Teaching-Research and Design Experiment – Two Methodologies of Integrating Research and Classroom Practice

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Introduction

The presentation will review the Teaching-Research and the Design Experiment methodologies – two approaches to teaching and research, which, with the progress of reform in mathematics education, have acquired new importance and significance (Lesh, Kelly, 2000). Teaching - Research, the process of developing the craft of teaching through the adoption and assimilation of scientific methodology in classroom work, originates in the principles of Action Research and its developmental history has been documented by several authors (King, Lonnquist, 1992; Noffke, S. (1994)). It is credited with the increase of teachers' classroom awareness, significant increase of work motivation as well as the increase of student achievement and interest in the subject matter. It allows the teacher to view her/his classroom as the scientific laboratory focused on the improvement of the process of learning. Design Experiment methodology in education, on the other hand, has its origins in Vygotskian notion of the Teaching Experiment performed "to study mental changes under the effect of instruction", according to (Menchinskaya, 1967; Hunting, 1983). The "scientific status" of Design Science was delineated by (Simon, 1970), while the Design Experiment as a contemporary tool of educational research was formulated by (Brown, 1992) and (Collins, 1992). Both approaches, Teaching-Research and Design Experiment share important characteristics of contributing to building the bridge between the educational research and teaching practice. The extension of the NRC report, *How People Learn: Bridging Research and Practice* (1999), notes that the most effective attempts at integrating the theory and practice have taken the form of small groups of teachers engaged either in designing teaching experiments in collaboration with researchers or by individual teachers researching classroom practices on their own in their classrooms.

We examine the common features as well as the most important differences of both methodologies; we propose a new model of teaching-research formulated recently in the community colleges of CUNY in New York City (NYCity model), which integrates their differences (Czarnocha, 2002).

Two approaches to the integration between teaching practice and research

The document *How People Learn* (NRC, 1999), asserts that one of the fundamental difficulties in the progress of reform in mathematics and science education is the lack of integration between research and teaching. This shortcoming results not only in a time lag between theory and practice but also reinforces the widespread belief that researchers' endeavors are irrelevant to classroom practices (Brown 1992, Saul 1995). One of the central issues, which motivate the emergence of methodologies that attempt to bridge that gap is the complexity of the classroom learning process. For an educational researcher, according to (Brown, 1992), the prospect of leaving the artificial environment of the psychological laboratory and with the help of the Design Experiment to enter the rich, complex, and constantly changing environment of the classroom is an unusual and exhilarating opportunity to observe and to understand the psychology of pedagogical dynamics directly in vivo. On the other hand, the NCTM-2000 Standards asserts that the teaching of mathematics is a complex practice in that it "must balance purposeful, planned classroom lessons with the ongoing decision-making that inevitably occurs as teacher and students encounter unanticipated discoveries or difficulties that lead them to uncharted territory" (p.18). To navigate this terrain and manage its inherent dilemmas (Lampert 2001), the ideal standpoint is that of a teacher-researcher, a professional who investigates the teaching/learning processes in her/his own classroom and uses this knowledge for furthering instruction and for the navigation in the "uncharted territories.

Consequently, the challenge of integrating the research with practice is being approached along two complementary directions, from teaching to research through the development of the Teaching-Research methodologies and investigations in the classes of individual teachers-researchers, and from research to teaching through the import of the educational laboratory into class-

rooms of teachers who, in collaboration with researchers, participate in designed experiments.

Both of those promising approaches, however, are besieged by significant methodological challenges, each bringing forth a host of new set of questions to be answered. On the side of the Design Experiment methodology one needs to ask how to design the experimental situation, which at the same time is imbedded in the regular life of the classroom? What research questions can be formulated for such a set up? Who is to perform the teaching experiments? Similarly the Teaching-Research methodology has to solve a multitude of equally serious methodological problems: what is the ethics of Teaching-Research? What are the research questions that a teacher can ask? How trustworthy is the research performed in a single classroom? How to increase the validity of classroom results?

Their similarities and differences

There are two main methodological similarities between the approaches:

◆   both of them rely on the cyclical nature of classroom research, which allows repeatedly refining the instruction and deepening the theoretical understanding of the issue at hand. Significantly, the researchers generally start their design experiments with the theoretical point of view to be verified or assessed through the classroom teaching experiment (The Design-Based Collective, 2003; Asiala, 1996), while the Teacher-Researcher usually starts with the practice of instruction (Malara, 2002), its observation and redesign followed by the possible formulation of the theory.

◆   both approaches agree also that the "central goals of designing learning environments and developing theories…of learning are intertwined" (The Design Based Collective, 2003, p.5)

The methodologies differ significantly in the set of priorities through which the central goals are realized. Teaching-Research is primarily concerned with the improvement of instruction in the classroom, and it draws its theoretical hypotheses out of particular instances of that improvement. The Design Experiment emphasizes the creation and development of theories of learning as its primary goal, with the improvement of learning process in a particular classroom seen as the secondary goal (Cobb et al, 2003). Similarly the role of the teacher is significantly different in both methodologies. In Teaching-Research methodology, the teacher is the main investigative agent and he/she organizes the classroom activities to fit them into the established research questions (Jaworski, 1994); in the performance of the Design Experiment the teacher is at most the member of the research team, rarely its central methodological

figure whose craft knowledge serves as the main spring for investigations.

The research questions asked by each approach differ equally significantly. On one hand (Cobb & Steffe, 1983) assert that the investigator's interest in the classroom always lies in "investigating *what a child might learn*". On the other hand, the interest of a Teacher-Researcher is to formulate ways and means to foster *what a child needs to learn* in order to reach a particular moment of discovery or to master a particular concept of the curriculum (Czarnocha, 1999). The research question here can be "what representations, and in what order should I use in Calculus so that my students fully understand the coordination between epsilon and N in mastering the definition of the limit of a sequence?". Since that process of understanding is understood by the contemporary theories of learning to take place within the autonomous cognitive structures of the student, the teacher-researcher must investigate the workings of these structures during a particular instructional sequence (Czarnocha, 1999). "Are my students more visual or verbal in terms of their cognitive processing, are they working in the process or object mode of thinking?" – could be the goal of classroom investigations.

Teaching-Research (NYCity model)

Hence, despite the integration of the educational researcher laboratory with the classroom, there are essential differences between the two methodologies, differences that still hark back to the theory/practice duality. These differences impact the interaction between the two approaches and can significantly lower their effectiveness by not utilizing the maximum of their implicit potential. In order to get the maximal effectiveness from both approaches, full integration of the two methodologies is the immediate task of educators in this domain. A new model of bi-directional Teaching-Research called NYCity model has been formulated recently in community colleges of CUNY (Czarnocha, 2002). The new model proposes an increase of validity and trustworthiness of classroom research through its coordination with modern cognitive and constructivist theories of learning. The process of coordination can proceed along two routes. A teacher-researcher can use a general theory of learning at the very beginning of the teaching-research process in the classroom, organize its practice in accordance with the suggestion of the theory or research and investigate its effectiveness using theory-based criteria (Baker, Czarnocha, 2002), or the teacher researcher can perform a classroom teaching experiment designed on the basis of practical craft knowledge and then seek an appropriate general theory to explicate the empirical results (Czarnocha and Prabhu 2001). This variety of possibilities of teaching-research points out to the inherent subtlety "par-

ticularly as it regards the management of the research activities in the classroom, as it requires the teacher's full immersion into the streams of classroom interaction, at first, and secondly his/her abstraction from such a stream in order to observe and control the classroom dynamics that arises" (Malara, Iaderosa, 1998).

In a similar vein, (Czarnocha, 1999), in his report about the discovery technique of teaching in a high school classroom, notes "the necessity to maintain a flexible flow of the course while employing the teaching experiment for the instructional purposes. This necessity is mandated by the dialectical interaction between the two aspects of the instructor's role: that of a teacher and that of a researcher. In order to facilitate the instructor's goal, the discovery of proportions, the researcher had to discover the elements of cognitive knowledge of the students relative to this concept. As these discoveries were often unexpected and contradicted teacher's suppositions, the teacher had to change his pedagogical goals and formulate new activities better adapted to students' cognitive tools. He had to ask new questions, which hopefully, through addressing newly discovered levels of understanding would bring students closer to their moment of discovery".

The presentation will contain excerpts from the interview with a teacher-researcher utilizing the methodology of TR/NYCity model while conducting teaching experiment into student understanding and mastery of the concept of the limit (Czarnocha, Prabhu, 2002). The excerpts will illustrate dynamics of bi-directional teaching-research and its impact upon the learning process.

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