

Reshaping The “Glass Slipper”: The Development of Reflective Practice by Mathematics Teachers Through Action Research

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Abstract

This article describes a professional development program designed to encourage middle and high school mathematics teachers to incorporate new classroom practices and to reflect on the effects of those practices. Two cohorts of mathematics teachers were guided to experiment with the practice of reflective inquiry through an action research (AR) process. In this article, we describe lessons we learned from teaching the AR process to Cohort 1. We then show how we altered the process for Cohort 2 by creating five predefined and required “mini- investigations” done through a “Cycle of Teaching and Inquiry Model” (CTIM). This model led to more frequent, more focused, and richer reflections by teachers, and to the development of better structured assessments. This process had transformative effects on teachers, students, and on our own learning.

Inquiry-based approaches to instruction, in which students have opportunities to construct their own understandings of basic concepts, have been found to be effective in developing both mathematical knowledge and competencies (Kilpatrick, Swafford, & Findell, 2001; National Council of Teachers of Mathematics [NCTM], 2000). Such approaches engage students in critical in-depth, higher-order thinking by providing opportunities for reasoning, verifying, comparing, synthesizing, interpreting, solving problems, making connections, communicating ideas, and constructing arguments. Inquiry-based practices depart in significant ways from “traditional” instruction as the classroom is transformed into a stage for mathematical discourse and student-centered instruction (Grouws & Shultz, 1996). Helping teachers make such a fundamental shift in practice requires very powerful approaches to professional development. The process of reflective inquiry through the Action Research (AR) cycle practice is one such approach.

Professional Development through Reflective Inquiry

In the reflective inquiry approach, teachers are engaged in a continual process of asking questions, understanding problems, and revisiting critical issues related to teaching and learning. They then design and implement plans to resolve problems, and collect and analyze data to assess their effectiveness. As teachers improve their pedagogical skills, they increase their ability to explain terms and concepts to students and to interpret students’ statements and solutions (Copland, 2003; Grouws & Shultz, 1996; Hill, Rowan, & Ball, 2005; NCTM, 2000). For Hammer and Schifter (2001), reform in teaching mathematics means that “inquiry is inherent in teaching itself” (p. 445), embedded in often invisible ways in the everyday work of mathematics teaching (Heaton, 2000).

Action research has become a fairly common mode of investigation in educational research, especially among researchers interested in classroom teaching practices (Freire, 1970; Mills, 2000; Smith & Heaton 2013). The approach has been described as a highly reflective, experiential, and participatory mode of research in which all individuals involved in the study, researcher and subjects alike, are deliberate and contributing actors in the research enterprise (Wadsworth, 1998). “Teachers having a stance of inquiry continually reflect on their past teaching, ask themselves questions to problematize their current practices, and collect and analyze data to inform future pedagogical decisions and teaching practices” (Smith & Heaton, 2013, p.148). Reflection is, therefore, critical to the practice of AR.

Almost all teacher education and professional development programs today incorporate some components of teacher research, because most educators agree that some form of reflection is a desirable practice among teachers (Farrell, 2012; Smith & Heaton, 2013). For Farrell (2012), however, the “agreement stops there.” He asserts that there is no agreement about what

reflective practice is (2012) and which reflective practices actually promote teacher development (Farrell, 2007). Farrell suggests beginning with what reflective inquiry is *not*. It is not just mulling over whatever is interesting, nor is it routine thinking. Teachers should, rather, be on guard against blindly following routines in which actions are guided by impulse, tradition, or authority.

For Henderson and Hawthorne (2000), reflective inquiry “involves continuous reflection of one’s professional activities with open-ended, disciplined critical inquiry that is conducted collaboratively, interplay among teacher reflection, critical thinking, and continuous learning” (p.40). Dewey (1933) noted that one of the main challenges of learning was learning how to think intelligently: “While we cannot learn or be taught to think, we do have to learn how to think well, especially how to acquire the general habits of reflecting” (p. 35). The challenge for teachers, therefore, is to acquire habits of reflection so they can avoid routine thought and action.

Reflective inquiry is among the practices recommended by the NCTM standards (2000), which are grounded in a constructivist perspective on knowledge, learning, and teaching (Davis, Maher, & Noddings, 1990; Fosnot, 1996). In this view, knowledge is socially constructed through human activity and shaped by context and purposes. It is then validated through a process of negotiation within a community of practice.

“Practice,” in Wenger’s social theory of learning, constitutes “a way of talking about the shared historical and social resources, frameworks, and perspectives that can sustain mutual engagement in action” (Wenger, 1998, p. 5). According to Wenger, practice relates to the learning community in which the worth of such practice is recognized, to the meaning that is generated when learners engage in such practice, and to the identity that is created and changed. The interconnection among practice, community, meaning, and identity explains the consequences of defining practice in a classroom. If it is defined in a way that builds on the resources and strengths of the learners, then the learners are positioned to experience learning that is positive and productive and that allows them to identify themselves as legitimate participants in the community (Lave & Wenger, 1991; Wenger, 1998).

This article shares our experiences guiding two cohorts of middle and high school teachers to experiment with the practice of reflective inquiry. It describes how we introduced the action research process to the first cohort and the lessons we learned from doing so. We then show how we altered the process for the second cohort and the results of that re-structuring.

Context

The process of inquiry is at the center of a five-year NSF-funded program designed to support the development of teacher leaders to strengthen mathematics teaching and learning in Yarmouth School District’s (pseudonym)

middle and high schools. Yarmouth maintains that improving student learning is rooted in improving teachers' pedagogical skills, which is largely accomplished by increasing their ability to carry out a cycle of inquiry.

As designers of the program, we believed that second-stage teachers, those with 4-10 years of experience, would benefit the most from this process. The second stage of teaching is characterized by some confidence in practice and an increased focus on student learning rather than predominantly on the teacher's own survival. Second-stage teachers have the readiness and the potential to begin refining their professional practice through the action research process without the pressure of getting a degree. At this stage, teachers are ready to judge the quality of their research themselves rather than having it judged by university professors (Jaworski, 2006; Smith & Heaton, 2013).

The professional development program was funded to support two cohorts of 40 teachers who each had at least four years teaching experience, permanent certification as a mathematics teacher, and a recommendation by their principal. Cohort 1 began in February 2009 and completed the program in June 2011. Cohort 2 began in July 2011 and completed the program in December 2013. Cohort 1 teachers received two semesters of coursework in conducting classroom action research in spring and fall 2010. Cohort 2 completed the two parts of the inquiry sequence in spring and fall 2012. Table 1 summarizes the characteristics of the two cohorts.

Table 1

Cohorts I and II: Characteristics of Participating Teachers

	Cohort I	Cohort II
Teachers	43	44
Middle School Teachers	13	26
HS teachers	30	15
Middle and High School	0	3
% Hispanic or African-American	60%	40%
% Who Majored in Mathematics	58%	32%
% Second-Stage Teachers	74%	73%
% Stage 3 (> 10 years)	26%	27%
Retention (after dropouts)	70% (total)	93% (after one year)

Implementation with Cohort 1

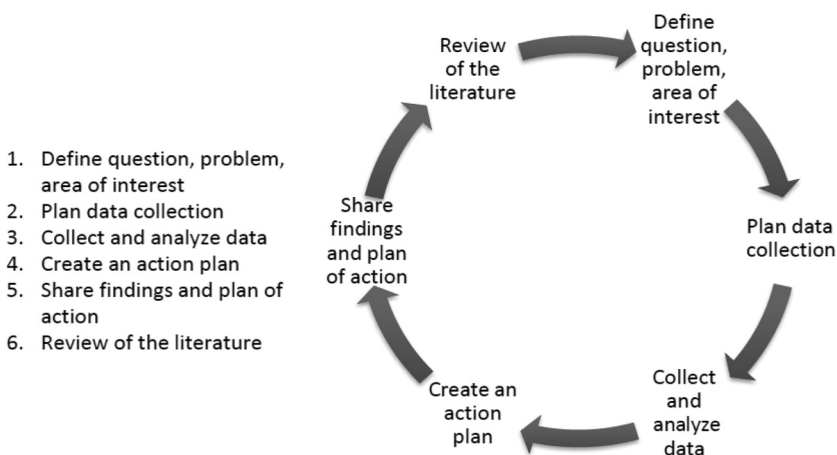
The introduction to theories and techniques of research for Cohort 1 teachers was similar to the two-semester sequence that was generally used to prepare Masters of Education students for their culminating research project.

Although the goal of such courses is for teachers to incorporate systematic inquiry as an integral part of their mathematics teaching, they rarely embrace teacher research as a stance (Smith & Heaton, 2013; Jaworski, 2006). Table 2 shows the inquiry cycle model, adapted from Johnson (2008), that we envisioned when we started the program with Cohort 1. We presented a model using “error analysis” in which teachers first identified and described misconceptions and errors made by some of their students and then designed and implemented instruction to address them.

The teachers collected and analyzed samples of students’ data and reflected on the experiments. They identified what worked and what did not work and refined the activities as needed. They reflected about and discussed the process, reviewed literature relevant to the issue, and reported what was learned through the process.

Table 2

Inquiry Cycle Implemented With Cohort 1 (Johnson, 2008)



Cohort 1 findings

As teachers were reflecting on their teaching and learning throughout the process, so did we. We kept reflective logs that described and analyzed the “obstacles teachers encountered in implementing their research, and how we needed to address them.” The following summarizes our findings:

- Teachers struggled to understand exactly what classroom action research is.** They were used to a more academic, formal meaning for the term

“research,” something more akin to the master’s theses several of them had already completed. In our attempt to clarify the differences between research and action research, we may have given them mixed messages. To some degree, we had expected the sort of rigor and polish of an academic research project, while in other ways we were more flexible. We wanted teachers to go through the steps of the research process, but time was of essence given the responsibilities and the increasing pressure they faced at the school. Identifying one issue among the myriads they faced everyday was problematic and took too much time. Many found the search for the relevant literature difficult because they could not determine the right “amount.”

We concluded that giving definitions of action research was inadequate. Providing an example or model of a research project might help, but people may copy such models somewhat slavishly. For the next group, we decided to minimize the use of the term “action research,” and emphasize rather the terms “reflective practice” which we thought was more in line with what teachers do inherently. We also decided to read and review sample reports and share some of the projects done in the class, which we thought would help.

2. **Teachers’ beliefs about locus of control were an impediment.** If a teacher believes that the performance of students is determined completely by forces and circumstances outside of the classroom, such as student attitudes, socioeconomic forces, or the educational system, the teacher has no incentive to try to do anything differently. An external locus of control can sound like: “I’m teaching well, but they just aren’t learning.” Amazingly, some of the teachers in the program seemed to have this belief, and, therefore, lacked any true motivation for examining or changing their teaching practices.

Convincing a teacher to undertake a small, well-designed experiment to try out a technique that others had found effective could change this type of belief. Generally, if given enough guidance in the technique, teachers will discover its effectiveness *for themselves*, and, as a result they may be more likely to continue trying something new. This “prescription” was difficult to implement with Cohort 1. By the time we knew our students well enough to realize this was an issue, the term was half-way over.

3. **A related issue was the level of teachers’ feelings of ownership and empowerment about the class/program.** For whatever reason, some teachers clearly felt that they were completing assignments for a class, as opposed to designing their own program of classroom-based self-directed professional development. This was, of course, a graduate course in which grades were given based on the extent to which students complied

with the teacher's expectations, so the issue of getting teachers to take ownership of the experience was the same one that those teachers faced with their students. We suspected that the task we set for them was not meeting some of their needs. Upon reflection, we concluded that broadening the scope of inquiry might have helped. We had focused the course on issues of student cognition (errors and misconceptions) when teachers face many other issues in the classroom daily. How to motivate students, communicate effectively with them, establish good relationships with their families, get them to work productively in collaborative groups, or get them to feel competent in math?

- 4. The format of the AR course offered to Cohort 1 allowed only one or two forms of investigation.** Each Cohort 1 teacher focused on the one or two inquiries they started from the beginning and researched intensively for two semesters. In the 27 research reports completed by 31 teachers (Some worked in teams of two), we found only five forms of investigation: Student Attitudes and Motivation; Student Error Analysis; Teacher's Error Analysis; the Use of Exit Cards; and Concept Attainment.
- 5. Finally, teachers simply did not have enough time in their busy lives to devote to their action research projects.** We did not have an idea of how to address this problem. We decided we would caution Cohort 2 teachers at the beginning of the term to make a commitment that, in addition to the class time, they would dedicate at least four hours per week to the inquiry. If they could not find that time, they were encouraged not to register for the course.

Modifications and Findings for Cohort 2

Reading Cohort 1 teachers' final reflections and paper led us to other crucial findings about how we would institute the second course. In their open-ended course evaluations, Cohort 1 teachers were asked to describe, "the ways in which the course has contributed to their growth as a teacher," most identified growth in the related areas of becoming a more reflective teacher, learning to pay greater attention to students' needs and prior knowledge, and trying out new techniques they did not have the chance to implement. They were developing assessments and teaching strategies "*in a more structured way and more frequently.*" We found a link between the investigations they did and the assessments and teaching strategies they used. Such a process can be described as a "Cycle of Teaching and Inquiry Model" (CTIM).

1. A new lesson is taught;
2. Data are collected at the end through exit cards (Exit Cards Activity);

3. Teacher analyzes the data collected and identifies errors and misconceptions (Teacher Error Analysis);
4. Teacher asks students to analyze their own errors at the beginning of the next day’s lesson (Student Error Analysis);
5. A new lesson is then taught and data collected on a two-question exit card that assesses the new lesson and reassesses the one of the day before.

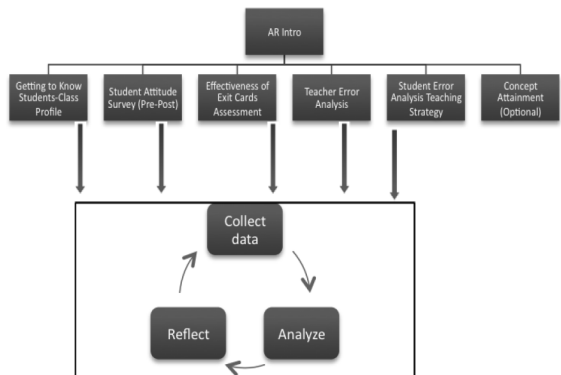
The cycle would continue with the teacher reflecting on each aspect, describing and analyzing successes and changes made, and critiquing and justifying actions taken such as revising and re-planning lessons. We also helped teachers to know the levels and characteristics (ELL, IEP) of their students by including a “Class Profile” activity using the automated school database and an “Attitude Survey” (Pre) activity to analyze students’ self-confidence, enjoyment, value, and motivation to learn mathematics at the beginning of the school year.

The CITM model of teaching and assessment led us to redesign the action research course to offer Cohort 2 teachers the double opportunity of learning new teaching strategies and conducting teacher research at the same time. The sequence of activities was restructured to include five interrelated modules of assessment and teaching strategies: Getting to know Students, a Student Attitude Survey, Exit Cards, Teacher Error Analysis, and Student Error Analysis. As shown in Table 3, for each of these modules, the teachers collected, analyzed, reflected on, and reported about student data.

Table 3
Cycle of Teaching and Inquiry Model (CTIM)

Six “Areas of Interest” identified. For each area, the following cycle was done:

1. Introduce topic
2. Read one introductory article;
3. Discuss issue;
4. Implement for 2-3 weeks;
 - a. Collect data;
 - b. Analyze;
 - c. Reflect.



At first, Cohort 2 teachers found it difficult to coordinate the different deadlines of this intensive and directed action research process with their own schedule of classes and curriculum map. The Exit Cards activities took at least three weeks to implement, while “Teachers Error Analysis” and “Student Error Analysis” took two weeks each. In between, they were required to read summaries of articles related to the five modules and a regular posting online on Blackboard.

In addition to having to deal with crowded and underfunded schools, Yarmouth teachers faced an incredible amount of scrutiny and pressure from high-stakes testing. We, in fact, had to move some deadlines to accommodate the shifts that many schools took because of test preparation. The investigations did, however, eventually become “affordable” because of the structured data collection forms we designed for the teachers. For the Exit Card activity, for instance, an Excel spreadsheet that tabulated daily and weekly score totals per student were created. Since the Exit Card strategy required immediate feedback, its usage with multiple classes averaging about 30 students could be overwhelming. The design of scoring (1 for a correct answer, or 0 for a wrong answer) made it easy to “visualize” trends in students learning and attendance. A few weeks of implementation convinced teachers of the effectiveness of the Exit Cards as an assessment tool. The ease with which they could analyze the data made it even more appealing.

As for teachers’ reflections, they became more frequent, more focused, and richer with anecdotes. Discussions were no longer about thirty different issues but focused on the one they were all investigating. We learned more from these theme-oriented investigations and discussions than the open-ended ones we had with Cohort 1. The issues of ownership and empowerment that Cohort 1 teachers felt about the course dissipated as they all found themselves within the different structured experiences.

As noted in their reports, Cohort 2 teachers did not, at first, think highly of the usefulness of the mathematics “attitude survey,” nor did they see the practicality and effectiveness of the “exit cards” because of past unfriendly usage. Changing teachers’ practices can be very difficult; it requires very convincing arguments in the form of structured experiences. Many teachers have preconceived ideas about the effectiveness of new strategies they learn from unstructured short-term professional development sessions. The new strategies teachers learn in such experiences require no follow up, no accountability, no data collection to gauge their effectiveness, and no in-depth quantitative or qualitative analyses of the impact they might have on students’ learning. Teachers consequently stay within their comfort zone, teaching the way they know with the belief that it’s their students who are not “motivated.”

Summary and Conclusions

We found the second AR course more effective in changing Cohort 2 teachers' views about what constituted good teaching practices than the course used with Cohort 1. The results that the teachers obtained during the five "mini- investigations" led them to believe in the need to change or adjust many practices. Some of their findings about students' attitude toward mathematics, for instance, were surprising to them. Some found that "public praise, encouragement, and other positive reinforcement led to gains in sense of security and self-efficacy, which coincided with academic achievement gains." Others found that "students were much more responsive to emotive interventions than academic ones" and that feeling of "security" decreased with the preparation for state testing because, "Students were burned out."

One teacher who conducted a structured error analysis activity for the first time concluded that it was a "very powerful method of helping students assess their own understanding of the concept through the inspection of others' errors. ...Students took over the class and did most of the teaching, and started to rely more on each other to validate their understanding."

Doing multiple inquiries also led to unexpected results. Teachers were learning and practicing new pedagogical vocabulary while reflecting. At first, most teachers felt ill equipped to express their thought process when reflecting or answering to the structured questions we provided them. Their students found the same difficulties in responding to "open-ended exit cards." One teacher wrote: "...the open-ended cards encourage mathematical language use and provide students with a pulpit in which to communicate difficulties, strengths and ideas." For example, in one open-ended response, a student referred to the second term in a trinomial as "*the number in the middle*," while another student thoughtfully wrote, "*I learned mistakes can make a person more stronger*." In both cases, for teachers and their students alike, the difficulty came from the lack of sufficient vocabulary. One teacher explained in these terms: "Similar to how I became more adept at discussing teaching strategies due to the introduction of new vocabulary, my students would be more successful at explaining their ideas through deeper adoption of new vocabulary terms."

Realizing the promise of teacher inquiry as a robust and professionally organized aspect of teacher's daily work has been and will continue to be a challenge at all levels. This paper recounts our experience in reshaping the "glass slipper" of a graduate teacher action research course to fit the "foot" of mathematics teachers' needs and constraints. It is our belief that the new features described here will give teachers the opportunities to meet their needs and those of their students. Restructuring the teaching of action research by including predefined research topics did not take away teachers' autonomy to make choices for themselves or to be the decision-makers in

their classrooms. *As long as the topics selected have relevance to teachers' everyday needs*, it reinforces it. After Cohort 2 teachers had experienced the "mini-inquiries" of the first course in the sequence, they were more primed to tackle their own larger inquiries in the second course of the sequence, armed with a belief in the efficacy of the process, based on their own experience. As we continue the search for answers as how best to lead teachers to meet their students' needs, we come to realize full circle, the transformative effects of action research on teacher, student and on our own learning.

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