CHAPTER

11

Legitimate Peripheral Participation in the Training of Researchers in Mathematics and Science Education

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Scene 1. The professor, Michael, is interviewing Celia, a Grade 6 student from the class involved in a study on science learning. Two graduate students initially unfamiliar with research in science education, Michelle and Carolyn, sit next to him; a research assistant, Sylvie, films the interview. At first, Michelle and Carolyn follow the interview quietly; later, they begin to ask a few questions themselves. To them, it's a dry run, for, on the next day, they conduct interviews with other students on their own. After Celia has left, the research team of four (Michael, Michelle, Carolyn, and Sylvie) debriefs about important conceptual aspects of physics to be probed in the interviews, about the interview protocol and details, and about details of the artifacts used to stimulate children's talk.

Scene 2. The research team of four comes together in front of Celia's classroom just before Michael begins teaching another lesson. Michael and Michelle provide Carolyn with a few suggestions for the interviews she is to conduct during the lesson with individual children; they suggest that Carolyn take the children into the hallway to reduce the noise level on the audiotape she uses to record the interviews. Michelle and Sylvie check with Michael for details of the lesson that will affect the way they operate the two video cameras.

Scene 3. The four sit around a low table on which there is a flip chart marked in different colored text and a few diagrams. A map of Celia's classroom printed on acetate marked with colored lines also lies there. A video camera records this data analysis session; this record will become a secondary data source.

At the moment, they are clarifying the distinction between two of their theoretical concepts, resources and tool-related practices:

Michelle: And also, as we saw, you don't need the hammer to be able to do it. You can use your liquid paper, your screwdriver, there are ways around.

Carolyn: But see, then, where is that, is that a resource? Or is it?

Michael: No, a resource means it's just the object.

Michelle: The resource is that object.

Carolyn: Great. So that hammer is a resource.

Sylvie: But when you use it.

Michael: But when you are hammering.

Carolyn: It's a tool-related practice.

Scene 4. The four are meeting to discuss the first draft of an article Michael has written based on their data analysis in sessions such as Scene 3. Michelle, Carolyn, and Sylvie have read the draft, and now ask questions for clarification, point out inconsistencies, and ask to check some of the claims against the data sources and against the records. Later, Michael asks Michelle, the more experienced of the two graduate students, to write a specific part of the findings section. Two months later, Michelle, Sylvie, and Michael present their paper during a poster session at a conference for research in science teaching, and subsequently publish it in a journal for research in science education.

These four scenes are autobiographical and come from our research project in a Grade 6 and 7 classroom in which Michael taught a unit on simple machines (cf. McGinn, Roth, Boutonné, & Woszczyna, 1995). In the scenes, two graduate students and a research assistant engage in various aspects of a study alongside an experienced researcher in science education. Rather than trying to implement directives for data collection from a professor sitting in an office, or learning in some haphazard way, the three relative newcomers to research in science education learn central aspects of doing research in practice, at the actual site of the research, and at the elbows from the more experienced researcher. Rather than sending graduate students and research assistants to do "slave labor," the professor considers that the three will learn essential elements of conducting interviews to elicit students' scientific and mathematical understandings only by participating in all aspects of the research. Even among the three, research competence is not equally distributed. Michelle, having participated in various research projects for some time, is, relative to Carolyn, already an old-timer, and assists the latter in learning important aspects of doing research in science and mathematics education. With respect to the transformation of video-based data, Carolyn and Michelle are relative newcomers compared to Sylvie, so that they learn important aspects of transcribing scientific discourse (including verbal and nonverbal aspects and actions) from the latter.

At the same time, Carolyn, a student in the master's program of counseling psychology, teaches the other members of the team about interviewing more generally, Here we see a small community with members who have different levels and areas of expertise. Expertise is heterogeneously distributed; that is, if one were to rank members of the group across areas according to expertise, the rankings would be different. By participating in research together, members learn from each other.

The purpose of this chapter is to outline a conception of learning to do research in science and mathematics education that takes practice as its core theoretical notion. The central locus of a practice is a community of practice. Essential aspects of any practice cannot be acquired by reading books or following verbal instructions at a distance from the actual site of the practice. In communities of practice, newcomers learn much of the craft by participating with old-timers in legitimate and initially peripheral ways. Eventually they become old-timers themselves. Doing independent research in science and mathematics education on their own too early in the process, graduate students would miss important opportunities to be enculturated to the specific practices of doing research in the domain.

In the next section, we expose one of the fundamental problems in learning to do research. We then provide a conceptual framework for understanding educational learning in communities of practice. Subsequently, we provide three examples from our own situation at Simon Fraser University that illustrate the main theoretical issues. Under Discussion and Implications, we outline some of the contradictions and problems with traditional approaches and our own approach to educating graduate students.

EXPOSING THE PROBLEM: DOING CODING

The following advice regarding coding is presented to novices by a widely used textbook of educational and social science research methods:

- Make codes exhaustive of the response range but mutually exclusive so that a given response will always carry the same code.
- Check consistency of coding across coders and over time. Determine the desired coding of certain sheets and slip them in the batch at random intervals to provide a coding audit.
- Provide each coder with a coding manual, and keep all manuals up-to-date as resolutions of coding problems are agreed on. (Krathwohl, 1993, p. 388)

Directions such as these make it seem as if coding is simply a matter of converting instructions or coding categories to the data at hand. These accounts suggest that novices can learn research by following instructions provided by detailed manuals. However, those with experience in coding (Schoenfeld, 1992) and those who research actual coding work (Garfinkel, 1967) paint a different picture. Learning to code cannot be done in general but has to be situated in the domain-specific practices of the relevant community.

Garfinkel(1967) and his colleagues observed coders of actual patient files to answer the question, "By what criteria are an outpatient clinic's applicants selected for treatment?" Their work showed that "coders were assuming knowledge of the very organized ways of the clinic that their coding procedures were intended to produce descriptions of" (p. 20). This knowledge appeared to be necessary to decide what really happened, regardless of whether they had encountered ambiguous file contents. Garfinkel concluded:

> No matter how definitely and elaborately instructions had been written, and despite the fact that strict actuarial coding rules could be formulated for every item, and with which folder contents *could* be mapped into the coding sheet, insofar as the claim had to be advanced that Coding Sheet entries reported real events of the clinic's activities, then in every instance, and for every item, "et cetera," "unless," "let it pass," and "factum valet" accompanied the coder's grasp of the coding instructions as ways of analyzing actual folder contents. (p. 21)

Ad hoc considerations in coding are irremediable and essential features of the act of coding. It makes little sense to treat ad hoc features of the coding work as if they were a nuisance or, from the coders' perspectives, to treat these features as grounds for complaints about the incompleteness of coding instructions.

A quarter century after Garfinkel's work was published, Schoenfeld (1992), who had worked for quite some time from a cognitive science perspective to mathematics education with assumptions not unlike Krathwohl (the author of the research methods text cited earlier), came to conclusions that were remarkably similar to those of Garfinkel. In the context of achieving reliability in coding mathematical problem solving, two or more coders need to see the world in very much the same way. This, however, is not achievable by means of written procedures and specifications. Schoenfeld realized that some experience in coding tapes of mathematical problem solving jointly was necessary to achieve the consensus that produced consistency; that is, written descriptions of the coding method did not suffice to define just how to get the "grain size" of a particular mathematical problem-solving episode. Coders made distinctions on the basis of "feel" rather than on specified, clean objective criteria. Much of the mathematical and analytic knowledge it took to code the tapes in a consistent way was not expressed in the coding protocols, despite the researchers' efforts to make them as explicit as possible. Much of the knowledge it took to code the tapes resided within Schoenfeld's research group. Schoenfeld concluded that this knowledge was not communicable by means of descriptions: "Employing the [coding] method is a matter of skilled practice, probably best learned in apprenticeship. That practice is rationalizeable and its results are defensible after the fact, but is not easily conveyed in a user's manual" (p. 208).

The lower interrater reliabilities observed between different research teams rather than within a team lies in part in the gap that exists between any description and the event so that, for example, researchers who want to replicate an experiment are frequently unable to achieve the correspondence previously achieved by the original investigator between what was actually observed and the intended event for which the observation is treated as evidence (Garfinkel, 1967).

Coding is but one example of the many aspects of research as practice. To be able to do educational research, a graduate student in mathematics and science education may be expected to learn how to design, test, and validate a questionnaire; plan and conduct an open-ended and unstructured interview; collect videotaped episodes from a science laboratory and conduct a discourse analysis; and engage many other aspects of quantitative research, qualitative research, or both. Central to our framework is the idea that the best way of learning to do research is to participate in varied aspects of research with one or more experienced practitioners. Learning is understood as a trajectory from legitimate peripheral to core participation in a community that practices educational research.

CONCEPTUAL FRAMEWORK

Research as Practice

Much recent research in the social sciences has debunked the myth of human activity as a rational pursuit of goals by application of rule-based knowledge, and has suggested that human cognition is fundamentally situated in and distributed across specific social and physical settings (Garfinkel & Wieder, 1992; Lave, 1988; Suchman, 1987). Most human activities are thus better understood in terms of practices. Practices are discursive and physical actions in specific settings. Although tools and many other characteristics of two settings may be the same, they often give rise to distinctly different practices. Thus, carpenters and cabinetmakers use chisels on wood, but they do so in essentially different ways. Conceptual tools such as mathematical formulae equally differ when they are used by engineers or physicists

(Brown, Collins, & Duguid, 1989); and aircraft engineering designs give rise to different discourse practices when used by design engineers, workers on the shop floor, stockroom managers, sales personnel, or general accountants (Henderson, 1991; Star, 1989). Within each of these communities, practices are relatively homogeneous and characterized by the conventions, standards, behaviors, or viewpoints that their members (practitioners) share.

Legitimate Peripheral Participation

There is an accumulating body of research studies on knowing and learning in a variety of scientific domains that supports the claims that essential aspects of any practice cannot be learned through reading or listening to lectures, whether the practice relates to a specific technique in microbiological analysis (K. Jordan & Lynch, 1993), Mayan midwifery (B. Jordan, 1989), detectors in physics research (Traweek, 1988), architectural design (Schön, 1987), or sociological research (Bourdieu, 1992). Rather, these aspects are appropriated (taught) through modes that are thoroughly practical, in the context of ongoing authentic activities in the domain. Lave and Wenger (1991) proposed the notion of legitimate peripheral participation to describe learning that is an "integral part of a generative social practice in the lived-in world" (p. 35). The adjective "legitimate" of this irreducible concept addresses the fact that newcomers participate in the activities of a community rather than being excluded from such activities (for example, high school students do not, in most cases, participate in legitimate ways in the discourses of the sciences they are to learn). The adjective "peripheral" denotes the fact that newcomers do not yet participate fully in the practices that characterize the community; phenomenologically, they participate in the world only partially in the way core members of the community do because newcomers look at the world and act in it in different ways. For example, graduate students, though participating in their advisors' research, are not responsible for the research in all its aspects.

The notion of ***legitimate peripheral participation*** implies that to really understand how to design and conduct research, students need to have opportunities to experience ***how research is actually carried out;*** they need to have opportunities to participate in research. Bourdieu (1992) suggested:

> There is no manner of mastering the fundamental principles of a practice-the practice of scientific research is no exception here-than by practicing it alongside a kind of guide or coach who provides assurance and reassurance, who sets an example and who corrects you by putting forth, ***in situation***, precepts applied directly to the ***particular case*** at hand. (p. 221, emphasis in the original)

To learn to write research reports, students have to participate in writing reports with someone who already is very familiar with this practice. Students need to experience all the false starts, wavering, impasses, renunciations, and situated decisions that after the fact, are rationalized and defended on the basis of some rule. However, what rules do not contain are descriptions of why in one situation they might be applied in a way that seems contradictory with their application in another situation.

Bourdieu (1992) further suggested that, to become researchers, graduate students have to break with their intuitive understandings of the world, a break that is facilitated when students participate in the culture of research; that is, educating social science researchers involves something of an "epistemological rupture" (p. 251), a break with viewing the world as students have done before, and a new beginning that includes the bracketing of ordinary preconstructions and common sense to make them a topic for research. This rupture demands something of a *conversion* of *one's gaze*, and one can say of the teaching of research that it must first give new eyes.

Why Participation?

Much of the knowledge in a community of practice is constituted by mostly unquestioned background assumptions and common sense. This common sense describes the situation that "amongst any given collection of persons organized into anything that can meaningfully be called a collectivity, there will be a corpus of matters which those persons will find 'obvious,' as 'going without saying' and as 'beyond doubt and investigation' "(Sharrock & Anderson, 1991, pp. 63-64). This is common sense, because it is not stated in the form of propositional knowledge, simply because it is so mundane, is unavailable for "transmission," explication, instruction, or inclusion in a textbook. These are the kinds of understandings that newcomers learn by participating with old-timers in the practice. Bourdieu (1990, 1992) talked of "mimesis," a form of "silent pedagogy" as the process by which newcomers come to know the implicit understandings characteristic of old-timers in a community of practice.

EXAMPLES FROM OUR EXPERIENCE

In this section, we describe three situations from our own work that exemplify how graduate students learn research by becoming part of a community and by participating in doing research. We describe how students learn to design research in two graduate **courses** taught by Michael: Research Designs in Education and The Research Basis of Mathematics Education. Our second example comes from a research support group of which both of us are members and that contains all students supervised by Michael. In the third example, we describe how Michelle increasingly participates in the writing of research articles.

Designing Research

Design is an activity in which indeterminate situations are converted to determinate ones (Schön, 1987); research design in social situations is no different here. Such a change in the ontological status of the situation is brought about through the situated practice of the designer. Beginning with uncertain, illdefined, complex, and messy situations, designers construct and impose coherence; they structure their setting in such a way that it maintains a coherence with their earlier experiences. This structure provides a horizon of possibilities and constraints. Consequently, designers develop the emergent design situation, reacting to the consequences and implications of earlier moves.

Because designing educational research is a practice, it makes little sense to learn about it in some decontextualized way. Rather, learning to design occurs as students participate in designing and critiquing design, for “research without theory is blind, and theory without research is empty” (Bourdieu & Wacquant, 1992, p. 162). There is a tight interdependence of theory, research design, and the object of study. Thus, research methodology as a subject independent of theory and the object of research makes little sense; it is, in fact, a “scientific absurdity.” What students need instead is to engage in the practice of designing research; and there is no better way than designing an authentic research project-their own thesis or a joint project with a faculty member-rather than designing a fake project for the purposes of completing a course:

> The most decisive help that the novice researcher can expect from experience is that which encourages him or her to take into account, in the definition of her project, the real conditions of its realization, that is, the means she has at her disposal (especially in terms of time and of specific competence, given the nature of her social experiences and her training) and the possibilities of access to informants and to information, documents and sources, etc. (Bourdieu, 1992, p. 252)

Here the array of methods used must fit the problem at hand and must constantly be reflected on in situ, at the very moment they are deployed to resolve particular questions.

In two of the courses Michael teaches-Research Designs in Education and The Research Basis of Mathematics Education-students learn to design research in a studio-like atmosphere that shares many similarities with Schön’s (1987) architectural design studio. Here students begin to design without knowing the ins and outs of design. Beginning with students’ initial and rather tentative ideas, professor and students begin asking clarifying questions to discover the presenting student's interests. In the process, possible research designs begin to emerge. Students are required to read certain textbook chapters, but use the precepts only later, as after-the-fact descriptions of what happens. In a similar way, occasional discussions of published articles are retroactively described in terms of precepts presented in the textbook.

Inevitably, students' interests lead to a variety of questions that, although sounding very similar, have considerably different consequences for the research to be conducted. Take the following example from one of our recent classes:

> Ron, a mathematics teacher interested in technology, proposes the following research question for his thesis:
>
> Does a computer-based graphing program facilitate students' understanding of functions and their transformations?
>
> This question implicitly suggests a comparison with other ways of teaching functions. It leads to comparisons among students who participate in different types of classes. After deciding how to assess understanding, the question calls for a traditional design in which two methods of teaching are compared on the basis of students' achievement. However, in our class conversation which involves several other students and Michael, it becomes clear that this is not something that holds Ron's interest. Michael then proposes a slight change in the question by adding the word "how" in front of Ron's original question:
>
> How does a computer-based graphing program facilitate students' understanding of functions and their transformations?
>
> In this case, the question asks for information about the processes of constructing understanding and, specifically, about the interactions of student learning and technology.. Michael then asks Ron and the other students to think about what kinds of data they will need in order to make claims about the interactions of student learning in the context of computer technology. One of the problems the class considers is how to elicit student sense-making activity in situ rather than asking them a posteriori. As part of this discussion, Michael suggests setting up collaborative groups as part of the research project and asking the high school students to produce and submit a joint product that any one member can present in a whole-class forum, thus encouraging students to engage in interactions so that every member understands. In this way, the class spends about 30 minutes with Ron's proposal, providing him with ample material to refine his design and to present an update about 2 weeks later.

The central activity in these courses is the presentation and analysis of research questions and associated designs. Each student's question and design is presented in a public forum. This has at least two advantages. First, other students can ask clarifying questions, provide their own perspectives, and elaborate the context of the presenting student's work. Second, an important aspect of this setting is the teacher's questions designed to help the student clarify his or her question. In this review/critique, other students learn to critique each other's work. Later in the course, one can observe that students adopt the teacher's form of questioning and interacting with the presenter. Frequently, students justify their critiques by making reference to one or more precedent-setting cases discussed early in the class. By engaging in such group discussions about other students' research proposals, most participants feel that they learn tremendously about critiquing their own research questions and study designs. Frequently, they revise their own questions and proposals before presenting to the class.

Although these research designs courses comprise 60 contact hours, they are certainly not enough to help students develop more than a cursory competence in designing research. However, the high level of interactions between the graduate students (which often continues into the data collection and analysis phases of their thesis research), facilitates their learning along the trajectory of increasing participation and competence. To increase the level of participation in research with others, we created a research support group consisting of all graduate students who have Michael as their advisor. We describe in the following subsection the continuing participation in research practice that characterizes our work in this group.

Creating a Research Support Group

In the summer of 1993, after a seminar-style course on research in mathematics education, we formed a research support group of ourselves and three graduate students working on their MSc theses in mathematics education. The support group has been meeting regularly for 2 to 3 hours about every third Saturday since that time. Although Michelle and the other graduate students each prepared research proposals during the course (and were therefore at similar stages in their academic lives), Michelle had previously written proposals and participated in research. From this perspective, she was already a legitimate peripheral participant in the educational research community.

As its name suggests, we created the research support group to provide a forum in which the students could discuss research issues associated with designing their master's research projects, planning data collection (in one instance even participating in data collection), interpreting the data collected, and writing parts of the thesis, An important outcome of this research support group was that it facilitated the graduate students' transition from their rather structured course work into the largely independent research aspect of their work toward a degree. The following narrative presents some of the typical features of our meetings and exemplifies several theoretical issues related to legitimate peripheral participation and communities of practice:

> To this meeting, Barry brought a copy of an interview with "Jonathan" (a pseudonym), one of his high school mathematics students. Barry was interested in students' views of mathematics, and particularly in the question why some students do not do well in school although they appear to have a great degree of mathematical intuition. He had interviewed Jonathan because his informal observations suggested that the student was very interested in and was highly competent in many mathematical practices including calculus, vector analysis, matrices, and other topics.
>
> We began by reading the interview individually, following our personal preferences for highlighting parts of the interview, using a variety of colors, or writing comments in the margins. Later, someone began to share observations, comments, and interpretations. After the initial exchanges, we (Michelle and Michael) alternated in asking Barry and the others critical questions about specific interpretations, what dis/confirming data were available in the interview at hand, or what additional data were needed to support or reject a tentative interpretation. Our questioning brought out that, at this stage, Barry did not yet have convincing data to show that Jonathan was more competent than his peers in many mathematical practices. After several suggestions, Michael asked Barry whether it was possible to videotape Jonathan while he was working on one of his fractal programs. Michael followed up by asking the group how to set up such a video session so that Jonathan could talk about the mathematics involved in the program and, in this, exhibit his mathematical understandings and provide material evidence thereof. This leds us to talk about the advantages and disadvantages of videotaping (a) a think-aloud programming session, (b) a joint programming session with Jonathan and one of his peers, or (c) a conversation between Jonathan and Barry in which the student explained a previously completed program or some other work in progress. Michelle, who for her own thesis on everyday mathematics had videotaped an elementary teacher doing mathematics while baking cookies, suggested that it would be important to record Jonathan doing mathematics while programming fractals. At this point, two different conversations emerged. Barry continued to pursue with Michelle the implications of her suggestion in his project Michael talked to Blair and Trish who had recorded, but not yet analyzed, videotapes of students engaged in mathematical activity.
>
> Later, the group shifted its focus to discuss a draft analysis Michelle had written for inclusion in her thesis. After reading the text, Michelle questioned the other participants about the soundness of her interpretations, and how her argument could be strengthened. At the end of the session, Trish asked Michael to meet individually. Barry, who had more questions about how to interview, retreated with Michelle into her office, where they worked out some of the details for further data collection and writing a first draft analysis of the interview with Jonathan to be shared in a future meeting.

This narrative of a typical meeting shows several characteristics of our group that are consistent with the theoretical perspective outlined earlier. We take a decentered view of apprenticeship into a community (Lave & Wenger, 1991), according to which mastery does not reside in an all-knowing professor master but in the organization of the community of knowers of which the master is just one part, In our research support group, the professor's job is not that of an all-knowing information provider. Rather, our activities are characterized by graduate student independence, mutual support, and mentoring by more experienced others. This view moves the focus of learning to do research away from individual accomplishments onto our community's intricate structuring of learning resources. As much as possible, our students acknowledge the influence of others on their work. Such a decentered approach to knowing allows us to maintain the research support group in the absence of the professor. The group, under the mentorship of the most experienced member (here Michelle) continues to function and accept newcomers.

What we had created was a small research community in which members were at different stages of legitimate peripheral participation. Those who had already developed greater competence in the practice of research mentored and provided advice to those with less. Initially, because of her prior participation in research, Michelle quickly became a resource for the other students. Later, Barry and Blair, who were already engaged in their data collection and interpretation, took on supporting roles for those less advanced in their projects. In this way, everyone developed a considerable understanding for what the others were doing, how the research progressed, what possible problems might emerge, and so on.

Collaboration in Reporting

Certainly the most ideal situation for learning how to do research is to participate with a competent researcher in all stages of ongoing research projects. Here, graduate students can appropriate both explicit and tacit aspects of research practices. The four episodes at the beginning of this chapter already provided a description of our practice of introducing graduate students to research in science teaching and learning. These episodes illustrate a form of graduate student education in research that is consistent with a model of learning as a trajectory from legitimate peripheral to core participation in social science research.

The aspect of research that appears to be most difficult to appropriate is that of learning to write papers, chapters, articles for publication, or grant applications. We know both from personal experience and from sociological research (Knorr-Cetina, 1981) that graduate students in the natural sciences frequently learn to write for publication by drafting a manuscript. They submit the draft to their professor, who marks it up to be redone by the student. After many cycles of this process of writing and critiquing, a publishable piece emerges. We take a different approach. Paralleling our on-site work during data collection, students begin with more manageable tasks such as editing, commenting, and critiquing. Later, they take on increasing responsibility for producing manuscript drafts. We proceeded in the same way in writing this chapter. Michelle commented on, critiqued, and suggested additions to Michael's initial draft. To facilitate the integration of texts and to avoid duplication of writing, we use the same word processor and exchange progressive versions of the final document. Any additional text-whether Michelle's comments to the drafts of this chapter, or Michael's comments to draft chapters of her MA thesis-was enclosed in parentheses and flagged by "$$." The following is an example from the first paragraph after the opening vignette, and ultimately led to the present version of this chapter:

> Carolyn is a relative newcomer compared to Sylvie, so that she learns important aspects of transcription from the latter. ($$I wonder if we could also include here that Carolyn a counseling psychology student, teaches us about interviewing or something to highlight her different area of expertise, and that we all learn from each other?) Here, we see a small community with members who have different levels and areas of expertise.

Or Michelle suggested an addition that led to the current version of the previous section regarding her mentorship role in the thesis support group:

> We need to work on the fact that I am taking over the thesis support group next semester, This really highlights the graduate student as mentor aspect. The others stated themselves that I would be capable of doing this, suggesting that they see me in a bit of a mentoring role as well. (personal note, August 14, 1995)

Through such writing and sharing of draft versions, Michelle participates increasingly in writing manuscripts.

DISCUSSION AND IMPLICATIONS

A community is the central location of knowing for any practice; it is a set of relations between people, activities, and the world over time and in interaction with other communities of practice. The community provides interpretive support necessary for making sense of tools, language, mores, heuristics, and other aspects that constitute the community (Lave & Wenger, 1991). An important consideration in the development of a community is its reproduction cycle. In the case of science and mathematics education research, this can be somewhere from 3 to 5 years, depending on the extent of the studies-a longer time period for a student who pursues a PhD degree than for someone in a master's program.

In our view, the notion of legitimate peripheral participation allows us to understand the career path of a researcher in new ways. It is not, for example, on accepting a position as a professor that a person assumes the functions of a member. Most frequently, the future professor has already done independent research and written research articles. However, the notion of legitimate peripheral participation allows us to consider other aspects of professional practice as beginning at an earlier stage than commonly believed. For example, graduate students themselves begin to serve as mentors to other even newer members in the community. Michelle, for example, is well on her way to becoming a core member. She has taught introductory research methods courses, participated in research designs classes, has mentored other graduate students, and is conducting the research support group on her own She also has participated in a number of different research projects, and conducted her own independent research. If she decides to pursue an academic career, all she will lack is the formal supervision of a new researcher (a graduate thesis).

The Problem of Class or Group Size

The notion of legitimate peripheral participation points out problems in current approaches to teaching graduate students about research, particularly in the number of students a competent old-timer can effectively supervise. Bourdieu (1992) explained in his *Paris Workshop* that the implications of a practice perspective on social science research were dramatic, and incompatible with much of current teaching of "research methodology." If one has to learn a practice alongside a seasoned practitioner-participating in the actual doing of design and research, constructing a questionnaire, reading statistical printouts, interpreting interview transcripts-it is clear that one can supervise only a small number of graduate student research projects (master's or doctoral theses). We experience this contradiction every time we have to teach a course such as Research Designs with a larger group of students. In our experience, group sizes of four to eight members including the professor are ideal for research classes, seminars, and on-site research. However, even more radically, Bourdieu claimed that those who purport to supervise a large number of students do not actually supervise those students. Here we disagree to some extent with Bourdieu. We believe (with Brown et al., 1989; Lave & Wenger, 1991) that the interactions between those who are not yet central members of the community are just as important as those with core members. These interactions constitute an important part of the experience on which later expertise as a researcher is founded. We find it, therefore, of the utmost importance to create a community of practice constituted of members at varying levels of competence. This allows not-yet-core members to do what their mentors do: engage in mentoring by becoming mentors themselves.

Contradiction and Dilemmas

Lave and Wenger (1991) indicated that by granting legitimate peripheral participation to newcomers, a community automatically becomes subject to the continuity-displacement contradiction that provides newcomers with a dilemma. On the one hand, the new researchers need to engage in a practice. To understand and participate in it, they have to adopt current standards of the community in which it exists. On the other hand, they have a stake in the development of the practice so that they can establish their own future identity. This means they have to establish their own ways of doing research, thus transforming the available practices in the research and therefore the entire community.

Thus, within the notions of legitimate peripheral participation and apprenticeship is embedded the danger of cultural reproduction. We find ourselves in a double bind. Bourdieu (1992) noted:

> Without the cultural tools bequeathed in acculturation, a person would be deprived of a mode of adaptation/learning characteristic to humans. But at the same time, acculturation has the danger of simply substituting for the naive doxa of lay common sense the no less naive doxa of scholarly common sense ... which parrots, in technical jargon and under official trappings, the discourse of common sense. (p. 248)

Bourdieu called for continuous vigilance, constant questioning, and methodological mistrust. Lave and Wenger (1991) suggested that with any new individual, new visions and transformation are automatically embedded in cultural reproduction through legitimate peripheral participation. From this derives the peculiar antinomy of research pedagogy. It must enculturate students in ways of using both tested instruments for constructing reality (problematics, concepts, techniques, methods) and at the *same* time, a formidable critical disposition to question ruthlessly those instruments.

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REFERENCES

Bourdieu, P. (1990). *The logic of practice.* Cambridge, England: Polity Press.

Bourdieu, P. (1992). The Paris workshop. In P. Bourdieu & L. J. D. Wacquant (Eds.), *An invitation to reflexiue sociology* (pp. 217-260). Chicago: University of Chicago Press.

Bourdieu, P., & Wacquant, L. J. D. (1992). *An invitation to reflexive sociology.* Chicago: University of Chicago Press.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Garfinkel, H. (1967). *Studies in ethnomethodology.* Englewood Cliffs, NJ: Prentice-Hall.

Garfinkel, H., & Wieder, D. L. (1992). Two incommensurable, asymmetrically alternate technologies of social analysis. In G. Watson & R. M. Seiler (Eds.), *Text in context: Contributions to ethnomethodology* (pp. 175-206). Newbury Park, CA: Sage.

Henderson, K. (1991). Flexible sketches and inflexible data bases: Visual communication, conscription devices, and boundary objects in design engineering. *Science, Technology & Human Values, 16*, 448-473.

Jordan, B. (1989). Cosmopolitical obstetrics: Some insights from the training of traditional midwives. *Social Science in Medicine, 28, 925-944.*

Jordan, K., & Lynch, M. (1993). The mainstreaming of a molecular biological tool: A case study of a new technique. In G. Button (Ed.), *Technology in working order: Studies of work, interaction, and technology* (pp. 162-178). London: Routledge.

Knorr-Cetina, K. D. (1981). *The manufacture of knowledge: An essay on the constructivist and contextual nature of science.* Oxford, England: Pergamon.

Krathwohl, D. R (1993). *Methods of educational andsocial science research: An integrated approach. New* York Longman.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life.* Cambridge, England: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge, England: Cambridge University Press.

McGinn, M. K., Roth, W.-M., Boutonné, S., & Woszczyna, C. (1995). The transformation of individual and collective knowledge in elementary science classrooms that are organized as knowledge-building communities. *Research in Science Education, 26,* 163-189.

Schoenfeld, A. (1992). On paradigms and methods: What do you do when the ones you know don't do what you want them to? Issues in the analysis of data in the form of video-tapes. *The Journal of the Learning Sciences, 2, 179-214.*

Schön, D. A. (1987). *Educating the reflective practitioner.* San Francisco: Jossey-Bass.

Sharrock, W., & Anderson, B. (1991). Epistemology: Professional scepticism. In G. Button (Ed.), *Ethnomethodology and the human sciences* (pp. 51-76). Cambridge, England: Cambridge University Press.

Star, S. L. (1989). Layered space, formal representations and long-distance control: The politics of information. *Fundamenta Scientiae, 10, 125-154.*

Suchman, L. A. (1987). *Plans and situated actions: The problem of human-machine communication.* Cambridge, England: Cambridge University Press.

Traweek, S. (1988). *Beamtimes and lifetimes: The world of high energy physicists.* Cambridge, MA: MIT Press.