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ABSTRACT

The purpose of this qualitative study is to examine to what extent high school teachers' purported beliefs in contemporary science education goals are embedded in routine classroom practice. The context of this study is a learning community-based high school that belongs to the Coalition of Essential Schools and is sensitive to reform issues. The goal of this study is to develop grounded research hypotheses and summative observations using an inductive case study approach. Data generation and taxonomic analysis is achieved through the use of video, observer field-notes, transcripts, semi-structured interviews, reflexive journals, and responses to a contemporary goals survey. Methodological issues of trustworthiness, credibility, transferability, dependability, and confirmability of data are addressed. Examples from transcripts of connections between teacher beliefs and classroom practices and implications for further research are included. Contains 35 references. (Author/DDR)

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A Case Study of Teacher Beliefs in Contemporary Science Education Goals and Classroom Practices

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ABSTRACT

A Case Study of Teacher Beliefs in Contemporary Science Education Goals and Classroom Practices

The purpose of this qualitative study was to examine to what extent high school teachers' purported beliefs in contemporary science education goals are embedded in routine classroom practice. The context of this study was a learning community-based high school that belongs to the Coalition of Essential Schools and is sensitive to systemic reform issues. The goal of this study was to develop grounded research hypotheses and summative observations using an inductive case study approach. Data generation and taxonomic analysis was achieved through the use of video, observer field-notes, transcripts, semi-structured interviews, reflexive journals, and responses to a contemporary goals survey. Methodological issues of trustworthiness, credibility, transferability, dependability, and confirmability of data were addressed. "Samples of thought" which reveal the connections between teacher beliefs and classroom practices are presented, as well as implications and recommendations for future research.

A Case Study of Teacher Beliefs in Contemporary Science Education Goals and Classroom Practices

Objectives of the Study

In order to continue reform in science education, beyond the dissemination of new goals by the research community, some insight needs to be gained about the degree to which teachers believe in the contemporary goals and whether classroom practice is changing in support of these goals. As an initial study investigating the connection between these two specific factors, the focus will be on Souhegan High School (New Hampshire). Therefore, a case study which involves a detailed examination of a single group or individual will best serve the purpose of this investigation.

By surveying teachers' beliefs in contemporary science education goals, observing their classroom practice, reviewing forms of assessment, and interviewing teachers, this study will shed light on the consistencies between classroom practice and stated beliefs in contemporary goals. Furthermore, only by investigating the implicit link between teachers' beliefs in the contemporary goals of science education and classroom practice can the science education research community probe deeper into the dilemmas of educational change.

Rationale for the Context of the Study

Souhegan High School was established in 1992 with a very ambitious and passionate mission statement: "Souhegan High School aspires to be community of learners born of respect, trust, and courage. We consciously commit ourselves: to support and engage an individual's unique gifts, passions and intentions; to develop and empower the mind, body, and heart; to challenge and expand the comfortable limits of thought, tolerance and performance; and to inspire and honor the active stewardship of family nation, and globe". Learning communities, as defined by McLaughlin and Talbert (1993), are groups of teachers working together in a conscious effort to adapt their practice to the learning needs of students. Accordingly, Souhegan High School has become a member of the Coalition of Essential Schools (CES) and prescribing to its Nine Common Principles (Sizer, 1984).

The general direction of reform in CES schools is consistent with many of the specific recommendations offered by the science education community (AAAS, 1989,1993; BSCS,1993; NSTA, 1992; NRC, 1996). For example, recommendations associated with engaging students in their own learning; changing the teacher's role from teacher-as-expert and giver-or-information to facilitator of student centered activities; and the mastering of skills and relevant knowledge to provide depth, not just memorization of many disconnected facts. These consistencies make a CES member school a viable place for a case study investigation of teachers' beliefs in the contemporary science education goals and teachers' routine classroom practice.

Research Questions and Corresponding Rationale:

(1) To what extent is a teacher's purported beliefs in contemporary science education goals embedded in routine classroom practice?

Rationale for (1): For students to attain the goals as outlined by the science education research community, instruction must aim toward these goals. The value of investigating teachers' thoughts relative to their classroom practice is strongly supported (Clark & Peterson, 1987; Shavelson & Stern, 1981; Tobin, 1987b; Zeichner &Teitelbaum, 1982, as cited in Onosko, 1989). Hart and Robottom (1990) state that "there is a major gap between teachers' stated expectations for their students and their actual teaching practices" (p.578). Evidence of a gap in particular conceptions of science and classroom practice have been reported by Lederman and Zeidler (1987). By gathering data on teachers' classroom practices and their stated beliefs, occurrences of the gap can be investigated. Substantial research has been reported on teachers' desires not coinciding with their classroom practices (Harms, 1981; Olson & Russell, 1984; Stake & Easley, 1978; Stallings, 1982; Yager & Penick, 1984). Similarly, Goodlad (1984) points to teachers' inability to square their classroom practices with their ideological beliefs. Research has shown a basic unwillingness on the part of teachers to reorient their practice for an innovative approach (Olson, 1982). During these times of educational reform, it is imperative that there be examination of teachers' beliefs in current goals and the extent to which their classroom practice aligns with the attainment of these goals.

There are two sub-questions listed below which will provide a thorough analysis of the one, main research question:

Sub-Question #1) To what degree do Souhegan High School science teachers believe in the contemporary goals of science education?

Rationale for sub-question #1: Zeidler and Duffy (1994) and Zeidler (1998) reported surveys in which science teachers whose school belonged to the Association for Supervision and Curriculum Development's (ASCD) High School Futures Planning Consortium III (HSFPCIII) significantly favored contemporary goals to past goal orientations. Likewise, the population for this study will be high school science teachers whose school is formally involved in restructuring as members of CES. However, the present study will examine the routine practices of teachers using qualitative inductive data analysis. The research has supported the investigation of teachers' systems of thought in order to understand the key variables in implementing new curriculum (Akenhead, 1984; Mitchener & Anderson, 1989; Olson, 1981). Therefore, it is logical to have teachers' beliefs in the contemporary goals of science education uncovered if their pedagogy, as it relates to contemporary reform issues, is to be investigated.

Sub-Question #2) What is a Souhegan High School science teacher's degree of conviction in his/her beliefs about particular goals?

Rationale for sub-question #2: In investigating the consistencies between a teacher's stated beliefs and his/her classroom practice, the degree of conviction in particular goals will provide data for greater understanding of the actual teaching behaviors. Fishbein and Ajzen (1975) explain that the strength of a belief "is indicated by the person's subjective probability that he will perform the behavior in question" (p.12). Abelson (1988) called for theorists and researchers to devote increased attention to attitudes held with conviction. Distinguishing strongly held beliefs from beliefs that are unimportant to a person could explain why some beliefs may be resistant to change (Abelson, 1988).

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Significance of the Study

By qualitatively investigating teachers' beliefs in contemporary science education goals and observing a teacher's routine classroom practice, this study will help in gaining an understanding of the connection between these two factors in science education reform. This is consistent with the direction of future research as outlined in the literature of current science education (Shymansky & Kyle, 1992). The studies of McIntosh and Zeidler (1988), Zeidler and Duffy (1994), Zeidler and Duffy (1995), and Zeidler, (1998) were significant in that investigating the perceptions of the contemporary goals in science education among various professionals in the field is vital to the study of change. Along this line of inquiry, equally tantamount is the next phase, the investigation of classroom practice relative to the attainment of those goals. Anderson (1992), in an essay on curricular reform, supports the direction of studies such as this: "Once the desired reforms are identified, there still remains the question of what actions have the most potential for producing the desired improvements" (p.874).

The recommendations from the science education community suggest changes in current classroom practice. These suggestions are consistent with the work of Newmann et al. (1995) who define authentic pedagogy as instruction and assessment that supports "active learners" and is rooted in high standards of intellectual quality. The significance of this study is based on the research community's need to gain a deeper understanding of teachers' beliefs in the goals and the level of engagement in authentic classroom practice which supports them. The degree to which science teachers believe in contemporary goals of science education and whether those beliefs are embedded in their actions will provide a snapshot of authentic pedagogy in action.

Design and Methodology

The goal of this study is to develop grounded hypotheses/research questions. Given the stated research questions, a case study design most appropriately met the intended purpose of this study.

Population & Sample / Instrumentation

The context of this study was Souhegan High School (SHS) in Amherst, New Hampshire, USA, a suburban rural, middle class to upper middle class community, and a member of the Coalition of Essential Schools (CES). For the first phase of this study, all nine science teachers participated by responding to the Contemporary Goals of Science Education Survey (Zeidler & Duffy, 1994) to assess their beliefs in these goals and their degree of conviction to the goals (see Table 1; note that items appear out of sequence because they have been "paired"). Zeidler and Duffy (1994; 1995) have reported acceptable face, content and divergent validity, and reasonably high internal consistency and split-half reliability (between 0.70 and 0.87, p=.0001).

Purposeful sampling was then employed to yield three "typical case" teachers who were willing to allow an observer in their classroom and participate in multiple interviews. The procedure followed Spradley's Developmental Research Sequence (1980) with the goal of the research being the development of grounded hypotheses/research questions or summative comments (Glaser and Strauss, 1967). Classroom observation were videotaped and extensive field notes support the collection of data. Case and cross-case (among the three teachers) data was coded and analyzed by looking for patterns and constantly comparing incidents to codes to help establish clearly defined categories.

The second phase of this study included participant interviews which served multiple purposes: member checking for accuracy and clarification of classroom observation data; to probe deeper into participants' beliefs in the contemporary goals of science education and their classroom practice; to explain the assessment tasks; and to analyze the previously established categories for definition and hypothesis/research questions development. Interviews were recorded on an audio tape and were semi-structured following Newmann's et al. (1995) instrument - Standards and Scoring Criteria for Classroom Instruction and Assessment Tasks.

Methodological Issues

Issues surrounding the trustworthiness (Lincoln and Guba, 1985) of this qualitative case study were addressed in the following manner:

Credibility This study employed several techniques to improve the likelihood that the findings and interpretations are credible: prolonged engagement, persistent observation, triangulation, and member checking. In terms of data collection relative to prolonged engagement, data was collected until redundancy of data was achieved and teachers' behaviors were being repeated. Triangulation of data to increase the probability that findings and interpretations were credible had been derived from the Contemporary Goals Survey, classroom observations (videotaped and transcribed), collections of written assessments used by the teachers for the students, and semi-structured interviews. A follow-up interview, while providing further data to better understand the teachers' classroom practice, also served as a member-checking procedure. This procedure allowed the participants the opportunity to react to the researcher's representation of the situation and to clarify uncertainties or inaccuracies.

Transferability According to Lincoln & Guba (1985) "It is...not the naturalist's task to provide an index of transferability; it is his or her responsibility to provide the data base that makes transferability judgments possible on the part of potential appliers" (p.316). The data base for the present study contained extensive interactions, documents, interviews, transcripts that provided the "thick description" one would expect from inductive data analysis and provided evidence by which outcomes of categories and interpretations could be negotiated.

Dependability and Confirmability Both dependability and confirmability were attended to in this study by the use of an audit trail - i.e. a reflexive journal. This technique required the researcher to record information about herself and the study's method. Given the context of the study and the close relationship between participants and the researcher, it was imperative that the researcher continuously be conscientious and aware of the affects of personal values and preconceptions on both data collection and interpretation. The reflexive journal helped to fulfill this condition.

Findings

Overall, SHS science teachers favor most, an emphasis on inquiry skills, covering fewer topics in depth, providing a learning environment which broadens and deepens students' responses

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to aesthetic consideration (beauty of ideas, methods, living organisms, etc.), emphasis on higher order thinking skills, and heterogeneous classrooms. Additionally, SHS science teachers showed preference for the goals of scientific literacy, promoting career awareness in the sciences, stressing the interactions among science, technology and society, science as value laden with moral and ethical dimensions, organizing courses around themes, and experiencing science as a process of extending understanding not as unalterable truth. Also, a strong distinction was shown for knowledge and processes common to all science disciplines over those specific to each discipline; the development of divergent thought processes over the "scientific method"; students acquiring new knowledge versus the acquisition of facts; and integration of science, technology and society over knowledge and processes specific to each discipline. Therefore, in response to research sub-question one, SHS science teachers consistently showed beliefs in the contemporary goals of science education. With respect to research sub-question two, teachers strength of conviction to particular goal orientations tended to favor contemporary over past goals; however, some convictions did indicate inconsistencies relative to whether or not STS interactions should be emphasized.

Analysis of moderate and strong emphases responses from the Contemporary Goals survey provided an index for "strength of conviction" (Zeidler & Duffy, 1994). Calculating the weighted mean indicated how strongly those in favor of a particular goal stated their selection (see Table 2). Then comparing the weighted means of goal pairs, the strength of conviction between contemporary and past goals was determined (see Table 3).

Zeidler and Duffy (1994), arbitrarily used the index, less than 0.15, to "suggest inconsequential differences in the strength of conviction between contemporary and past goals" (p. 9). Using this same index, only one goal pair (30 - 4), met this criterion (-1.7). Interestingly, while seven teachers stated "no emphasis" on the past goal (#30 - "Science education should focus on knowledge acquisition and process skill unrelated to the interactions of science technology and society."), one teacher stated "moderate emphasis" and one teacher stated "strong emphasis" thus producing a weighted mean of 2.50. In contrast, contemporary goal #4, "Science education should stress the interactions among science, technology, and society.", three teachers stated "strong emphasis", six teachers stated "moderate emphasis" and no teachers stated either "slight emphasis" or "no emphasis", thus producing the weighted mean of 2.33. Therefore, calculating the difference in the weighted means: 2.33 - 2.50 = -.17.

Pursuing this inconsistency further, one teacher responded "moderate emphasis" to both contrasting goals #30 and #4. While another teacher responded "strong emphasis" to #30 and "moderate emphasis" to #4. These responses, although mathematically compelling, do not necessarily articulate the intended goal of the weighted mean as an index for "strength of conviction". In other words, it is difficult to conclude that those who stated a belief in the past goal (#30) do so with the same strength of conviction that those who stated a belief in the contemporary goal (#4). In fact, for one teacher, the strength of conviction for each goal, past and contemporary, is the same.

While no other goal pairs fall within the established index of less than 0.15, as outlined by Zeidler and Duffy (1994), one pair is close enough for further investigation. Goal pair #16 and #3 had a difference in weighted means of 0.17. The past goal, #16 states, "The most important knowledge that a science student should have are those facts, concepts, principles, and processes that are specific to each discipline". The contemporary goal, #3 states, "The most important knowledge that a science student should have are those facts, concepts, principles, and processes that are common to all science disciplines". While the group does show preference for the contemporary goal (mean = 1.78 versus the past goal's mean of 1.00), the claim can be made that those stating a belief in the past goal, do so with almost the same degree of conviction as those of the contemporary goal (weighted mean of contemporary goal = 2.17, weighted mean of past goal = 2.00).

Except for the two goal pairs addressed above, the science teachers of SHS showed a consistently higher degree of conviction to contemporary goals over past goals. Again excluding the two previous goal pairs, the average difference in the weighted means for the pairs was 1.57, with a range of 3.00 - .34, among the remaining twelve paired goals. Overall, the average difference in the weighted means for all the pairs was 1.35, with a range of 3.00 - (-0.17).

The primary research question (one) concerning the consistency between teachers' purported beliefs in contemporary goals and their routine classroom practice was assessed through focused observations, interviews, and taxonomic analysis of field notes, reflexive journals and video tapes with participants. This process produced generated codes of classroom practice (see Table 4) which were created at the time of the observation. Once the researcher felt that a thorough understanding of each teacher's routine classroom practice had been reached, there was a need to determine if these classroom practices were associated with any particular contemporary goals of science education and if so, which goals? In order to do this, the researcher reviewed all the codes and the contemporary goals as they were stated in the Survey of Contemporary Goals. A category was generated when a code, with its operational definition, showed some relation or connection to a contemporary goal (see Table 5 - Categories, Operational Definitions, and Corresponding Contemporary Goals). Initial judgments were made by the researcher as to whether these categories did relate to corresponding contemporary goals. Therefore, at this time, interviews with the teachers were necessary to provide the researcher with a form of verification about the connections being made. This form of a member check gave each teacher the opportunity to react to and clarify uncertainties or inaccuracies of the researcher's representation of the classroom observations, the categories that were generated, and the corresponding contemporary goals. Selected samples of thought and observations that reveal consistencies or inconsistencies between teacher beliefs and practice based from the category codes on Tables 4 and 5 are as follows:

• Heterogeneity - There is clear evidence of heterogeneity in this class. Beyond three different grade levels represented, 10,11, and 12, varying student abilities are apparent. There are students who finished the required measurements quickly and went on to sample additional solutions on their own. Teacher B assisted two students who struggled with graphing their data. Many students worked collaboratively and offered assistance to their peers with and without prompting by Teacher B.

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• Technology- There are various types of technology used in Teacher B's class, from centimeter sticks, calculators, and microscopes to the advanced spectrophotometers. Another example today is that there is satellite technology used by the collaborating university which generates data for the students' research on remote sensing. In another case, Teacher A expressed frustration over not having all the technical support to teach the class the way she would have like: "I could've done so much more with this lab if I had a computer program with pH probes. We need more instrumentation to get us out to the dark ages. I wouldn't have taught it this way if I had those pH probes."

• Higher order thinking- Teacher C continued to use real life examples as students advance their understanding of acids and bases. "You're going to have to use some logic to figure out the estimated pH. ... This is a logic problem more than anything else. You've got to analyze your data and compare it to this chart to figure out your pH's."

• Process skills, inquiry, and authentic assessment- After a week of studying acids and bases, Teacher A used this class time to introduce students to their final assessment activity activity. Students ere asked to play the role of a Consumer Reports chemist, design an experiment to test each antacid is best, carry out that experiment, and then write an article for the magazine which outlined their process and stated their recommendation for the best antacid. Teacher A: "You will design an experiment to test the neutralizing power of antacid. In doing that, I fully expect that you guys are going into the back room and playing...they (Consumer Reports chemists) don't have set tests. They have to come up with their own tests, and that's what you guys are going to have to do. When you are ready to do the write up, look here at these Consumer Reports magazines. You'll see how they write their data and summaries of each product. ... You are going to have to figure out how much base there is there. It's not an easy thing to do because there are several factors. You decide what concentration of acid to use. Play around with those equations for molarity to figure that out. You'll also need to make your own standard solutions and pick your own indicators. Ask yourself, 'Which one would work best for this concentration?' "

•STS / Moral & Ethical Issues- "This is a hard movie to watch (Lorenzo's Oil). Not only is it hard to watch Lorenzo getting sicker, but I found myself getting mad at the doctors and researchers. Remember to think about these two questions (pointing to the white board) while your watch this: 1. How are scientific discoveries made? 2. How is scientific knowledge disseminated?"

• Collaboration- Although Teacher C supports collaboration in her class, she is sure to see that group work doesn't allow for students to not engage. "What, are you guys a group of five now? What I'd really like is for you to do the lab, not just watch. Why don't you break up into small groups?"

• Affect- This particular activity produced one consistent response from the students to the sharp color changes as they tested the products with different indicators. Student: "Cool. Boy, those look so cool." Student: "Isn't that cool?" Teacher C: "This is cool. Look at the cabbage one." As the students figured out the pH ranges using the indicators and the chart from the textbook, there were various expressions of celebration, exchanging a "high five" and comments like "Yes, we got each one!"

• Constructivist- Teacher A: "I'm going to have you do a survey. I want you to do it individually. Do this completely for yourself. It's a test, but not for me to get a grade. It's a test of your own knowledge right now. Then in two weeks, when we've finished the genetics unit, I'm going to have you take it again to see if your beliefs of certain topics have changed. Do this quietly and independently."

• History - The class ended with Teacher A further developing the definitions of acids and bases: "I didn't mention this yesterday, but sort of a cool aside. Bromstead was in Sweden or Norway, up in that area, and Lowry was in England. It was really weird that these two guys published the same theory at the same time having never spoken to each other. And so they're both credited with that."

Clearly, the samples of thought and observations above suggest that while all three teachers varied greatly in their actual practices and the way they embedded their beliefs in their practice, in each case, there was a high degree of evidence of teachers' beliefs in the contemporary goals of science education embedded in their routine classroom practice. Table 6 provides further evidence which addresses the main research question to this study: To what extent is a teacher's purported beliefs in contemporary science education goals embedded in routine classroom practice? The case study evidence for these three teachers indicates that the average number of contemporary goals stated (strong and moderate emphasis)was 14 out of 16 possible statements, while the average number of categories observed as evidence of contemporary goals (derived from Table 5) through observations of classroom practices was 11. Hence, the average percentage of evidence of categories to stated contemporary goals was 79% --- an encouraging indication that the purported beliefs of teachers with respect to contemporary goals were in fact embedded (to a large degree) in their classroom practices.

While this analysis provides interesting evidence of the degree to which these teachers embedded their beliefs in the contemporary goals of science education in their classroom practice, judgments should be reserved. The percentages can be misleading and should not be equated to "good" or "bad" teaching relative to the contemporary goals of science education. For example, given this study's research questions and methodology, a teacher could state a strong belief in one contemporary goal of science education and show evidence in his/her class of that one goal, therefore the overall percentage would equal 100%. However, in these particular cases, all three of these teachers expressed belief (moderate to strong) in 16, 14, and 12 (respectively) of the 16 contemporary goals.

Summary

With the use of Spradley's Developmental Research Sequence (1980), this study sought to determine to what extent science teachers' purported beliefs in contemporary goals of science education are embedded in routine classroom practice. While addressing this issue, the study generated the grounded research question, what role do authentic science research projects play in a teacher's ability to embed his/her beliefs of science education in routine classroom practice? *Authentic science research projects* are investigations and lines of inquiry relating to an issue relevant to students' lives which, through research and experimentation, would demand

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engagement in the knowledge and processes of science (observing, hypothesizing, collecting data, inferring, etc.) and have value or meaning beyond school (Newmann et al., 1995).

All sources of data - observations, interview, and student assessment documents, revealed that, although in different ways, these three teachers' beliefs in the contemporary goals of science education were embedded in their routine classroom practice. There were two goals, however, that caused tension for the teachers. Goal #15 - "Science courses should cover a few topics in depth" and goal #23- "Science courses should be offered in a mixed ability (heterogeneous) classroom" were the goals providing the greatest challenge. This was evident in interviews with the teachers; for example:

> (O.C.) She has expressed frustration with heterogeneous Chemistry classes. 'How can you teach Chemistry to the whole class if some kids can't even do ratios or solve an equation?' she asks somewhat rhetorically. Teacher C does identify deficiencies in mathematics skills as her greatest opposition to heterogeneity. 'I think it's great that all kids get exposed to the material, but how can I go fast enough not to bore the bright kids, but slow enough not to lose the kids without strong math skills?'

It would be interesting to pursue this tension further with Teacher C. Are her frustrations about the students' skills or are her frustrations about her classroom practice? What techniques does Teacher C use in support of heterogeneous classes? Does Teacher C feel confident in utilizing possible strategies to address heterogeneous challenges? Teacher C did share her desire to collaborate with a math teacher to help bridge the gap between the study of math and the applications of math in chemistry classes.

In reference to science courses covering few topics in depth, Teacher A and Teacher C commented,

> Teacher A: I honestly believe in the principle, "less is more", but practicing that is still more difficult for me here in many ways. I'm not completely content driven, but I still carry around a certain idea of what I need to cover. I jettison stuff all the time. And with such heterogeneous classes, which I believe in, it's hard to cover

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all the material thoroughly for everyone. I've had trouble keeping continuity with our team schedule. It's been really, really hard for me.

Teacher C: Absolutely. But it's very hard to decide what you're going to let slide. I believe in going deeper and not just covering a ton of concepts, but even still, there are basic concepts that are necessary to be able to understand the bigger projects. It's a real struggle.

These sentiments seem to be shared among many science teachers as expressed in the literature. With the recent publication of national and state standards, which claim to also support "less is more", this tension for many teachers may not lessen. Again, if this research study was to be pursued in a different directions, the question, "To whom do you feel accountable to cover the content?" may have provided interesting insight in to how teachers decide what material they teach.

And finally, through this study, it became clear that reelection on beliefs in the contemporary goals of science education and classroom practice raised the teachers' awareness, both of what they do and what they do not do. This was evident in comments such as the following:

Teacher A: You know what will be interesting?

Researcher: What?

Teacher A: Seeing if I don't contradict myself in the classroom, because I struggle with that.

Researcher: Can you say more about that?

Teacher A: Yeah, I just feel like I'm not doing what I'd really like to be doing. I feel comfortable with my beliefs about what I should be doing as a science teacher, but I'm not really doing all that I'd like to. I don't know. ... I know that I'm not doing all that I'd like to be doing. My beliefs are still evident, but there's so much more I'd like the students to be engaged in. That's where the projects would come in. Projects could get at a lot of the things I haven't done this year.

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Teacher B: ...you know, sometimes I do have a sense of myself, sometimes. I think about what I'm doing. But, sometimes I just get up and do what I do and then the next class comes in, and I do it again. You know what I mean? But working with you (the researcher) is neat. It's really neat. I've never thought hard about what I do and why I do it. It's been so good for me to talk to you. It's fun.

Allowing this study's methodology to emerge from the interactions between researcher, participant, the data collections and analysis, provided the researcher the opportunity to develop a research questions from the data as outlined in grounded theory by Glaser and Strauss (1967). Again, the research questions that emerged was: What role do authentic science research projects play in a teacher's ability to embed his/her beliefs of science education in routine classroom practice?

Implications

This study provided the teachers, researcher included, a safe and supportive environment to discuss, reflect on , and analyze teaching practices and goals of science education.; The value of and need for this type of reflection and collaboration is thoroughly documented in the literature of professional development and school reform. research suggests that teachers' classroom practice "can be changed if teachers are actively involved in the process of identifying what needs to be changed and are provided with opportunities to practice, analyze, discuss, and receive assistance and encouragement to succeed" (Tobin and Espinet, 1989, p. 107). While an increase in awareness was evident, and is valuable, it is interesting to wonder if it will continue to provide enough motivation for change. The participants in this study have capitalized on opportunities for learning. Participants, since the completion of this study have initiated further discussions with the researcher, seeking support for their desire to change and improve their classroom practice.

Similarly, the literature has asserted that research on education improvement needs to involve teachers in ways which respect and engage their ideas, interpretations, observations and analytical strategies. Respect for a teacher's expertise as a vital component to educational change is consistent with the approach championed by Fullan (1993), "educators must see themselves and be seen as experts in the dynamics of change"(p.4). The relationship between the researcher and the three participants in this case study was based on a sense of shared expertise, respect, and trust. By engaging is this process of inquiry together, collegial relationships were deeply enhanced. This partnership of shared expertise, support, encouragement, and analytical reflection provides the teachers with the necessary foundation for making changes in their classroom practice.

Rather than being subjects of the research, these teachers were participants in the inquiry. Therefore, while addressing the primary research question, this study not only adds to the knowledge within the science education research community, but it indirectly benefited the participants and the researcher in their pursuit of effective science education. While schools across the nation are struggling with issues of reform, this study provides the field of science education with a case study of a school which is actually engaged in the recommendations for improved science education. Souhegan High School is a unique learning institution which values the recommendations and results of contemporary educational research. this study shows evidence of these recommendations embedded in the institution and found in its science classroom, therefore acting as a model for other schools grappling with the challenges of change.

The insights gained through this research provided a rich understanding of the degree to which these teachers' purported beliefs in science education are embedded in their routine classroom practice. The specific context and focus of this initial inquiry leaves open the same questions for much larger populations and in other settings; while the same methodology would be difficult to implement, the same line of inquiry is worthy of study on a larger scale. There are even more questions which have been raised through this inquiry, which are posed here as recommendation for further research:

1) If a teacher's purported beliefs in the contemporary goals of science education are not embedded in his/her routine classroom practice, does awareness of this dissonance initiate change in classroom practice, beliefs, or both?

2) Does an increase in the awareness of a teacher's beliefs in the contemporary goals of science education and his/her classroom practice provide enough motivation for change? What are the other necessary supporting components to sustain improvements in classroom practice?

3) To what degree do preservice science teachers believe in the contemporary goals of science education and how would the preservice teachers describe routine classroom practice supportive of these beliefs?

4) What role does the school's philosophy and/or mission play in the science teachers' beliefs in the contemporary goals of science education?

5) How can research of this nature incorporate students' perspectives of their science education relative to their teachers' classroom practice?

These are all questions raised as the result of this inquiry. As the education research community continues to construct meaning, generate theory, and participate in the process of change, research of this kind not only helps to inform that body of knowledge but generates more questions. Continued research studies, such as this one, which push teachers' thinking about their beliefs and their classroom practice. will help support the quest for understanding the process of educational change.

Table 1: Goal Statements Paired (Note: Contemporary Goals are in bold type)

31. Science education should not include career awareness. **2. Science courses should promote career awareness in the sciences.**
16. The most important knowledge that a science student should have are those facts, concepts. principles,

Table 1: Goal Statements Paired (Note: Contemporary Goals are in bold type).

and processes that are specific to each discipline.

3. The most important knowledge that a science student should have are those facts, concepts, principles, and processes that are common to all science disciplines.

29. Science education should demand those logical, convergent thought processes that are associated with the "scientific method".

12. Science education should demand the development of divergent thought processes associated with a range of societal, personal, social, and technological problems.

30. Science education should focus on knowledge acquisition and process skill unrelated to the interactions of science, technology, and society.

4. Science education should stress the interactions among science, technology, and society.

5. Science courses should be offered in a similar ability (homogeneous) classroom.

23. Science courses should be offered in a mixed ability (heterogeneous) classroom

24. Science should be presented as value free without moral or ethical issues.

9. Science should be presented as a value laden subject that has both moral and ethical dimensions.

8. Science courses should be organized around a single discipline.

21. Science courses should be organized around themes such as energy, stability, evolution, systems, and inquiry.

25. In science courses competition among students should be encouraged.

17. Science education should stress cooperation rather than competition.

18. Science courses should help students acquire facts, concepts, and principles.

11. Science courses should help students to restructure their own knowledge, therefore acquiring new knowledge.

28. Science education should provide a learning environment where scientific understanding precludes aesthetic considerations.

19. Science education should provide a learning environment in which students are able to broaden and deepen their responses to the beauty of ideas, methods, tools, structures, objects, and living organisms.

27. Science courses should cover as many topics as possible.

15. Science courses should cover a few topics in depth.

6. Science courses should be primarily designed to produce scientists to solve scientific problems.

1. Science courses should be primarily designed to produce a scientifically literate citizenry.

(cont'd.)

20. Science education should focus on knowledge acquisition and process skill development specific to each discipline.

13. Science education should focus on attitudes, values, beliefs, risks and economic considerations related to science, technology, and society.

26. Science should be presented as a rigid, unchanging discipline.
32. Science courses should provide students with the opportunity for experiencing science as a process for extending understanding, not as unalterable truth.

14. Science education should focus on the training of future scientists.
10. Science education should stress the intrinsic nature of each subject area.

7. Science courses should emphasize inquiry skills.
22. Science education should emphasize higher order thinking skills

Table 2: Data for Paired Goal Statements

Goal Statement #	Mean	Weighted Mean
31	0.22	0.00
2	**1.44**	**2.00**

16	1.00	2.00
3	**1.78**	**2.17**
29	1.33	3.00
12	**2.22**	**2.22**
30	0.56	2.50
4	**2.33**	**2.33**
5	0.22	0.00
23	**2.11**	**3.00**
24	0.22	0.00
9	**1.67**	**2.20**
8	0.67	2.00
21	**2.11**	**2.67**
25	0.11	0.00
17	**2.67**	**2.88**
18	1.44	2.00
11	**2.22**	**2.34**
28	0.33	2.00
19	**2.33**	**2.50**
27	0.00	0.00
15	**2.44**	**2.44**
6	0.89	2.00
1	**2.56**	**2.56**
20	1.33	2.00
13	**1.78**	**2.60**
26	0.00	0.00
32	**2.67**	**2.86**
14	1.11	2.00
10	1.56	2.25
7	**2.78**	**2.78**
22	**2.78**	**2.78**

Note: Contemporary Goals are in **bold** type

Table 3: Differences in Paired Goal Statements

DIFFERENCES IN PAIRED GOAL STATEMENTS

Mean Difference = Contemporary goal mean - past goal mean
Weighted Means Difference = Contemporary goal wt. mean - past goal wt. mean

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Goal Statement #	Mean Difference	Weighted Mean Difference
31 - **2**	1.22	2.00
16 - **3**	0.78	0.17
29 - **12**	0.89	0.78
30 - **4**	1.77	-0.17
5 - **23**	1.89	3.00
24 - **9**	1.45	2.20
8 - **21**	1.44	0.67
25 - **17**	2.56	2.88
18 - **11**	0.78	0.34
28 - **19**	2.00	0.50
27 - **15**	2.44	2.44
6 - **1**	1.67	0.56
20 - **13**	0.45	0.60
26 - **32**	2.67	2.86
14 - 10	*	*
7 - 22	*	*

* These two goal pairs were not meant for comparison. They were included as validity checks for comparison with prior items.

Note: Contemporary Goals are in **bold** type

Table 4: Classroom Codes and Operational Definitions

The following codes and their operational definitions were acquired through classroom observations and teacher interviews. The codes were developed *from* the observations and interviews and were not previously determined. The operational definitions describe more specifically the *language or behavior of the teacher* as observed by the researcher.

ABCs - a comment or behavior relating to the development of bigger ideas, building on ideas, after mastering basic concepts.

accuracy - a comment or behavior relating to accurate measurement in data collection.

affect - a comment or behavior relating to an emotion or feeling attached to an idea, observation, and/or some issue of science.

analogy - a comment that relates new concepts to already known concepts to aid in the development of understanding.

application - a comment or behavior which addresses the use of knowledge and/or skills beyond the current academic study, or relating to the use of the science content or skills in everyday life.

appreciation - a comment or behavior relating to the worth or value of science concepts and ideas.

assessment - a comment or behavior relating to general aspects of student evaluation which may include: quizzes, tests, papers, or projects, for example.

authentic science - any comment or behavior relating to "real life" science, an activity or project, as it would be among the general scientific community.

beliefs - a comment or behavior relating to what teachers beliefs are.

classroom resources - a comment or behavior relating to technical support for the class (materials, technology, etc.)

collaboration - any comment or behavior which addresses individuals working together.

college - a comment or behavior relating to students' advancement in school beyond high school.

communication - any comment or behavior that addresses the exchange of information or the importance of communicating either in school or among the scientific community.

constructivist - a comment or behavior which shows evidence of students building new knowledge or a teacher addressing students building new knowledge.

content coverage - a comment or behavior relating to scientific concepts studied in class or the amount of concepts covered.

curriculum change - a comment or behavior relating to changes in the current curriculum of that class.

data analysis- a comment or behavior relating to the science process skill of interpreting data.

data collection- a comment or behavior relating to the science process skill of gathering information.

demands - a comment or behavior relating to challenges of expectations for teachers.

demonstration - a comment or behavior relating to the teacher displaying an activity or skill.

directions - a comment or behavior by the teacher to instruct the students in how to do an activity.

discipline specific discourse - class discussion relating to a specific area of science content.

enjoyment of problem solving - a comment or behavior relating to the pleasure gained in solving a problem.

expectations - a comment or behavior that expresses the teacher's desired or anticipated actions of students.

experimentation - a comment or behavior relating to the scientific method or processes of scientific inquiry.

freedom - a comment or behavior that shows the lack of restrictions or supervision over the teacher relating to the teacher's ability to make individual decisions (on content coverage, actions, etc.) or a comment or behavior address the lack of restrictions or supervision over students.

goals - a comment or behavior relating to the teacher's goals/objectives for the science class explanation or relating to the teacher's goals of science education.

graphing - a comment or behavior relating to the science process skill of graphing.

heterogeneity - any comment or action by the teacher related to mixed ability classes.

higher order thinking - a comment or behavior addressing any general aspect of advanced student thinking which may include: analysis, synthesis, or evaluation, for example.

history - a comment or behavior relating to the study of the history of science.

hypothetical - a comment or behavior relating to what class might look like if ...

inferring- a comment or behavior relating to the science process skill of concluding or deciding.

inquiry - a comment or behavior relating to the higher order thinking skill of questioning.

integration - a comment or behavior which addresses the connections between science disciplines (biology, Earth science, chemistry, and/or physics).

interdisciplinary - a comment or behavior which addresses the connections of science to another discipline, mathematics, English, or social studies, for example.

journal- a comment or behavior relating to reflective writing as a form of student assessment.

logic - a comment or behavior relating to the use of logic.

member checking - during the interview, the researcher verifies with the participant the accuracy of an observation and/or interpretation.

misconceptions - a comment or behavior relating to the identification of student misconceptions in science.

model- a comment or behavior relating to making a model or replica as a form of student assessment.

mutual benefits - a comment or behavior relating to research that is of value to both researcher and participant.

nature of science - a comment or behavior relating to what science is and what science does.

observing - a comment or behavior relating to the science process skill of gathering information through the five senses.

obstacles - a comment or behavior relating to the challenges that keep teachers from not meeting their goals/objectives.

outside audience - a comment or behavior relating to presentation of school work for individuals outside of the immediate school community.

paper- a comment or behavior relating to a formal paper as a form of student assessment.

pedagogy change - a comment or behavior relating to changes in current classroom practice.

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personal history - a comment or behavior relating to any information about a teacher's past personal experiences.

personal teaching goals - a comment or behavior relating to a teacher's individual goals of teaching.

problem solving - a comment or behavior relating to students' higher order thinking around problem solving and decision making.

portfolio - a comment or behavior relating to the use of portfolios as a form of student assessment.

professional culture - relating to the atmosphere or behaviors of teachers with other teachers and the school's administration.

professional history - a comment or behavior relating to a teacher's previous experiences in teaching.

project based learning- a comment or behavior which address the use of a "project" or exhibition to frame the study or class.

rapport - an interaction between teacher and student(s) that shows evidence of a positive relationship between teacher and student.

reflection - a comment or behavior which shows a teacher thinking back on previous experiences and analyzing the situation for further learning.

relevancy - a comment or behavior relating the science content to students' lives.

school-wide goals - a comment or behavior relating to goals and objectives of the entire school.

science as human endeavor - a comment or behavior relating to the part of the definition of science literacy of science being done by people.

science process skills - comments or behaviors relating to the skills of science (for example, observing, collecting and analyzing data, hypothesizing, etc.)

scientific literacy - a comment or behavior relating to scientific literacy as defined by AAAS - the awareness that "science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes" (1990, p. ix).

scientific method - a comment or behavior relating the step-by-step experimental process.

scientists' responsibility to society - a comment or behavior relating to the responsibility scientists have to society.

STS - a comment or behavior relating to connections to social issues and the links between science, technology, and society, and/or moral and ethical issues in science.

student decision - making - a comment or behavior relating to students' thought processes and decisions.

student engagement - a comment or behavior relating to students' participation in the class discussion or activity.

student feedback for teacher - comments made by students relating to the teacher or the class for the teacher's reflection.

student reflection - a comment or behavior which addresses a student(s) thinking back on previous experiences and analyzing the situation for further learning.

teacher as learner - a comment or behavior that shows learning on the part of the teacher.

teacher collaboration - a comment or behavior relating to teachers working together.

teacher feedback for student(s) - comments made by the teacher relating to the student(s) or the students' work for their reflection.

teacher planning - a comment or behavior relating to teacher's thinking around future classes.

teacher professional development - a comment or behavior relating to a teacher's professional growth and plan for growth as a teacher.

teacher - researcher relationship - a comment or behavior relating to the relationship between teacher/participant and researcher.

technology - a comment or behavior referencing the use of technological equipment (computers, calculators, pH probes, satellites, etc.).

test - a comment or behavior relating to a content test as a form of student assessment.

time - a comment relating to time constraints for covering content, planning instruction, and/or assessing student work.

trial and error - a comment or behavior relating to trial and error as a method for solving a problem.

work in progress - a comment or behavior relating to ideas or practices being developed.

worksheet- a comment or behavior relating to a worksheet as a form of student assessment.

Table 5: Categories, Operational Definitions, and Corresponding Contemporary Goals

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The following categories and their operational definitions were generated when a code showed some relation to a contemporary goal. (Codes were developed from the observations; they were not previously determined.) Initial judgments were made by the researcher as to whether these categories did relate to corresponding contemporary goals. Interviews (member checks) with the teachers were conducted to provide the researcher with a form of verification about the connections being made.

Below are the categories, their operational definitions, and the number(s) of the corresponding contemporary goal(s) as stated in the Survey of Contemporary Goals.

category - ...operational definition...(# of contemporary goal from the Survey which is connected to this category).

accuracy - a comment or behavior relating to accurate measurement in data collection (1, 3, 12, 19).

affect - a comment or behavior relating to an emotion or feeling attached to an idea, observation, and/or some issue of science (1, 13, 19).

analogy - a comment that relates new concepts to already known concepts to aid in the development of understanding (1, 11, 32).

application - a comment or behavior which addresses the use of knowledge and/or skills beyond the current academic study, or relating to the use of the science content or skills in everyday life (1, 2, 4, 9, 11, 13, 19, 32).

appreciation - a comment or behavior relating to the worth or value of science concepts and ideas (1, 13, 19).

authentic science - any comment or behavior relating to "real life" science, an activity or project, as it would be among the general scientific community (1, 2, 13, 19, 22, 32).

collaboration - any comment or behavior which addresses individuals working together (17).

communication - any comment or behavior that addresses the exchange of information or the importance of communicating either in school or among the scientific community (1, 17).

constructivist - a comment or behavior which shows evidence of students building new knowledge or a teacher addressing students building new knowledge (11).

content coverage - a comment or behavior relating to scientific concepts studied in class or the amount of concepts covered (1, 3, 15).

discipline specific discourse - class discussion relating to a specific area of science content (3).

experimentation - a comment or behavior relating to the scientific method or processes of scientific inquiry (1, 3, 22).

heterogeneity - any comment or action by the teacher related to mixed ability classes (23).

higher order thinking - a comment or behavior addressing any general aspect of advanced student thinking which may include: analysis, synthesis, or evaluation, for example.

history - a comment or behavior relating to the study of the history of science (32).

inquiry - a comment or behavior relating to the higher order thinking skill of questioning (1, 22).

integration - a comment or behavior which addresses the connections between science disciplines, for example, between biology, Earth science, chemistry, and/or physics (1, 3, 13).

interdisciplinary - a comment or behavior which addresses the connections of science to another discipline, mathematics, English, or social studies, for example (1, 4. 9, 12, 13).

logic - a comment or behavior relating to the use of logic (1, 22).

nature of science - a comment or behavior relating to what science is and what science does (1, 19, 32).

problem solving - a comment or behavior relating to students' higher order thinking around problem solving and decision making (1, 12, 22).

project based learning- a comment or behavior which address the use of a "project" or exhibition to frame the study or class (1, 4, 9, 11, 12, 19).

relevancy - a comment or behavior relating the science content to students' lives (1, 19).

science as human endeavor - a comment or behavior relating to the part of the definition of science literacy of science being done by people (1, 9, 13).

science process skills - comments or behaviors relating to the skills of science (for example, observing, collecting and analyzing data, hypothesizing, etc.) (3, 12)

scientific literacy - a comment or behavior relating to scientific literacy as defined by AAAS - the awareness that "science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes" (1990, p. ix). (1)

STS - a comment or behavior relating to connections to social issues and the links between science, technology, and society, and/or moral and ethical issues in science (1, 9, 13, 19).

technology - a comment or behavior referencing the use of technological equipment (computers, calculators, pH probes, satellites, etc.). (1, 4, 12, 19)

time - a comment relating to time constraints for covering content, planning instruction, and/or assessing student work (15).

trial and error - a comment or behavior relating to trial and error as a method for solving a problem (1, 3, 19).

Table 6: Analysis of Categories Observed and Contemporary Goals Stated

Teacher A

11 contemporary goals stated with a strong emphasis

5 contemporary goals stated with a moderate emphasis

TOTAL = 16 of the 16 contemporary goals were stated with strong to moderate emphasis. Of the 16 goals stated, there was **evidence of 11 categories** which corresponded to the stated contemporary goals, therefore:

OVERALL PERCENTAGE FOR TEACHER A = 69%

Teacher B

7 contemporary goals stated with a strong emphasis*

7 contemporary goals stated with a moderate emphasis

TOTAL = 14 of the 16 contemporary goals were stated with strong to moderate emphasis. Of the 14 goals stated, there was **evidence of 13 categories** which corresponded to the contemporary goals, therefore:

OVERALL PERCENTAGE FOR TEACHER B = 93%

Teacher C

10 contemporary goals stated with a strong emphasis

2 contemporary goals stated with a moderate emphasis

TOTAL = 12 of the 16 contemporary goals were stated with strong to moderate emphasis. Of the 12 goals stated, there was **evidence of 9 categories** which corresponded to the contemporary goals, therefore:

OVERALL PERCENTAGE FOR TEACHER C = 75%

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