment showed that teachers believed that in the next school year, support from peers and lead teachers, mentor and model teachers, principals and middle school science supervisors, and students who worked well together would likely occur. The results further showed that the MSST were less optimistic about student motivation, students taking control of their own learning, parental involvement with student learning, and support and involvement from local colleges and universities (see Table 3).

By a considerable margin, most of the MSST believed that state and national guidelines were sociocultural factors somewhat or very likely to be available during the next school year (see Table 4). A substantial number of the teachers also believed that it was somewhat or very likely that team planning time would increase, tutoring and after-school support would be provided for students, and policies to support science teaching would be maintained. The MSST responded *less likely* and *very unlikely* to the possibility of increasing class time or increasing regular class planning time as well as decreasing the amount of content required for teachers to teach, course teaching load, and class size.

Paired *t*-test. A paired *t*-test was used to examine whether there were statistically significant differences between teachers' enabling and likelihood beliefs. This procedure was performed with a statistical significance level set at .05 (see Table 5). The resultant *t*-test was significant for enabling and likelihood beliefs: t (90) = 11.54, $p < .000$.

Number of years of teaching experience. For the number of years teaching science, Table 6 (on next page) shows the mean score and standard deviation for each item in the enabling factor. The results showed that for the number of years of teaching experience:

- 44 teachers had 0-5
- 19 teachers had 6-10
- 12 teachers had 11-15 and
- 16 teachers had 16+

Table 6. *Mean Scores for Enabling Factor Based on Number of Years Teaching Science*

	Number of years teaching science	*M*	*SD*
Human Environment	0-5	44.0	4.7
	6-10	42.8	5.0
	11-15	43.1	7.2
	16+	42.6	3.7
	Total	43.4	5.0
Sociocultural Environment	0-5	44.7	5.0
	6-10	46.0	5.6
	11-15	46.7	8.7
	16+	46.0	5.3
	Total	45.5	5.7

Table 7. *Mean Scores for the Likelihood Factor Based on Number of Years Teaching Science*

	Number of years teach science	*M*	*SD*
Human Environment	0-5	37.8	5.6
	6-10	36.9	5.6
	11-15	37.0	5.0
	16+	38.3	5.7
	Total	**37.6**	**5.5**
Sociocultural Environment	**0-5**	**34.2**	**5.9**
	6-10	35.1	6.2
	11-15	30.9	6.5
	16+	31.4	4.8
	Total	**33.5**	**6.0**

Table 8. *Ranking of Enabling and Likelihood Beliefs Based on Total Mean Scores of the MSST*

Enabling		Likelihood	
Factor	Mean	Factor	Mean
Sociocultural	45.2	Human	37.6
Human	43.4	Sociocultural	33.5

This result support national trends where a significant number of teachers are new to teaching or new in the teaching profession (Ingersoll, 2011).

The results show no statistically significant difference among the items for this enabling factor.

As displayed in Table 7, the MSST ranked somewhat high items in the human environment with those in the sociocultural being slightly lower.

When the data were analyzed for the likelihood factor, the mean scores for the MSST were lower overall, yet no statistically significant difference was evident. Table 8 shows how the human and sociocultural school environmental factors ranked based on their total mean scores.

Analysis of variance (ANOVA). In this component of the larger study, one of the questions explored whether different patterns of contextual factors would likely enable MSST to effectively teach science based on the number of years of teaching science and other demographic factors. An ANOVA was used to test whether different patterns would emerge from the five variables. The results showed that neither the human nor the sociocultural factors ranked as the single most enabling or the most likely factor to impact their effectiveness as teachers. One exception prevailed for the likelihood factor for semester credits in science where females believed that human factors were most important and males did not.

With an alpha level of .05, the effect of the likelihood factor was statistically significant, F (2.8, 261) = .003, $p < .05$ for the number of semester credits in science (see Table 10).

The survey showed that for the enabling and likelihood factors, a number of items in the human environment and sociocultural environments would enable the MSST to be effective science teachers and that these items would likely be available during the next school year. The *t*-test results showed a statistically significant difference for the enabling and likelihood items exist when $p < .000$, while the ANOVA showed a statistically significant difference for semester credits in science.

Qualitative Results and Findings: Human Environment

The qualitative results and findings were based on a small sample of teachers who for the purpose of this study will be called Jeannie, Nida, and Joe. As noted by Ford (1992) and Bandura (1997), factors in the human environment include people from all aspects of schooling that come in contact with teachers during the teaching and learning process. In that regard, data showed that the three teachers believed a number of people influenced their approaches to science teaching and contributed to their effectiveness in using inquiry and continuing in the teaching profession.

First, Jeannie, Nida, and Joe stated that early in their careers, parents, teachers, and siblings helped to shape their interest in education and gave them the courage to be teachers. Second, they believed that working collaboratively with peers further shaped their beliefs about science teaching and did not interfere in their approach to teaching science, except for Jeannie.

Table 9. *Patterns of Enabling and Likelihood Factors Based on Number of Years Teaching Science, Certification in Subject Taught, Semester of College Credits in Science, Degree Earned, and Gender.*

Variable	Enabling	Likelihood	
# of Years Teaching Science	Sociocultural	Human	
	Human	Sociocultural	
Certification in Subject Taught	Sociocultural	Human	
	Human	Sociocultural	
Semester Credits in Science*	Sociocultural	*Females:*	*Males: **
	Human	Human	Standards
		Sociocultural	Sociocultural
Degree	Sociocultural	Human	
	Human	Sociocultural	
Gender	Sociocultural	Human	
	Human	Sociocultural	

** Denotes the difference between responses of females and males. The standards environment was added to the larger study and only featured in this article to show statistically significant differences for the likelihood factor for number of semester credits in science.*

Table 10. *Within and Between-Subject Statistics for the Likelihood Factor and Number of Semesters Credits in Science*

Source	*Df*	*F*	*Sig.*
		Within-Subjects Effects	
Likelihood	3.0	5.4	.001*
LIKELIHOOD * TRAINING	9.0	2.8	.003*
Error (LIKELIHOOD)	261.0	(87)	
		Between-Subjects Effects	
Intercept	1.0	576.1	.000
TRAINING	3.0	1.3	.267
Error		(87.0)	

Notes: Values enclosed in parentheses represent mean square errors; $*p < .05$

While Jeannie expressed no real concern about working with her peers, there was one teacher she described as having been at the school longer than anyone else. Jeannie learned how to use this teacher to help get things done. For example, Jeannie said as chair of the science department, "If I know I cannot get certain issues across to the department as a whole, I ask this teacher to present the idea. Usually when I take this approach, everything works out." Despite using this strategy, Jeannie stated, "I will make the hard decisions if I have to." Jeannie further stated that overall, "We are a good group that works well together." Joe expressed no real problems about working with peers, but stated that sometimes his peers did not agree with him when he volunteered the grade level to pilot a course or unit, which he continued to do anyway.

Data showed that peer teachers supported each other in professional development activities. For example, Nida stated that teachers have some flexibility in choosing professional development for personal growth and development. As such, teachers usually share what they learned with their peers. Jeannie reported that as chair of the science department, she frequently convened science teachers to share new ideas and opportunities as well as to learn from each other.

Generally, these teachers shared materials to facilitate inquiry, discussed ways to meet the needs of all students, shored up each other in times of isolation and frustration, and shared moments of joys when lessons worked well and students understood the content. For all of the teachers, interactions among peers were very apparent on grade level; however, the support was not as strong across grade levels.

Teachers and students faced challenges. The science curriculum is based on structured inquiry and the approach to teaching required middle school students to manage multiple tasks simultaneously. For this reason, Nida felt that sometimes seventh grade students seemed to struggle more at the beginning of the year with inquiry since they also had to keep an interactive assessment notebook. Nida believed most seventh graders experienced difficulty because both inquiry and the interactive assessment notebook required them to be self-guided and to follow through many tasks concurrently. According to Nida, in their assessment notebooks, students have to reflect on their work, make sure that specific points about the content are clearly made, be creative in their responses, and make sense of their own knowledge gains. Additionally, they needed to be mature enough to get the work in on time.

All told, the three teachers believed that student maturity was a school environmental factor that sometimes negatively impacted their ability to teach science using an inquiry approach. Both Jeannie and Nida stated that sometimes students entered seventh grade with little or no experience with the inquiry-based approach to teaching. These teachers learned quickly that starting early in the school year to address this issue worked best. Jeannie and Nida stated that students usually grasped the approach relatively fast and made steady progress overcoming the problem as they moved throughout the school year.

Of the two female teachers, Jeannie appeared to have made the most progress using inquiry. During observation sessions with Jeannie, it was easy to discern that her class was student-centered. When students entered her classroom, they immediately moved to their work stations, put on safety equipment (when needed) and conducted safety checks without being told to do so. Depending on the subject at hand, students might have tested the level of chemicals in water samples, recorded data, made inferences, developed solutions, and drawn conclusions about what they observed within and across groups. In contrast to Jeannie, Nida continued to be slightly less student centered in her teaching styles and focused on making sure students completed their assessment notebooks. With Joe it depended on which class was observed. In one class Joe's teaching might have been quite traditional, while in another it was not. Joe stated that students' lack of maturity and low interest in science have made him resort to using less inquiry-based practices than he would have liked too.

Principal leadership is key. The three teachers spoke positively about their principals' impact on their teaching. In fact, the teachers felt that their principals supported their teaching and left them alone to teach. These teachers also give their principals high marks for providing the materials needed to be successful. The teachers' reported that sometimes their principals provided them with too many opportunities for professional growth and that they sometimes turned down opportunities so that they could have time to reflect on, choose from, and integrate knowledge and skills they learned from previous activities into their lessons.

Parental impact both positive and negative. The teachers' beliefs about parental support were somewhat mixed. While they believed that parental support is critical to student success, Jeannie, Nida, and Joe sometimes felt troubled by the tremendous amount of pressure parents placed on their children to get good grades. Even a "B" on any assignment was a problem for some parents. They felt bad about the pressure some students faced and sometimes wondered whether parents understand how difficult it is for students to make the transition from 6th to 7th grade and how overwhelming it is to move from three teachers to eight teachers.

Qualitative Results and Findings: Sociocultural Environment

Diversity. At the time of this study, Jeannie, Nida, and Joe cited no major impact from issues related to the increase in the diversity of the student body on their use of inquiry. They all indicated that the county has a good system to deal with issues, such as getting information to parents about school activities, keeping them up on how well their children are progressing, and making them aware of services the county provides for parents to help their children at home. The teachers further noted that their schools had parent liaisons and a well-developed department that handled many of the concerns (e.g., language, homework), or that some teachers had learned to deal with diversity-related issues on their own.

Though student diversity was not interfering with their ability to teach, Jeannie stated that "the students influence you in many ways. Sometimes, students come to class and you have to do a little more to get them started, but once they do, they usually get it. I work hard to get to know the students . . . so that I can meet their needs." Jeannie further stated that "once you get to know the student and get into their minds…let them know what you expect and want them to learn, I usually do not have any problems."

Culture. Study data did not reveal any alarming concerns about culture. Jeannie, Nida, and Joe indicated that the county's support system for dealing with cultural issues was handled via outreach programs and liaisons as well. Throughout the study culture and language differences were only mentioned by Joe in regard to parents who might not understand English well enough to help their children at home. Otherwise, culture did not surface as a problem at the time of this study.

General Discussion

The triangulation of data showed that the MSST appear to have an encouraging and supportive environment in which to work. Despite minor school environmental context factors, these teachers fair better than most.

Significance. This study is potentially significant because it showed that when policies (Church, Bland, & Church, 2010), school and classroom support are available, few school environmental context factors can negatively impact teachers' ability to engage in inquiry teaching. The outcomes revealed valuable information for district policymakers about the capacity of the district at the middle school level to implement the science reform policy mandates. The findings for this study could also prove valuable to other states and districts that might look closer at this county's middle school science model.

In fact, this county is implementing most of the elements identified by the National Research Council (2011) as characteristics of successful K-12 STEM education. These include: adequate instructional time, equal access to high-quality STEM learning opportunities, school conditions and cultures that support learning, school leadership as the driver for change, parent community ties, student-centered learning climate, and instructional guidance.

Limitations. The study was subject to several limitations. First, instruments used to capture teachers' enabling and likelihood beliefs need to be researched and improved because eliciting a teacher's thinking is not a simple task. Researchers argue that what a teacher means by certain language in discussing instructional practice could likely be ambiguous to an outsider (the researcher), and the language by itself cannot always represent a teacher's voice unless it in more deeply anchored in the context of the teacher's perspective and actions.

Second, the small number of participants for the interviews and observations and even for the survey could have been enhanced by a larger participant pool. Third, research at the middle school level is limited and more is needed to help anchor new studies, make comparisons, and entice future research.

Implications for Practice

The outcomes of this study highlighted the importance of examining teachers' beliefs regarding the role that school environmental factors might play in classroom practices (Luft, 2008; Roehrig & Luft, 2004). The outcomes also indicated that investigating how science is taught at the elementary level might be useful for facilitating inquiry at the middle school level. Since it was evident that peer support and team planning were well established at each respective grade level, efforts should be taken to improve cross-grade peer support and team planning to improve overall school articulation.

Despite the lack of cross-grade peer support, data showed that over 95% of the MSST indicated that peer support and team planning were important to their effectiveness and valuable tools in helping them to teach science. This study's finding is inconsistent with most research that shows that teachers often work in isolation of each other. Hence, whatever strategies are being used, in other counties and districts, what was uncovered here might be helpful in reducing teacher isolation, fostering collaboration among teachers, and reducing attrition (Ingersoll, 2011).

Another finding worth noticing is the level of support principals have for their teachers (Peled, Kali, & Dori, 2011). Since the teachers were near universal in their agreement about principals' support, it might prove beneficial to other states and districts to find out what professional development and/or approaches this county used.

The data from this study also showed that, although school-related environmental factors influenced science teachers' classroom practices, many factors actually facilitated teachers' ability to teach. Therefore, sharing the county's strategies could help other districts establish similar structures to support their teachers' instructional needs (NRC, 2011). This finding could place the district in a unique position to serve as a model as many middle schools are not evidencing such success.

Moreover, unlike many districts across the nation that focuses most efforts on reading and mathematics, this county places a high priority on science teaching as well (NRC, 2011). Notably, instructional materials and supplies MSST needed to be effective were also readily available.

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