Using Transformative Research To Explore Congruencies Between Science Reform and Urban Schools

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Abstract: The Urban Science Education Center at Teachers College, Columbia University is attempting to inform how science reforms are introduced to urban middle school classrooms. In our work we are exploring three levels of congruency necessary in order for new innovations to result in sustained reform in individual school settings. To explore these congruencies we use the framework of transformative research, which is research that while focused on generating new ideas also works to "transform" or improve the teaching and learning of science. This paper describes our collaboration with one public middle school in New York City, using the concepts of congruencies to frame our efforts with the school as we collaboratively developed a project-based school-wide science curriculum plan. Through this process we learned both about ways to consider innovative reforms in relation to this school setting, and more general characteristics of conducting transformative research with urban schools.

Introduction

Many recent science education reform programs have demonstrated success in a variety of educational settings, including urban schools (i.e., Rivet & Krajcik, 2004a; Songer, Lee, & McDonald, 2003). However, little systematic work has been done to explore the process of bringing reform-based science curriculum materials to new learning environments, and to document the ways in which urban teachers enact these materials and adapt them to meet the needs of their differing urban classrooms. These issues are critical for learning how to leverage the best of new science education reforms and bring sustainable change to scale, particularly in urban settings where they are most needed.

The Urban Science Education Center at Teachers College, Columbia University is attempting to change the way science reforms are introduced to urban middle school classrooms. We believe that in order for effective reform to take root, we need to not only capitalize on existing innovative reform programs, approaches and resources for teaching science, but we also need to identify and work with each school's specific goals and needs, while at the same time recognizing and building from the similarities that urban schools share. We describe our approach to research and science education reform through the framework of *transformative research*. Our goals are to learn from the urban classrooms in which we work while also attempting to initiate change and innovation in the school's science program. This is accomplished through developing collaborative partnerships with teachers and the school leadership, and exploring teachers' and students' efforts to think about and engage with science in new ways.

We have partnered with several New York City middle schools to explore these issues in high-poverty neighborhoods such as Harlem, Morningside Heights, and the Bronx. Through our partnerships we are exploring three levels of congruency necessary in order for new innovations to result in sustained reform in individual school settings. First is the congruency between the vision of the innovation and the goals of the teachers and/or school, both in terms of content coverage and pedagogical approach. Second is the congruency between the supports offered in the innovation and the needs and resources of the classroom teachers. Third is the congruency between the contextualization of the innovation with students' experiences and prior knowledge they bring to the learning setting. We believe that the curricular innovation must work at each of these three levels in order for sustained reform to take hold. Achieving congruency at each of these three levels, however, involves an active process of adaptation and development of school ownership with the innovation.

The paper begins with a discussion detailing the three levels of congruency we explored as part of our work with schools to adapt new science innovations, as well as our framework of transformative research which guided our efforts. We then describe in detail our work with the administration, teachers, and students in one of our partner schools, PSW (1) to illustrate how we used the lens transformative research to inform and shape the nature of the reform adaptation process with the school. In our work with PSW we attempt to both identify and work with the school's specific goals and needs, while at the same time recognize and build from the similarities that PSW shares with other urban schools. This process of moving between the specifics of the local setting and the generalities of urban school reform enabled us to reflect upon the congruency of our reform efforts at each of these three levels.

Theoretical Underpinnings

Research describes many of the general challenges facing urban schools in their attempts to reform their science education programs, including overcrowded classrooms, under-prepared teachers, and lack of resources (Goetz, Floden, & O'Day, 1995). However, there is also much variation among individual schools within a given district or urban area. Each school has its own dynamic character and vision for educating its students. These differences arise from the unique personalities that constitute the school culture, including its leadership and administration, teachers, and students, as well as the community and environment in which the school is situated (Tyack & Cuban, 1995). Yet in this era of standardizations and accountability, often all urban schools are painted with the same brush, and assumed that they have the same deficiencies and same needs. This is also true for attempts to reform the teaching and learning of science in urban schools. In order to have the greatest impact and meet as many needs as possible, often reforms address the needs of 'typical' urban schools or try to be as general as possible (Fishman & Krajcik, 2003).

Rather than focus on the adoption of reform-based innovations and the fidelity of program implementation (Cho, 1998; Dede, 2000), designers and researcher are beginning to recognize that innovations must be adapted to fit within the social and instructional contexts into which they are enacted (Fishman et al., 2003), and local conditions likewise adapted to fit the innovation in order for them to succeed in new classroom settings (Ball & Cohen, 1996; McLaughlin, 1990). Similar to the framework for systemic reform described by Blumenfeld and colleagues (2000), we view this mutual adaptation process in terms of three levels of congruency necessary in order for new innovations to result in sustained reform in a particular school setting. The first is congruency between the vision of the innovation and the goals of the teachers and/or school, both in terms of content coverage and pedagogical approach. Second is congruency between the supports offered in the innovation and the needs and resources of classroom teachers. Third is congruency between the contextualization of the innovation with students' experiences and prior knowledge they bring to the learning setting.

Congruency between the vision of the innovation and the goals of the teachers and/or school: Every science education reform program, whether it is a curriculum, a pedagogical approach, or an innovative tool or piece of technology, had its own inherent vision for how science should be experienced by students in order to facilitate learning. Informing this vision is a set of assumptions about both the nature of science and about how people learn. These assumptions are used to define success in both the design and enactment of the innovation. School leaders, including administrators and teachers, also have their own ideas of what it means to teach and learn science and how success is defined in these areas. When there is congruency between the innovation and the school leadership around these ideas, it is easier for the school to adapt the innovation to their setting and a greater likelihood that the reform will be successful (Blumenfeld et al., 2000). However, the vision and underlying assumptions are not always clearly articulated, nor understood by those in the classroom and school settings who are adapting the innovation. Likewise, school administrators and teachers do not always recognize or articulate their own assumptions for learning and teaching science. Unawareness of discrepancies between the innovation and the school leadership in this area can lead to obstacles and roadblocks towards the successful adaptation of new reform programs.

Congruency between the supports offered in the innovation and the needs and resources of the classroom teacher: Urban schools range widely in the resources they have available to support student learning. Likewise, there is also a range of teachers' familiarity and comfort level with the science content, pedagogical support, and use of tools called for in a given innovation. If new innovations are to be successful, they need to provide sufficient support and information in order to allow their programs to be usable by a wide variety of teachers. This is especially true given that new programs often push the boundaries in terms of the types of opportunities students are given to engage in science and the use of new technology tools. The new tools and teaching methods to support these approaches can be demanding, and in some cases overwhelming, to even experienced teachers in the classroom. A direct response to these challenges would be to provide teachers with extensive support, including content and pedagogical resources, samples of variations and adaptations of lessons, models of classroom dialogue, etc. The catch, however, is that providing teachers with sufficient support and resources can quickly become unwieldy. There needs to be a careful balance struck between the providing the necessary information, hints, models, suggestions, and alternatives to help teachers enact the reform, but not too much of this support as to overwhelm them. Too much support can cloud the intent of the intervention itself, and *why* something should be done gets lost in *how* it can get done. However, too little support, whether in the form of materials, tools, or information, can render a reform program useless as well. Therefore congruency is necessary between the teachers' needs and the level of support offered as part of the innovation.

Congruency between the contextualization of the innovation and students' experiences and prior knowledge: Students bring a range of experiences and prior knowledge to science learning settings, including both content and "out-of-school" knowledge of their home, community, and culture. Science innovations attempt to connect to the knowledge and experiences students bring to the classroom through contextualizing aspects of the program, such as driving questions, anchoring events, and real-world application problems (Rivet & Krajcik, 2004b). Research has shown that students develop more integrated understandings of science content and perform better on assessment measures when they make connections between their prior knowledge and experiences and science concepts through the contextualization of the innovation (Rivet, 2004). However, it is a challenge for developers and teachers to identify those contexts which will be both engaging for students as well as provide a useful cognitive framework to support their science learning. Additionally, one group of students may find a context or problem meaningful, while another group may not identify or connect with that same context. Thus it is critical that serious thought be given to the contextualizing features of a new innovation, and how congruent they will be with the prior knowledge and experiences of students in a particular learning setting.

These three levels of congruencies provide a lens through which to view the process of bringing innovative science reforms to new settings, and identify the appropriate types and amount of support needed for the innovation to be successful. In the Urban Science Education Center, we use these three levels of congruencies to frame a transformative research approach to our work with our partner schools.

Transformative Research

The Urban Science Education Center (USEC) is committed to addressing the challenges that face the teaching and learning science in city schools. In doing so, we utilize the lens of transformative research to guide our work. Transformative research is a form of collaborative research that while focused on generating new ideas also works to "transform" or improve the teaching and learning of science, particularly in urban settings. We refer to transformations as occurring in three areas. The first is in transforming *understanding* – our understanding of how schools work, urban students' understandings of the intersections between schooling, science, community and personal interests, and teachers' understandings of their students and their role in school improvement. The second is in transforming *action*, in terms of the direct and immediate application of new understandings to the work we do in schools. The third is in transforming *relationships*, and in particular relationships between colleges of education, urban schools, and communities. As researchers, we bring to schools particular experiences, expertise, and agendas. However, we also recognize the uniqueness of the local contexts in which we work, including the knowledge of the school administrators and teachers, the intricacies of the school culture, and the needs of the community. We need to work together to foster these relationships in order for new understandings and new actions to positively impact teachers and students in these settings.

We view transformative research as a confluence of teacher action research (Briscoe & Wells, 2002; Tillotson, 2000) and design research (Brown, 1992; Design-Based Research Collaborative, 2003; Fishman, Marx, Blumenfeld, Krajcik, & Soloway, 2004), and having many similarities to each of these traditions. Although distinct, action research and design-based research both focus on the intertwining of research and practice. In a similar vein, transformative research attempts to develop both specific and more general understandings of complex classroom environment, as well as transforming practices which occur in those environments through curricular innovation and professional development. Transformative research builds from both of these traditions through a collaborative partnership between researchers and practitioners that is focused on not only learning new information, but also transforming the current situation. As with both action and design research, transformative research is situated at the nexus between research and practice, resulting in findings intended to inform both aspects of the work. We used this approach to frame our work in the USEC with our partner schools. Below we describe an example of such a partnership, and how we utilized transformative research to guide our efforts with the administration, teachers, and students in this urban setting in order to explore the three levels of congruency needed for lasting reform to occur.

Research Setting

PSW is a small public middle school located in the Morningside Heights area of New York City. It was one of the first schools started as part of New York City's small school movement approximately eight years ago. The school has a strong project-based curriculum which integrates technology with humanities and the arts. Classes are intentionally kept small, around 20 students or so, and teams of teachers work together to present multiple subjects at each grade level using a variety of individual and small group instruction strategies (NYC Department of Education, 2005). The student population is diverse, but predominately Hispanic and African American. 70% of students are eligible for the free lunch program. In 2003 the school was labeled with School Under Registration Review (SURR) status by the state due to only 25% proficiency ratings on both the city and state middle school mathematics and reading tests. SURR status required the school to develop a comprehensive improvement plan, which included reorganizing the curriculum and substantially increasing the instructional time given to reading, writing, and mathematics. Consequently, many challenges faced this school as we began to work with the students, teachers, and school administrators through a partnership with the USEC. These challenges included maximizing the limited amount of time allocated to science, providing quality instructional models for science inquiry and project-based curricula, and supporting the teachers' efforts to improve their science instruction, most of whom did not have a science background.

The first step in the transformative research process was to learn about the current science instructional practices and what the teachers and principle wanted to see happen at the school in the future with respect to science instruction. Several sources of data were collected in an ongoing process throughout the school year as conversations progressed between USEC researchers and PSW participants. Detailed fieldnotes of planning meetings between USEC researchers, the principal, AP, and teachers were recorded and artifacts from these meetings (i.e., agendas, curriculum outlines, standards alignment documents) were collected. Classroom observations of science lessons were conducted in conjunction with the related transformative research studies occurring in the school at the same time. Informal interviews were conducted periodically with teachers and school leaders about the process of collaboration and the direction of the curriculum recommendations, during which the interviewer recorded notes both during and after the conversations. These diverse data sources were iteratively reviewed and organized as new information was added. From this data, we described a set of characteristics of PSW which impacted how science was conducted at the school. These characteristics presented us with a unique set of strengths and challenges that would need to be taken into consideration when collaborating with the school to improve its science program. Two key characteristics of PSW are described below.

In terms of current practices, what stood out most about PSW was the intricate way the school had scheduled time for science instruction, in between the demands from the district on the amount of time for literacy and math and the school's focus on project-based work in the humanities. All students took science class for half the year in 6^{th}, 7^{th}, and 8^{th} grades, which alternated with art class the other half of the year. Science and art were taught during the same ninety-minute block twice a week, for a total of three hours of science each week for approximately 20 weeks each year. The science curriculum was also structured in an unusual manner. For science class, the students were further divided into three sections in 6^{th} and 8^{th} grade, and two sections in 7^{th} grade. Rather than one group of students staying with the same science teacher for the whole time, the teachers selected one unit of the curriculum to teach and repeated it two or three times with a new group of students each round. Thus each teacher taught the same unit multiple times during the school year to different groups of students. The history of this schedule was not made clear, however the school had a limited number of teachers and almost all were asked to teach multiple subjects during the day. A 6^{th} grade teacher may teach mathematics, science, reading, and humanities to different groups of students all over the course of a week. Of the five teachers who taught these science classes at PSW, four were certified in literacy or the humanities, with only one as a certified science teacher. Challenges associated with this schedule for science education were many. First there was the limited amount of time allocated for science instruction, much less than in comparable schools. Second, almost all of the science instruction occurred with teachers who were teaching out of field. As a consequence of this, in addition to the lack of an established science curriculum in the school, the administration often let teachers teach topics that they felt most comfortable with and gave a lot of leeway in how science was taught in these classes. However, one benefit of this program was that teachers had three, and in the case of the 7^{th} grade, four opportunities to teach the same unit within one school year. We recognized that this provided an excellent opportunity to study change in practice over multiple iterations of the same unit, and to perform design experiments in collaboration with these teachers.

A second interesting aspect of PSW was the project-based nature of the curriculum. The core of this curriculum was a set of literacy and humanities projects that ran throughout the language arts and social studies curriculum across the three grades. These projects had been developed by teams of teachers several years before and used repeatedly by whoever was teaching that subject at the time. The existence of these projects meant that new teachers entering the school had a base of curriculum materials to work with that was established across teachers and grades, and also led to consistency for the students in both the content and project-based approach to these subject areas. Although project-based approaches were espoused across the school's curriculum, such projects did not exist for literacy, mathematics, or science.

In meetings with researchers, the principal expressed her desire to have a science curriculum in a form that existed outside of individual teachers. In her experience, teachers would leave the school for new positions and take their projects, curricula, and ideas with them, while new teachers would have to re-create their science lessons based on their knowledge and past experiences with very little else to support them. This created a challenge to the consistency of the science instruction which students receive, especially given the high rate of teacher turnover in urban settings. Thus, the principal requested that the curriculum materials that were recommended and adapted to meet the needs of the PSW teachers and students be in a written form that could be passed from teacher to teacher, with records of each teacher's notes and changes from each enactment of the units.

Findings

Building from the information gathered about the characteristics of PSW we worked with teachers and school leaders to formulate a set of recommendations for our partnership, in terms of research areas to purse and changes to be made to address the goal of improving the school's science instruction. Together we decided on two initial steps in this process. The first was to design a school-wide science curriculum plan, which both identified the content that would be taught at each grade and how these content areas aligned with the state's core curriculum for science. The second was to begin to identify existing projects and innovations that could serve as models of project-based science instruction for the teachers, and as a jumping-off point for adaptation and development of the school's own curriculum. In this paper, we situate these efforts in terms of the three levels of congruency described above.

Congruency of Vision

With there already being a project-based focus in other subject areas, we recommended continuing this approach through the PSW science program. Thus the innovations that were selected as models for adaptation by the school included reform-oriented project-based science units and other curriculum resources which had demonstrated previous success in urban settings (Marx et al., 2004). This change resulted in congruency between the vision of the curriculum programs and goals that the school had for teaching and learning science. However, a key challenge was to ensure that the meaning of "project-based" was consistent between the innovation and the school administration and teachers. What we found was that some characteristics of project-based science were common, in particular the focus on a driving question and the development of a final product. However some features were not in agreement. For example, project-based science emphasizes investigations and experiments to address the driving question. The teachers and school leaders viewed investigations differently, and had difficulty conceptualizing the role of experiments in the curriculum. The differences in vision were addressed through multiple conversations and professional development sessions with researchers from the Urban Science Education Center.

Congruency of Teacher Support

In our discussions with teachers at PSW, most expressed willingness, but also discomfort, for teaching science. Since many did not have a science background, they were unclear in how best to engage students with the content or address their questions and curiosities. The highest priorities named by the teachers for the science curriculum included content support, sound curriculum models, and new ideas for pedagogical strategies. However, they also expressed apprehension about letting go of their current practice and taking on new projects. Although they recognized that their science instruction was lacking and that improvements would benefit students in multiple ways, they were concerned both with the time involved in learning how to teach a new unit and with their unfamiliarity with new content in these units. There was also a range of responses from the teachers in the group when it came to this issue. Some were willing to experiment with new approaches, others were willing to follow along with new curriculum units, and others were very reluctant to give up their current practice.

Given this range of responses, we approached achieving congruency between the needs of teachers and the curriculum innovations in two steps. First, to make the most of the unique class schedule at PSW, it was decided that each teacher should be responsible for teaching only one or two units of the curriculum, and for addressing a single broad concept and focus on developing the performance indicators for that concept. This way, each teacher may be able to develop expertise in teaching their unit because they would have multiple opportunities to work with the materials over the course of the year. The second was to begin to identify existing projects and innovations that could serve as models of project-based science instruction for the teachers, and as a jumping-off point for adaptation and development of the school's own curriculum. A challenge in this area was that projects and innovations were often either too advanced or too complicated to be used directly in this setting. Most were structured as 6-10 week units with a minimum of four hours of science instruction each week. Each selected unit needed to be extensively adapted specifically for the school, teachers, and students, both in terms of the background, experiences, and cultures which students engaged with the curriculum, and also adaptations to the structure of the units to fit within the limited instructional time available.

Congruency of Students' Experiences

Initially, the experiences and prior knowledge of students at PSW were taken into account through the use of project-based science programs designed for other urban settings and which had demonstrated success in those areas. These programs were ones in which interest in and engagement with the contextualizing features were used as a way to support students science learning (Rivet, 2004). Some of the contextualizing themes for these innovations could be easily adapted to the PSW setting, such as altering a water quality unit to focus on the Hudson River. Other contextualizing themes were included because they were thought to be of interest more generally to middle school students, such as a focus on diseases. We recognized that each unit needed to be suited to fit each classroom situation and group of students, but that this process would happen gradually as teachers became more comfortable with the programs and adapted them to meet their needs and teaching style. Initial attempts to adapt these contextualizing aspects to PSW classroom settings had mixed results, and appeared to be closely tied with the teacher's interest and enthusiasm in the project. For example, in a study of invasive species students were focused on the introduction of sea lamprey in the Great Lakes. Although this problem is not immediately relevant or connected to New York City youth, the teacher worked diligently to make connections and foster interests in the issue, even dissecting a sea lamprey in class, and consequently the students became very engaged with this problem. On the other hand, another teacher described how she struggled to make a unit about machines interesting to her students, even though there were many machines working on local construction sites near the school.

Conclusions

The new project-based science curriculum units are currently being enacted at PSW. We are actively collecting information about the enactments, their success, and teachers' and students' reactions from working with these materials. The PSW curriculum plan and the adapted curriculum units will be revisited during the upcoming summer with the teachers to consider progress and address additional concerns that were raised after this first enactment of the new plan. Through this process we will address and make concerted efforts to improve the congruency between the new science reform programs and PSW at each of these three levels.

A key characteristic of this effort, which has informed our broader work, has been our developing understanding of the roles taken up by each contributor to this partnership as framed through the lens of transformative research. The role of the researcher expanded beyond the traditional position as data collector and analyzer, and took the form of an advisor, information-gatherer, bringer of new ideas, and facilitator of the partnership for discussions about change. The role of the teacher also expanded in this framework. Rather than being viewed as one who simply implemented an intervention, the teacher was asked to be a risk-taker who was willing to commit to the process, and who needed to recognize and embody the work because the changes had the largest impact on him or her. The administrator's role was found to be particularly important to this process. Their role included supporting and encouraging the process, finding resources, and providing leadership and vision for the broader impact of this work on students and the school more generally, rather than just in individual teachers' classrooms. We have found that it is not simply participation at each of these three levels, but the *quality* of the participation as described by each of these roles, that is critical in order to achieve congruency between the innovation and individual school settings. Without these broader visions and underlying supports, the success of these reform efforts would likely not be possible.

Additionally, this work has begun to identify the characteristics of an urban school science curriculum that need to be considered in order for substantive and lasting reform to take place. Next steps in this process include working with teachers and administrators to adapt and utilize the selected specific innovative curriculum projects in ways that meet the needs of PSW's teachers and students. Through this process, we hope to learn more about utilizing transformative research to frame partnerships with schools to improve the teaching and learning of science in these urban settings.

Endnotes

(1) All people and school names have been changed.

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