The Mathematics Educator
2007, Vol. 10, No.2, 1-26

Classroom Research as Teacher-researcher

Leong Yew Hoong
National Institute of Education, Nanyang Technological University, Singapore

Helen L. Chick
University of Melbourne, Australia

Julianne Moss
University of Melbourne, Australia

Abstract: In the field of education, research projects that involve both the researcher and teacher being the same person are common today, as attested by the significant number of teacher-researcher studies. One issue confronting the dual role of teacher-researcher is the nature of interaction between the underlying goals that come with each of these roles. There are some researchers who express concern that the combination of these goals within the teacher-researcher may compromise either or both of the work of teaching and research in an unproductive way. This paper is an account of my[1] adventure in attempting to fulfil both teaching and research goals in my work as teacher-researcher in a year 7 (Secondary One) geometry class in Singapore. My experience is then re-interpreted in the context of the ongoing conflicting-versus-complementary talk on the interaction between teacher/researcher 'selves'. A model is proposed to account for the seemingly opposite sides of the camp as reported in the literature on this issue.

Key words: Teacher-researcher; Geometry; Goals

The Teacher-researcher Enterprise

Over the last decade, there has been a noticeable increase in reports about classroom research projects that involve persons assuming dual roles of researcher and teacher (Ainley, 1999; Chazan & Ball, 1999; Fleischer, 1995; Lampert, 2001). These teacher-researchers enter the classroom with both the intention to teach and to conduct research. The effort to research "from the inside" (Mason, 1994) while performing the actual work of teaching has a long history. Zeichner and Noffke (2001) traced the roots of the current teacher-researcher movement from a few traditions. The contributions that were identified include the teacher-as-researcher movement in the United Kingdom (Stenhouse, 1968, 1975; Elliot, 1976-77, 1991,

[1] The first person singular pronoun in this paper refers to the first author.

1997) which began in the 1960s, the participatory action research movement in Australia (Carr & Kemmis, 1986, Grundy & Kemmis, 1988; Kemmis & McTaggart, 1988a, 1998b) which has close intellectual links with the pioneers in the United Kingdom, and the North American teacher research movement (Schön, 1983; Cochran-Smith & Lytle, 1993) which started in the 1980s.

There are many reasons for the continued interest in the role and function of the teacher-researcher mode in classroom research projects. One source of motivation is the increasing frustration with traditional theories and the perceived inadequacy in directly informing and reforming teaching practice (Bishop, 1998; Christiansen, 1999). Hiebert, Gallimore, and Stigler (2002) argued that "traditional research knowledge" is different from the "craft knowledge" that teachers use. Unlike the knowledge produced by educational researchers, teachers' craft knowledge "is characterized more by its concreteness and contextual richness than its generalisability and contextual independence" (p. 3). The authors then call for the need to "bridge the gap" between traditional research knowledge and teachers' practice. What is refreshing in the authors' argument is that they acknowledge both of these branches of knowledge as valuable. Practitioner knowledge can complement traditional research knowledge in that it is linked with practice; it is detailed, concrete, and specific. Moreover, unlike traditional research that organises knowledge according to types, "in practitioner knowledge, all these types of knowledge [referring to content knowledge, pedagogical knowledge, and pedagogical content knowledge] are intertwined, organised … according to the problem the knowledge is intended to address" (p. 6). Studying teaching through the teacher-researcher position can potentially tap into this alternative knowledge base of practitioner knowledge in understanding actual teaching practice.

One can, of course, argue that researchers can access practitioner's knowledge without themselves being the practitioners. That is, they collect data from teaching practice via conventional methods as an outsider, not as an insider[2]. However, it is doubtful if the kind of information gathered from the outside would be as "experience-near" (Geertz, 1983) as those obtained from insider's accounts. Many of the problems of the teaching practice reside not only on the externally observable teaching acts, but also in the perceived thought-world of teachers. The internally unobservable problems include managing dilemmas (Lampert, 1985) and coping with conflicting goals of teaching—what was called "walking the pedagogical tightrope" (Wood, Cobb, & Yackel, 1995). These thought reflections of the teacher can be suitably accessed when the researcher takes on the actual role of classroom

[2] The language of "outside/inside" is credited to Cochran-Smith and Lytle (1993).

practitioner. Anderson (2002) agreed that "for practitioners, who act daily in the setting . . . [their] knowledge is deeper, more nuanced, and more visceral" (p. 23).

Another compelling reason for teacher-researcher work is found by asking the question, "who are the 'consumers' of educational research?" If teachers are the intended main 'consumers' of classroom research, then the issue of the kinds of research that are most likely to attract their interest becomes of central importance. Anderson (2002) observed that "many practitioners currently do not find that academic research—formal or applied—is very useful" (p. 24). Cochran-Smith and Lytle (1993) similarly commented that "even when educational researchers have addressed problems that are of interest to teachers, their findings have frequently been reported in ways that are inaccessible, seemingly unrelated to the everyday realities of teaching, and counterintuitive to lessons learned from experience …. To many teachers, research is more or less by definition something that is distant, uninteresting, and impenetrable" (p. 89). In contrast, practitioner inquiry taps from practical knowledge that arises from concrete and situated experiences in the classroom and it is the source of the realities that teachers can relate to. Thus, if the key purpose of classroom research is to benefit practice, then "practitioner research … seems a natural methodological fit for problems of educational practice" (Anderson, 2002, p. 24).

Teacher-researcher Work: Conflicting or Complementary?

Wong (1995a), however, sounded a warning about the relationship between the two roles contained in the teacher-researcher's work. He cautioned that the teacher-researcher enterprise can create tensions between the respective roles in the duality. His premise rested on the Aristotelian distinction between theoretical sciences (such as research) and practical sciences (such as teaching). "The primary purpose of research is to learn through investigation …. The primary purpose of teaching is to bring others to understand" (p. 22). In carrying out teaching and research simultaneously as teacher-researcher in the classroom, he "felt a distinct tension between trying to be systematic and thorough [as a researcher] and trying to be responsive and compassionate [as a teacher]" (p. 25).

In his paper, Wong related a short episode to illustrate the conflict between the two roles he assumed. He recounted how a girl gave a response to his teaching question which was not satisfactory for the researcher-self in him in relation to the scientific requirement of an "explanation". He repeatedly asked the girl to elaborate on her answer. In the process, the class grew restless and the student was "put off" by the attention on her. Wong used this vignette to illustrate the tension between his role

as teacher to help students learn and his role as researcher to want to see how students upon deeper probing can carry out an explanation.

Wilson (1995) objected to the "conflict-full" picture that Wong painted of the work of a teacher-researcher. Taking the same example, she offered a different insight:

> "Wong pits the concerns of the teacher in opposition to the researcher's. I protest. To teach [the girl], to help her clarify her confusion, to examine closely what happens--these are legitimately the agenda of both the teacher and the researcher." (p. 20)

Wilson then explicated her experiences engaging in teacher-researcher work in the classroom. She viewed the two motivations not as being in tension but rather as intentions that she mobilised to improve both the work of teaching and research.

The above debate should be of interest to those who enter the classroom with the dual purposes of teaching and research. As one such person, I am indeed interested to know where I stand in this debate and how I can further contribute to this discussion in the light of my own experience as teacher-researcher.

As a way to study the interaction between the teaching and the research motivations in her teacher-researcher work, Ainley (1999) labelled her classroom behaviour according to whether they were done in her role as a teacher or as a researcher. She found "it useful to focus on the differences in the underlying purposes of [her] actions" (p. 46, emphasis in the original). It was through the tool of differentiated purposes that she analysed the nature of interaction between her research agenda and her teaching agenda in the context of the 'complementary versus conflicting' talk between Wong and Wilson above. In the study of my teacher-researcher work, I employed a similar method whereby I labelled my actions in the classroom according to my teaching and research purposes. For this reason, I use the language of "teaching agenda" and "research agenda" to allow me to label and to study the interactions between the teaching and research goals respectively within the teacher-researcher duality.

The language of differing agendas is, however, not to be interpreted as presenting an actual distinction between dual selves in the teacher-researcher. I identify with Wilson (1995) in that "when I decide to do research on my teaching, I don't enter the classroom one part teacher, one part researcher. I am … [Yew Hoong], moved at once to help students learn and intensely curious about teaching and learning" (p. 20). This difficulty in partitioning intentions at times illustrates a merger of sorts between the two traditional worlds within the teacher-researcher. My concern in

teacher-researcher studies is not that a teacher-researcher amalgam self emerges, but that it develops in such a way that would compromise either or both of the work of teaching and research in an unproductive way. This paper is devoted to a description of my teacher-researcher work that attempted to avoid these unproductive compromises.

The focus here is on the conflict/complementarity between the teaching agenda and the research agenda as experienced within[3] the teacher-researcher. This approach of introspective analysis of the two roles within the duality is also adopted by Wong (1995a) and Wilson (1995), and is thus appropriate here for the purpose of adding a contributing voice to their discussions.

The Research Setting

Prior to the project reported in this paper, I spent the first seven years of my professional career teaching mathematics in school settings to students ranging from year 7 to year 12. The next stage of my education career was spent in the university, where for the last three years, I have begun learning the ropes of doing research. It is important to clarify my professional history at this juncture of the paper insofar as it helps to clarify my expertise and awareness of teaching and research.

The study reported here is part of a project to investigate the problems of teaching in a naturalistic classroom context that involves (1) students' use of the computer software *Geometer's Sketchpad* (hereafter *Sketchpad*) to learn geometry and (2) students' participation in discourse on geometry.

The project covered a period of eleven mathematics lessons, each of seventy minutes. The class chosen for the study was a year 7 Singapore class[4]. During that period, I replaced the resident teacher to assume the role of the class's mathematics teacher. I taught the geometry curriculum requirements just like other ordinary teachers, and also included in the lessons the two features of *Sketchpad* usage and

[3] It is likely that another researcher looking at the same data might view the interactions of my teaching and research goals differently and can therefore offer an 'outsider' perspective of the 'conflict-vs-complementary' talk. The authors share Kemmis' (1995) stance in valuing studies of practice both "from the 'outside' and from 'within' the individual and social relations of the group" (p. 24). The view from the 'outside' is, however, beyond the scope of this study and would be in a different vein from the Wong-Wilson dialogue, which was about their internal tensions/harmony.

[4] Year 7 in Singapore is the first year of secondary schooling.

students' active participation in discourse, as reflected in the project design. Students were expected to participate in a 'natural' capacity.

My teaching actions and thoughts were captured through in-class video and post-class same-day reflections respectively. The reflections were made whilst reviewing the teaching actions in the class via the video-recording, inserting footnotes on the thoughts and decision-process at each stage of the lesson. Each reflection exercise was verbally recorded over an approximate duration of two hours. The transcribed reflections ranged between 4000 – 6000 words per lesson.

The research began with the planning and organisational work both at the curricular and at the logistical fronts. That included a careful analysis of the geometrical ideas targeted by the curriculum and a re-sequencing of those ideas so that it would fulfil the same coverage of the ideas albeit in a setting that incorporated the use of *Sketchpad* as a prominent tool for students' explorations. Similarly, logistical preparations in the form of ensuring workability of classroom facilities, data-capturing devices, computer software and hardware were carried out to minimise disruption with respect to the entire research process.

Despite much pre-teaching and outside-the-classroom preparations to increase the likelihood of success of the research agenda, this study remains *within* the classroom. The focus is on whether the teacher-researcher can carry out the objectives of research and teaching when he or she teaches in the classroom.

What Does It Means to Implement the Research Agenda in Class?

The term "research agenda", when used in this paper, refers to the set of purposes underlying the parent research project on the problems of teaching while using *Sketchpad* to help students engage in geometric reasoning. When I enter the classroom as a teacher-researcher, the researcher-self in me is concerned about implementing the "research agenda" in the sense that while I teach, I should have in mind the fulfilment of the intended goals of the research project within the instructional setting of the classroom.

One of the requirements of the research project is to provide the environment for students to learn geometry using *Sketchpad*. Fulfilling this aspect of the "research agenda" in class, however, goes beyond simply making the software available to the students to use. The way the software is to be utilised within the classroom should be informed by the wider community of researchers who have similarly examined its use in teaching geometry.

One of the most popular features of *Sketchpad* that is being harnessed for geometry instruction is the drag-mode (Hoyles & Noss, 1994; Laborde, 1995; Leung & Lopez-Real, 2001). When a student drags a part of a drag-resistant figure and moves it around on the computer screen, the critical attributes of the figure remain invariant while the non-critical ones vary. An example of the drag-mode in operation is when a drag-resistant parallelogram is dragged: sides lengths may vary but the parallelism of opposite sides is maintained. While observing the visual stimuli on screen, students can be asked by the teacher to make guesses of what properties of parallelogram they find invariant. Laborde (2002) called such tasks "tasks for interpreting visual phenomena" and stated that in "this kind of tasks, children learn to recognize a geometrical property from its various spatial-graphical representations" (p. 18). In other words, such tasks potentially help students to shift their focus of attention away from the mere visually-driven perspective of a parallelogram to that of the properties of a parallelogram.

Another much-discussed potential of *Sketchpad* is its suitability as a tool for encouraging students to learn by exploration and experimenting (Chazan & Yerulshamy, 1998; Clements & Battista, 1994; Laborde, 1995; Lampert, 1988; Leung & Lopez-Real, 2000; Olive, 1998). A conducive experimental environment is one where students can make accurate observations leading to conjectures, test conjectures, do modifications quickly, and retest conjectures. All these are supported by *Sketchpad*. Accurate observations of precise data—both graphical and numerical—are possible; testing of conjectures can be done using the drag-mode; changes on screen can be done quickly by retracing the steps using editing functions; and modifications can be performed by clicks on the onscreen menu. This cycle of observe-conjecture-test-observe can be performed tirelessly by the computer and provides support to students' experimental approaches.

The other research focus of the project is to encourage students to participate in mathematical discourse as a way to stimulate reasoning. This motivation towards getting students to engage in discussion is derived from the Vygotskian perspective, where learning is seen to be largely sociocultural in nature—an action that internalizes outward forms of social discourse into internal forms of discourses between intramental states. Thought is therefore internal language (Vygotsky, 1986). Seen through this perspective, the social interactions and classroom discourses become important, meaning that the teacher can structure them to promote students' reasoning, as "forms of discourse become forms of thinking" (O'Connor, 1998, p. 22). Therefore the instructional approach taken in the classroom to fulfil the research requirement of "student participation" in this project is to encourage reasoning via "social discourse".

Based on the literature above, the way I intended to implement my research agenda in the classroom can be summarised as follows:

R1. To investigate the use of the drag-mode of *Sketchpad* in helping students move from visual-based view of geometrical objects to seeing them as holders of geometrical properties;

R2. To study the participation of students in social discourse about geometry as a way of modeling geometric reasoning;

R3. To examine the utilisation of *Sketchpad* as a tool to observe, conjecture, and test geometrical properties to support the learning of geometry.

My Teaching Agenda When in Class

R1 - R3 represent how I focus my role as a researcher in the classroom. My attempt to study instructional practice while engaging in the actual work of teaching is in line with the method of research as an "insider" (Cochran-Smith & Lytle, 1993). However, apart from the research agenda, I also need to fulfil my teaching responsibilities within the same lesson time span. These other teaching goals which are not captured by R1 - R3 are referred to in this paper as "my teaching agenda in class". I consider the primary goal of a teacher in class is to help students learn mathematics. How I see myself fulfilling this role of teaching is in turn influenced by a number of factors. These include the wider schooling culture in Singapore and my beliefs about teaching.

One influential factor in determining what and how mathematics is taught in Singapore schools is the end result of the schooling process—assessment. In Singapore, students sit for a centralised examination designed by the education authority at the end of their secondary schooling. The students are, however, evaluated not only at the end of their schooling years but are required to sit bi-yearly for school-based examinations. There is therefore a pervasive examination-oriented culture in the schooling environment in Singapore. The school and the society place heavy emphasis on students' outcomes in examinations. This is in part due to the placement implications for future schooling and the perception that an individual's self-esteem is related to examination performance. The high value placed on grades in assessments can be traced to a pervasive and effective meritocratic system of governance which has become increasingly entrenched over the last forty years. I therefore see it as my social responsibility, as a teacher, to teach students mathematics in a way that will prepare them for the impending examinations. I see this responsibility to include the teaching of mathematical

skills, procedures, and techniques that are directly relevant to the tackling of exam-type questions.

My beliefs[5] in mathematics teaching also play a significant part in the shaping of my teaching agenda. I believe that the time that students spent in class should be solely on mathematically-productive tasks. I find it unacceptable for students to engage in off-task activities—such as chit-chats among themselves about casual matters—that are incongruous to the overarching goal of learning mathematics.

I also believe in teaching *every* student in my class, not leaving anyone behind in the attempt to proceed from one task to another. This belief is likely premised upon another more fundamental belief that all students in my class can achieve at least the basic level of mathematics. I believe in setting reasonable expectations for all my students in respect of their mathematical ability and I believe that they will subsequently live up to these expectations if I persist in trying to help them.

It is useful at this juncture to clarify that the goals of mathematics teaching described above are *mine*. These goals are influenced by how I view my social and professional roles as a teacher in relation to my interpretation of the social and cultural emphasis of mathematics education in Singapore. They are therefore rightly termed as *my* teaching agenda because they show my perspective of the teaching task which may not all be shared by other teachers. Nevertheless, it is heartening to know that they are also similarly shared by other teachers, as reported in Wiske (1995) and Newman et al. (1989), even though the cultural setting in which we operate may be different. Thus, although the teaching agenda that I bring into this study is indeed my own in the sense that it is conceived and implemented by me as the teacher, there is an added sense that the teaching goals are shared and can be appreciated by a wider group of teachers who may be familiar with these objectives.

In summary, my teaching agenda comprises:

T1. The teaching of skills, techniques, language and procedures that will equip students to tackle exam-type questions;

T2. The desire to see *every* student meet the expectations of the curriculum objectives;

---

[5] I arrived at these beliefs through introspection and retrospection. How to account for these beliefs in teaching makes for interesting study but is beyond the scope of this paper.

T3. The engagement of the students solely in mathematically productive work.

A reader, upon examining the *research* agenda points that I stated previously may argue that they may also be considered *teaching* agenda points. Some teachers may already believe that the use of *Sketchpad* or/and the engagement of students in discourse is an appropriate way to teach their students. In my case, my research questions—to investigate the problems of teaching in such a classroom—impose the need to teach in a particular way that takes account the requirements of R1 - R3. My clarification is that the R1 - R3 and T1 - T3 classification above do not imply that they are instrinsically distinct categories, but rather a reflection of the goals of this particular research setup and my view of what teaching objectives entail. The framing of the agenda enables me to label my actions in class. My actions are motivated by research or/and teaching goals and thus provide the framework for the discussion of the interaction between the two roles within my teacher-researcher duality.

In addition, the presentation of the respective agendas in a list is not to be taken to imply a view that they are easily separable when observing the actual teaching behaviour. In practice, classroom happenings may fulfil one or more of the agenda points simultaneously. The delineation into points is for the ease of checking against whether any of the research goals and teaching goals are carried out or omitted.

In the list of teaching goals presented, there is also no claim of comprehensiveness. The stated goals are those that I perceive to be directly related to the teaching of mathematics. Other goals such as teaching students to respect one another and to cooperate during paired work are not included in the list of goals as they are not central to the current research. Moreover, as this paper presents a preliminary analysis of the data, the goals T1 - T3 form an operational starting point in the process of analysis of my goals of teaching. It is likely there are more goals involved. It is expected the list of goals will be progressively refined through the process of deeper analysis over time.

Administrative Separation of 'Roles' across the Boundary of the Class Lesson Time

In planning to successfully carry out both the research and teaching agendas in class, I took heed of Wong's (1995a) post hoc suggestion that he "might have concentrated primarily on teaching during class and then later reflected back on the class as a researcher" (p. 25) as a way to lessen the purported conflict between the teaching and research functions in his study. I similarly considered that some form

of separation of roles of researcher and teacher across the boundary of the classroom may be helpful in reducing the tension in carrying out the respective agendas in class. I made a conscious decision—the teaching agenda was my main focus during class time, and when I was outside the classroom I would reflect and scrutinise my teaching with research goals primarily in mind. As for carrying out the research agenda in class, I relied on the research consciousness that I brought with me into class and the teaching materials used which were designed to carry out the the research requirements.

The "separation" that I refer to here is a deliberate administrative decision on my part as the teacher-researcher to serve the dual purposes of my teaching and research work better. It was not intended nor perhaps possible to actually separate the two functions altogether at any point in the entire teaching/research enterprise. This complex fusion of roles has already been discussed at the introductory section of this paper.

With the stage set in terms of explicating the research/teaching agendas and the stating of the theoretical/administrative premises, it now remains to examine the fulfilment of teaching and research agendas in carrying out the teacher-researcher work in class. This report focuses on the in-class data and post-class reflections taken from one[6] randomly chosen lesson taught in the eleven-lesson geometry module for a year 7 class.

The Lesson

This lesson in consideration was the sixth lesson in the module and it was the first time that the topic of "quadrilaterals" was introduced in the year level. In their earlier school years prior to entering year 7, the students had encountered square, rectangle, parallelogram, rhombus, and trapezium. At years 1 and 2, the students would have been introduced to quadrilaterals via shape-naming and shape-differentiation exercises. The focus was on gestalt (shape recognition) and topological (curve versus straight boundaries) impressions. In the mandated Singapore mathematics curriculum, formal geometric language and properties are found in the syllabus from year 3 and proceeded with greater complexity to year 6. During these middle grades the focus is on the properties of quadrilaterals (angle, perpendicularity, parallelism). The focus of my lesson, being the first on

[6] Due to the depth of analysis involved, only one lesson is discussed in this paper. The authors acknowledge that the arguments here could perhaps be enhanced if more than one lesson is analysed and reported. Nevertheless, this single lesson can be regarded an exemplifying case study (Bryman, 2004).

quadrilaterals at the secondary level, was therefore on revisiting the different types of special quadrilaterals mainly through visual processes. Efforts to help students become aware of the *properties* of the special quadrilaterals at that initial stage of development was via a more intuitive route of observing figures and drawing representative diagrams rather than an explicit discussion on "properties". The latter would take place in subsequent lessons.

Chronologically, the lesson can be divided into five natural sections, with the transitions between sections marked by a clear change in the nature of class activity. The sections are given in the Table 1 below.

Table 1
Description of geometrical activities in the respective sections of the lesson

Section	Duration (correct to the nearest minute)	Description of geometrical activity
1	33	Students work with a Sketchpad template
2	8	Teacher shows how to draw a rhombus using a setsquare and a marked ruler on whiteboard to the whole class
3	9	Students draw other quadrilaterals using a setsquare and a marked ruler on a distributed worksheet.
4	3	Teacher shows how to draw a kite using a setsquare and a marked ruler on whiteboard to the whole class
5	8	Students continue with the worksheet
Total	61[7]	

In the first section of the lesson, students worked on a given *Sketchpad* template to classify the different special quadrilaterals shown on screen. Upon opening the sketch, the screen appears as shown in Figure 1.

[7] Although the time allocated for each lesson is 70 minutes, the time taken for students to move from their resident classroom to the math room can take up to 10 minutes, depending on whether the lesson before this is delayed. This accounts for the total duration of the class time in this lesson being 61 minutes.

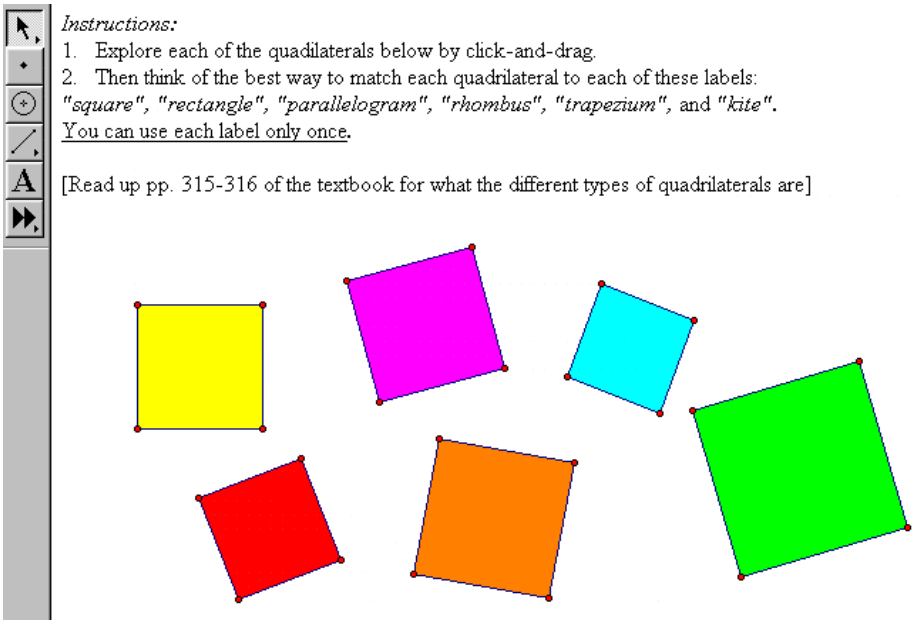

Figure 1. Screenshot of the sketch when it is initialised

Although all the quadrilaterals appeared as squares when the file was opened, they were each constructed with built-in geometrical properties that uniquely matched the respective special quadrilaterals listed. Upon dragging, the figures revealed their intrinsic properties. Figure 2 shows how the screen appeared when the drag-mode is applied. As the students had done a similar classifying exercise on *Sketchpad* in an earlier lesson on special types of triangles, they were familiar with the need to explore each figure by click-and-drag to look out for drag-resistant properties. A number of students also used the 'Measure' tool—a *Sketchpad* function introduced in previous lessons—to measure sides and angles of the quadrilaterals to provide numerical data for verification.

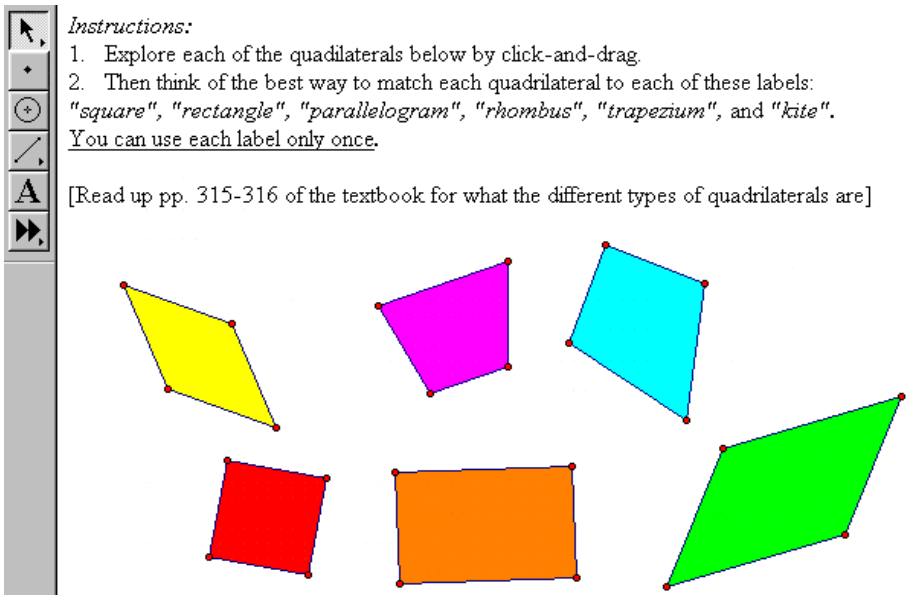

Figure 2. A screenshot of the sketch upon dragging

After working on dynamic figures of the respective special quadrilaterals, the next step of the lesson required the students to draw representations of each of these quadrilaterals. The insertion of a drawing activity was both to reinforce students' familiarity with each type of quadrilateral as well as to meet curriculum requirements—that students are to be able to "construct simple geometrical figures from given data" (Ministry of Education, 2000. p. 37). At this stage, the drawings were done using a setsquare (for drawing perpendicular and parallel sides) and a marked ruler. However, as the students had no prior experience in this module using the setsquare to draw quadrilaterals, I needed to explain the procedure before asking them to launch into the activity. I demonstrated to the class how I drew a rhombus on the board. This explains the order of progression from section 2 to

section 3 of the lesson. An example of a drawing task given in the worksheet is shown in Figure 3 below.

For each type of special quadrilateral listed below, draw a representative example. You may make use of a setsquare, a ruler and a pencil to do the drawing.

Special Quadrilateral	Draw an example
Square	

Figure 3. A drawing activity taken from the worksheet on "special quadrilaterals"

During section 3 of the lesson, I walked around the students' tables to guide them in their work and to monitor the difficulties they faced so that I could address them in a whole-class discussion later in the lesson. Section 4 of the lesson served this purpose of highlighting students' errors and presenting a feasible way to correctly draw the required quadrilaterals. As it was observed that a number of students were 'stuck' at the kite and showing signs of frustration, I chose to focus the discussion on the kite during section 4 of the lesson before letting the students continue working on their worksheets in the last section of the lesson.

Fulfilling Research and Teaching Agenda in Lesson: The Overall Picture

The results of examining the 'agenda-point fulfilment' throughout the whole lesson are presented in Table 2. The table gives an overview of how the teaching and research agenda points occurred across the different sections of the lesson. The

intitial picture is one of uneven distribution, with the teaching purposes being more prominent than the research goals.

Table 2
Distribution of agenda-fulfilment across sections of the lesson

Section of the lesson	Conspicuous research/teaching agenda points
1	R1, R3, T2, T3
2	R2, T1
3	T1-T3
4	T1
5	R2, T1, T2

It should be noted, however, that what is presented in the table is the more *conspicuous* fulfilment of agenda goals in the respective sections of the lesson. Nor does the table imply that only those research/teaching objectives that are listed are operative in that section of the lesson.

As an example, although only "T1-T3" are listed as being ubiquitous in section 3 of the lesson, there are traces of the research agenda being carried out as well. The following exchange that took place in that section of the lesson illustrates the hidden research intents lurking in the background.

Wan Yan:	[raises her hand to draw teacher's attention]
Teacher:	Yes, Wan Yan?
Wan Yan:	[pointing to a drawing on her worksheet] Considered trapezium or not?
Teacher:	What do you need for trapezium? [pause] Two [pointing to Wan Yan's drawing on her worksheet] -
Wan Yan:	Parallel.
Teacher:	Yeah. Are these two [pointing to the two parallel sides that Wan Yan drew] parallel?
Wan Yan:	[Nods her head]
Teacher:	Yes? Then it's done.

While the thrust of this part of the lesson was to help students draw various special quadrilaterals, reflecting the teaching goals of helping students acquire skills stipulated in the curriculum, the responses to Wan Yan's questions showed that there were indeed opportunities to engage in the research agenda. I was not merely

teaching her a method or a skill to perform a procedure. I was drawing her into participating in a conversation that would ultimately lead to her verbalising the critical attributes of a trapezium. I went beyond a "Yes/No" verdict from the teacher to one where basic reasoning—that "a parallel pair of opposite sides" is necessary to determine whether a quadrilateral is a trapezium—was necessary. Thus, there were shades of R2 alongside this instructional episode involving Wan Yan.

Despite the prominence of the teaching purposes during class time, a large part of the lesson reflected both teaching and research goals being carried out, as seen from the concurrence of "T" and "R" in sections 1, 2 and 5 of the lesson. This showed that classroom practice can be conducted in such a way that both the teaching and research agendas develop hand-in-hand. This complementarity between the two goals seems to contradict Wong's (1995a) proposition that when the teacher-researcher attempts to concentrate on being a teacher in class, his original research design would be "compromised".

However, to paint the picture of the two goals working out in perfect harmony throughout the lesson is not an adequate depiction either. The post-lesson reflection of my thought-world during the lesson indeed revealed one occasion where competition between both purposes was experienced. It happened at the beginning of section 2 of the lesson where I was about to explain the procedure of drawing a rhombus using a setsquare and a ruler in a whole-class instruction setting. The reflection piece on my thoughts at that moment is reproduced below for the reader's reference.

> I am beginning to draw a rhombus. I draw two sides that are not perpendicular. And I asked, "can I do that?" And a number of them were saying "no". But I had thought of pausing at this moment and asked, "why do you think I couldn't do that?" [to address R2] instead of proceeding on … I *should have conducted a discussion* that would encourage reasoning, but *here again my main purpose was to show the procedures* [important for T1] …
>
> [from post-lesson reflections, emphases added]

At this juncture of the lesson, two 'forces' seemed to be at work—"demonstrate procedure" and "explain underlying reasoning". It appeared that T1 was competing with R2 for prominence at that moment when I had to decide what course of action to take in the instructional process. One can make post hoc suggestions of what I could have done to avoid this difficulty in the first place. As examples, I could

weave reasoning into the construction procedures or do a quick revision on properties of rhombus before proceeding. These post-lesson reflections of possible alternative instructional routes provide insights that can be useful for future work of teaching. However, the point remains that in the dynamic situation that is part of actual teaching practice, decisions on the course of teaching actions are made on an ongoing basis and in some of these decisions, like the one explicated above, constraints such as the limitation of time or inadequate teacher understanding of the content and method of instruction may lead to the pursuance of one action over another. In the case of this lesson juncture, I felt an internal struggle of two courses of action vying for adoption. Although the tension can be resolved in hindsight, it remained a real conflict at that moment when it was experienced and it called for a choice of one over the other.

In summary, the overall picture with respect to the teaching and research agendas in the lesson as described is one where the teaching goals are more visibly portrayed, with the research agenda evident at the background. In almost all parts of the picture, the teaching and research purposes are carried out without any conscious compromising of one or the other. At *one* point though, the struggle of simultaneously fulfilling aspects of both objectives was clearly felt. This interaction between the teaching and research agendas may perhaps be best illustrated as in Figure 4 below.

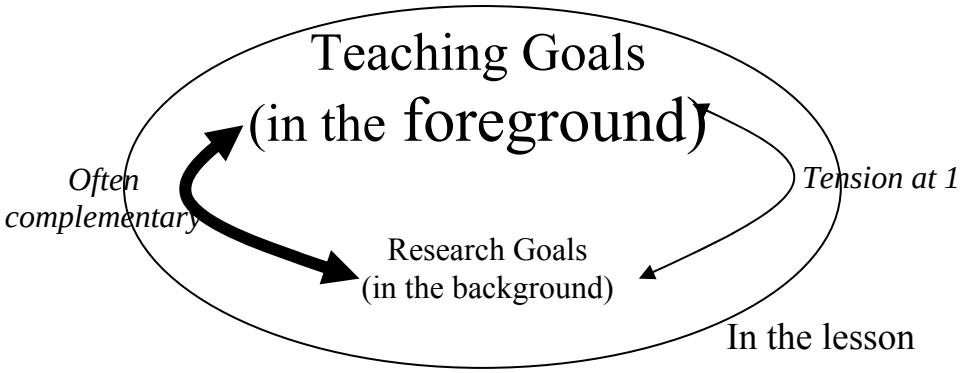

Figure 4. Overall Picture of Research and Teaching Goals in the Lesson

The Teacher-researcher Experience: Revisiting the 'Complementary-vs-Conflicting-talk'

In the beginning of this paper, I made a reference both to Wong (1995a) and Wilson (1995) in how they view the interaction between the dual purposes of teaching and research in the work of a teacher-researcher. The former highlighted the tension between the two goals while the latter argued that in her teacher-researcher practice, she was able to harness the experience of each of her teaching and research capabilities to fulfil the respective agendas in a complementary way. More recently, Ainley (1999) contributed to the discussion by noting that there are both complementary and conflicting aspects of the teacher-researcher work. This assertion is similarly borne out in my teacher-researcher work as reported in this paper, although the degree in which the conflict was acknowledged does not seem comparable. While Ainley felt an ongoing tension once she stepped into the classroom as teacher-researcher as a result of students' perceived ambiguities in her dual roles, the conflict I experienced was not of a sustained kind but rather an occasional one. I realised that my teacher-researcher experience is yet a shade different from those of the cited authors and it can contribute further to this complementary-vs-conflict-talk.

One factor that appeared to contribute to the degree of unproductive conflicts between the research and teaching goals is the research design itself. One aspect of the research design is the research focus—whether it is on students' learning or on the work of teaching. In Wong's (1995a) vignette of his attempt to teach the girl in his class (presented at the beginning of this paper), the conflict that Wong spoke about seems to be tied to the research focus that he took: to examine students' scientific argument. In my research project, my interest was not so much in students' learning as in the work of teaching. My focus was thus to study the *teaching* problems as I went about doing what I thought a teacher should do in that context. If I had been the teacher-researcher in Wong's classroom, I would have proceeded with the discourse and helped the class (not just the particular student) to engage in a joint discussion towards an explanation that would be seen as derived from their discourse. Thus, given another research focus, the 'conflict' might not have surfaced. In fact, Wong conceded that "… the particular features of my conflict may not apply to others, particularly those who are doing research on their own teaching rather than student learning" (p. 27).

Yet another aspect of research design is the administrative apportionment of teacher-researcher work across the boundary of the classroom. Outside the classroom, I consciously focused on the research goals in my reflections and in curriculum decision-making. Once I stepped into the classroom, I focused solely on the work of teaching and rarely thought about my role as a researcher. My

conviction in giving the students a full-hearted devotion to my teaching task while in class is perhaps one reason why, unlike Ainley (1999) who was more sensitive of her dual selves, the research purposes do not weigh on me while teaching. My experience with the conflicting goals was a fleeting one.

Another major factor affecting the interactions between the teaching and the research agendas that is not explicitly covered in the current literature so far is the level of competence and experience of both teaching and research work that the teacher-researcher brings to the study. Wilson (1995) was perhaps alluding to this when she wrote that "I used the *skills of teaching and research* intentionally, to look in different ways at everything I do" (p. 21, emphasis added). She considered herself an "insider" to teaching because of her ability to assimilate to the work, having prior experience as a teacher, and surmised that Wong, who seemed to view teaching work as separate from research, was an "outsider".

The differences in experience between Wong (1995a, 1995b) and Wilson (1995) seemed to point to the different teaching and research backgrounds they have prior to and in teacher-researcher work. While teacher-researcher studies are conventionally associated with practitioner research, in which teachers take on the work of researching their own practice, the term "teacher-researcher" apparently now also includes someone in the inverse situation—university researchers becoming teachers. This distinction between "practitioner researchers" and the inverse situation of "researchers as practitioners" are often not made clear in most essays which use the term "teacher-researcher" (or its equivalent). Ainley (1999) makes this distinction explicit.

The "insider" experience of teaching that I brought into my teacher-researcher work as reported in the study here seems to support Wilson's (1995) argument that one's familiarity with the expertise of teaching can help bring the research and teaching elements of the teacher-researcher enterprise together in a harmonious way. Like her, I did not find the meeting of the two worlds of teaching and research in the classroom to be so filled with conflict and tension as Wong (1995a) has experienced.

However, the language of "inside/outside" should not be wrongly taken to mean a distinct separation of the research role from the teaching work once the insider enters the classroom. In my situation, being an "insider' to teaching in the classroom meant that I had prior professional expertise in instructional practice that enabled me to focus primarily on the teaching task while keeping the research intents of the project at the back of my mind for most parts of the lesson. This is where the foreground/background metaphor may be appropriate in seeing the

relationship between the teaching and research agendas. Both research and teaching goals are at work in the classroom but they do not share equal prominence in the teacher-researcher practice. When I enter the classroom, the teacher-at-work is at the foreground and teaching goals become the main driving force for instructional choices and action; however, the research intents are not altogether absent, but are rather actively working at the background to influence the thoughts and actions of the teacher. In my study, apart from one point of conflict when the research agenda sought to surface to the foreground to challenge the teaching agenda, this teacher-at-the foreground and researcher-at-the background situation enabled me to carry out both the goals of teaching and research in a largely productive way.

It is, then, perhaps time to move away from 'complementary-vs-conflicting-talk' to explore ways to enhance the productivity of each of the roles within the teacher-researcher duality within the classroom. It is hoped that the foreground/background language can be a start towards this direction of inquiry.

References

Ainley, J. (1999). Who are you today? Complementary and conflicting roles in school-based research. *For the Learning of Mathematics, 19*(1), 39-47.

Anderson, G. L. (2002). Reflecting on research for doctoral students in education. *Educational Researcher*, 31(7), 22-25.

Bishop, A. J. (1998). Research, effectiveness, and practitioners' world. In A. Sierpinska & J. Kilpatrick (Eds.), *Mathematics Education as a research domain: A search for identity, an ICMI study* (pp. 33-45). Dordrecht, Netherlands: Kluwer Academic Publishers.

Bryman, A. (2004). *Social research methods* (2nd ed.). Oxford, UK: Oxford University Press.

Carr, W., & Kemmis, S. (1986). *Becoming critical: Education, knowledge and action research*. London: Falmer Press.

Chazan, D., & Ball, D. L. (1999). Beyond being told not to tell. *For the Learning of Mathematics, 19*(2), 2-10.

Chazan, D., & Yerushalmy, M. (1998). Charting a course for secondary mathematics. In R. Lehrer & D. Chazan (Eds.), *Designing learning environments for developing understanding of geometry and space* (pp. 67-90). Mahwah, NJ: Erlbaum.

Christiansen, I. (1999). Are theories in Mathematics Education of any use to practice? *For the Learning of Mathematics*, 19(1), 20-23.

Clements, D. H., & Battista, M. T. (1994). Computer environments for learning geometry. *Journal of Educational Computing Research, 10*(2), 173-197.

Elliot, J. (1976-77). Developing hypotheses about classrooms from teachers' practical constructs: An account of the work of the Ford Teaching Project. *Interchange, 7*(2), 2-22.

Elliot, J. (1991). *Action research for educational change*. Philadelphia: Open University Press/Milton Keynes.

Elliot, J. (1997). School-based curriculum development and action research in the United Kingdom. In S. Hollingsworth (Ed.), *International action research: A casebook for educational reform* (pp. 17-28). London: Falmer Press.

Fleischer, C. (1995). *Composing teacher-research. A prosaic history*. Albany, NY: SUNY Press.

Geertz, C. (1983). *Local knowledge: Further essays in interpretive anthropology*. New York: Basic Books.

Grundy, S., & Kemmis, S. (1988). Educational action research in Australia: The state of the art (an overview). In S. Kemmis & R. McTaggart (Eds.), *The action research reader* (3rd ed.) (pp. 321-335). Geelong, Victoria, Australia: Deakin University Press.

Hiebert, J., Gallimore, R., & Stigler, J. W. (2002). A knowledge base for the teaching profession: What would it look like and how can we get one? *Educational Researcher, 31*(5), 3-15.

Hoyles, C., & Noss, R. (1994). Technology Tips−Dynamic Geometry environments: What's the point? *Mathematics Teacher, 87*(9), 716-717.

Kemmis, S. (1995). *Action research and communicative action: Changing teaching practices and the organisation of educational work*. Paper presented to the National forum of the Innovative Links Project, May 1995.

Kemmis, S., & McTaggart, R. (1998a). *The action research planner* (3rd ed.). Geelong, Australia: Deakin University Press.

Kemmis, S., & McTaggart, R. (Eds.). (1998b). *The action research reader* (3rd ed.). Geelong, Australia: Deakin University Press.

Laborde, C. (1995). Designing tasks for learning geometry in a computer-based environment. In L. Burton & B. Jaworski (Eds.), *Technology in Mathematics Teaching* (pp. 35-68). Chartwell-Bratt: Sweden.

Laborde, C. (2002). The process of introducing new tasks using dynamic geometry into the teaching of mathematics. In B. Barton, K. C. Irwin, M. Pfannkuch, & M. O. J. Thomas (Eds.), *Mathematics Education in the South Pacific* (*Proceedings of the 25th annual conference of the mathematics education research group of Australasia, Auckland*, pp.15-34). Sydney: MERGA.

Lampert, M. (1988). *Teaching that connects students' inquiry with curricular agendas in schools* (Technical report). Cambridge, MA: Education Technology Centre. (ERIC Document Reproduction Service No. ED303370)

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American Educational Research Journal*, *27*(1), 29-63.

Lampert, M. (2001). *Teaching problems and the problems of teaching.* New Haven, CT: Yale University Press.

Leung, A., & Lopez-Real, F. (2001). Reflections on a TIMSS geometry lesson. *For the Learning of Mathematics, 21*(3), 25-31.

Mason, J. (1994). Researching from the inside in mathematics education – locating an I-you relationship. In J. P. da Ponte & J. F. Matos (Eds.), *Proceedings of Eighteenth Conference of the International Group for the Psychology of Mathematics Education* (Vol. I, pp. 176-194). Lisbon, University of Lisbon.

Ministry of Education. (2000). *Mathematics Syllabus Lower Secondary*. Singapore: Author.

Newman, D., Griffin, P., & Cole, M. (1989). *The construction zone: Working for cognitive change in school*. Cambridge, England: Cambridge University Press.

O'Connor, M. C. (1998). Language socialisation in the mathematics classroom: Discourse practices and mathematical thinking. In M. Lampert & M. Blunk (Eds.), *Talking Mathematics* (pp. 17-55). Cambridge, NY: Cambridge University Press.

Olive, J. (1998). Opportunities to explore and integrate mathematics with the geometer's sketchpad. In R. Lehrer & D. Chazan (Eds.), *Designing learning environments for developing understanding of geometry and space* (pp. 395-418). Mahwah, NJ: Erlbaum.

Schön, D. (1983). *The reflective practitioner*. New York: Basic Books.

Stenhouse, L. (1968). The Humanities Curriculum Project. *Journal of Curriculum Studies*, *23*(1), 26-33.

Stenhouse, L. (1975). *An introduction to curriculum research and development*. London: Heinemann Educational Books.

Vygotsky, L. S. (1986). *Thought and Language*. Cambridge, MA: MIT Press.

Wilson, S. M. (1995). Not tension but intention: A response to Wong's analysis of the Researcher/Teacher. *Educational Researcher*, *24*(8), 19-22.

Wiske, M. S. (1995). A cultural perspective on school-university collaboration. In D. N. Perkins, J. L. Schwartz, M. M. West, & M. S. Wiske (Eds.), *Software goes to school: Teaching for understanding with new technologies* (pp. 187-212). Oxford, UK: Oxford University Press.

Wong, D. E. (1995a). Challenges confronting the researcher/teacher: Conflicts of purpose and conduct. *Educational Researcher, 24*(3), 22-28.

Wong, D. E. (1995b). Challenges confronting the researcher/teacher: A rejoinder to Wilson. *Educational Researcher, 24*(8), 22-23.

Zeichner, K., & Noffke, S. (2001). Practitioner research. In V. Richardson (Ed.), *Handbook of Research on Teaching* (4th ed., pp. 298-332). Washington, DC: American Educational Research Association.

Authors:

Leong Yew Hoong, Mathematics and Mathematics Education Academic Group, National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616; yewhoong.leong@nie.edu.sg

Helen L. Chick, Science and Mathematics Education Cluster, Faculty of Education, The University of Melbourne (Parkville), Australia, VIC 3010; h.chick@unimelb.edu.au

Julianne Moss, Artistic and Creative Education Cluster, Faculty of Education, The University of Melbourne (Parkville), Australia, VIC 3010; j.moss@unimelb.edu.au