Pedagogical Content Knowledge as a Means of Professionalizing Preservice and Inservice Teacher Education

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Over the past 100 years effective teaching has been defined in a variety of ways, ranging from the identification of personality characteristics to instructional behaviors to decision-making ability to pedagogical content knowledge (PCK). Currently, PCK is the primary theoretical perspective through which teachers are educated and evaluated. It is believed that the stress a PCK perspective places on teachers' knowledge and thinking professionalizes what it means to be a teacher. The PCK perspective transforms what used to be known as "teacher training" into a profession. The preservice and inservice teacher education programs at Illinois Institute of Technology (IIT) are guided by a PCK framework.

Graduates of IIT's programs are expected to meet the following goals:

- be leaders in instructional innovation in mathematics and science
- actively conduct classroom-based research to assess the effectiveness of instructional innovation
- integrate current and emerging subject matter into the development of mathematics and science curriculum that enable secondary students to function as productive citizens in contemporary society
- effectively address the needs of diverse students (including special needs) in diverse contexts
- promote the productive integration of emerging technology into science and mathematics teaching practice

The overall set of goals and the context and nature of the IIT program make it unique among teacher education programs. With virtually no exceptions, IIT is the first engineering and technologically-oriented university to become directly involved in both preservice and inservice teacher education. The program is unique in its focus solely on mathematics and science within a discipline-based and technology rich context. Just one example of this unique approach are the field practica students are required to complete with active researchers in science/mathematics and in informal educational venues, in addition to the more traditional student teaching experience. These experiences provide students with experiences in authentic inquiry/problem solving and the various places in which learning and teaching take place, other than classrooms. The program does not contain courses that are independent of a subject matter context (e.g., general educational psychology). For example, students develop their knowledge of student learning and motivation through specific attention to, and experiences with, learning in mathematics and science. Consistent with current research, all attention to pedagogy is intimately integrated into a meaningful subject matter context. Herein lies the true uniqueness and strength of the program.

Along with the preservice programs, MS and PhD programs are also provided in the Department of Mathematics and Science Education, using the same PCK framework. The activities of both faculty and students involved in the MS and PhD programs are used to further inform the preservice programs and its approach to developing excellence in mathematics and science teaching. Overall, the program will always be viewed as developing and emerging. We strongly believe that our collaborations with IIT colleagues and external agencies and schools, along with assessment data collected within the Department serve to continually provide resources and evidence for subsequent revisions of program initiatives.

Overall Program Framework and Knowledge Base

Our program directly derives from the recognition that students learn science and mathematics by "doing." They are not simply vessels to be filled with knowledge. Just as is the case with science students, teachers learn their profession best by "doing." However, as Piaget and Bruner recognized several decades ago, "doing" is not enough in and of itself. Learners must consistently learn to monitor their progress in a self-regulated fashion that allows continued development and revision; also known as lifelong learning. As a reaction to the behavioristic notions of Thorndike, Watson, and Skinner, the aforementioned perspectives on learning have been well developed by some of the most influential educators of the latter 20th century; Piaget, Bruner, Ausabel, Gagne, among others. Interestingly, it has not been until the last decade that such notions were forcefully and directly associated with constructivist epistemology.

When attempting to define a program knowledge base, the process must be based on a theory of knowledge development (or an epistemology). Epistemologies typically focus on, but are not limited to, the nature of cognitive processes, sources of human knowledge, and methods of validating knowledge. The particular epistemology of our program is constructivism. In particular, the program recognizes that individuals (students and teachers) construct their own sense and meaning of reality as they interact with the world and its phenomena; and, through one's constructed meaning, future events and phenomena are filtered. Given that reality can never be known or understood in any definitive sense (even if one believes that "objective reality" exists), the program places no emphasis on one reality or viewpoint being THE correct reality or viewpoint. Surely, it can be argued that certain instructional approaches may be superior to others in particular contexts, but individual teachers need to develop these conceptions on the basis of their own backgrounds and abilities. Consequently, within the program, the faculty stress the development of those intellectual abilities and skills that provide the individual teacher with the ability to make informed and rational decisions (based on the teacher's reality) when confronted with the ever increasing complexity of instructional decisions that comprise classroom life. Further, the faculty consciously work to assist preservice teachers in determining their own instructional philosophy based upon the study of a variety of theoretical and practical perspectives. It is only through the recognition of multiple and diverse perspectives that highly individualized teachers can meet the needs of an equally diverse body of students. It is important to note, however, that the program strongly believes in standards of quality derived from the research literature and is not accepting of any perspective our students may develop. Consistent with the constructivist perspective,

certain “constructions” are viable while others are not. It is the viable “constructions” that research has supported and from which the wisdom of practice is derived. It is important to note that, although mental constructions of knowledge implies passive learning, what constructivism strongly emphasizes is that individuals learn about their world through active interaction with their surroundings. Consistent with this view, students in the preservice programs develop their understandings of teaching by DOING (i.e., developing instructional activities and then trying these activities) and then reflecting upon what was done and the decisions that were made.

The sources of our theoretical and practical perspectives are the following:

- scholarship in content disciplines
- materials and settings of the institutionalized educational process (for example, curricula, textbooks, school organizations and finance, and the structure of the teaching profession)
- research on schooling, social organizations, human learning, teaching and development, and the other social and cultural phenomena that affect what teachers can do
- the wisdom of practice itself (Magnusson & Palinscar, 1995; Shulman, 1987, p. 8).

Knowledge in the field of education is developed, advanced, and extended through empirical research, including qualitative, quantitative, and hermeneutic approaches. Specifically, the IIT program strongly relies on the knowledge, skills, beliefs, behaviors, and instructional dispositions emphasized in the most current research on teaching and learning. The program supports the notion that cognitive, social, cultural, psychological and moral development empower and emancipate teachers as well as all individuals. However, the reference point for the program knowledge base ultimately derives from systematic research on teaching and learning. The program also relies on theory developed from practice, the wisdom of experience, if you will. Emergent theory is not only relevant to work in schools but is often the catalyst for the formulation of new visions and research in education. It is anticipated that our graduates will be leaders who will actively participate in setting new visions and conducting the necessary research to assess the effectiveness of these visions.

The overall organizational framework for our program borrows heavily from Shulman’s (1986) ***Knowledge Growth in Teaching*** with the ultimate focus on ***the Teacher as Transformer of Subject Matter***. At an operational level, the program focuses on the development, revision, and elaboration of six primary domains of knowledge that both theory and research have indicated are essential for effective instruction (Gess-Newsome & Lederman, 1999; Shulman, 1986,1987; Wilson, Shulman & Richert, 1987). It is this combination of domains of knowledge that distinguishes the expert teacher from others possessing one or more of the following domains of knowledge.

1. **Subject matter knowledge**: Knowledge of foundational ideas and conceptual schemes, data and procedures within a specific subject matter area.

2. **Pedagogical knowledge:** Knowledge of generic principles and strategies of classroom instruction (e.g., instructional models and integration of technology) and management.

3. **Knowledge of schools**: Knowledge of educational contexts, i.e., the place of the classroom in the school, school in the community and other social contexts.

4. **Knowledge of learners**: Knowledge of all aspects of intellectual, social and emotional development of all students regardless of cultural, social, ethnic background.

5. **Curricular knowledge:** Knowledge of development and implementation of programs and materials.

6. **Pedagogical Content knowledge:** The way of representing and formulating subject matter knowledge that makes it comprehensible to others (i.e., knowledge of how to transform and represent subject matter so that it is comprehensible to students or others).

It is this last domain of knowledge that focuses primarily on the teacher as a transformer of subject matter knowledge. Clearly, the teacher must possess knowledge in each of the specified knowledge domains. However, the ultimate test of the effective teacher is the ability to transform what he or she knows into a form that is readily accessible to all learners. This ability is the essence of Shulman's final domain of knowledge - Pedagogical Content Knowledge (PCK). It is PCK that separates the expert mathematics or science teacher from the subject matter specialist and the expert pedagogue. Consequently, the IIT program is housed within the Department of Mathematics and Science Education the College of Science and Letters and program requirements stress disciplinary-based teacher education and the intimate interaction between subject matter knowledge and instruction. The overall organizational structure and historical academic focus of IIT make it particularly well-suited context for the development of teachers' PCK.

Although we have explicated six domains of knowledge important to the program, it is essential to realize that these domains are highly interactive and this inter-relatedness typifies all program activities and experiences. Two-dimensional representations of the domains of knowledge and their relationship are by nature inadequate. Figure 1, however, attempts to display the high level of interaction and synergy among the six domains of knowledge. The relationship is fluid with no domain totally distinct or separate from another, with the relative amount of overlap among these domains constantly changing depending upon one's progress within the program. In this representation, the Pedagogical Content Knowledge domain is placed in the center because of its importance to the model and because it is the ultimate test of effective teaching, the teacher's ability to transform what he/she knows into a form that is readily accessible to learners.

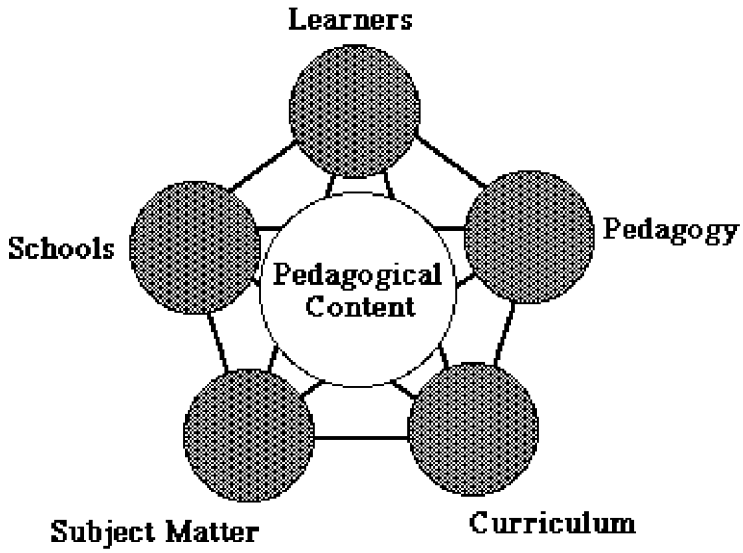

Figure 1. Relationship of the six domains of knowledge

Within the ***Knowledge Growth in Teaching*** model, the IIT preservice programs are committed to providing students with experiences that help them develop a full range of knowledge and skills in the areas of subject matter, pedagogy, pedagogical content knowledge, schools, learners and curriculum within a framework of moral and ethical societal norms, including a commitment to equity and diversity. A primary purpose in the program is to provide students with the ability to respond in a variety of ways to the instructional decisions they will surely face. Exactly which decisions the preservice teachers make remain a function of the individual and how he/she makes sense of or prioritizes the multitude of environmental factors, political interests/forces (federal, state, local), parental interests, etc. specific to the workplace.

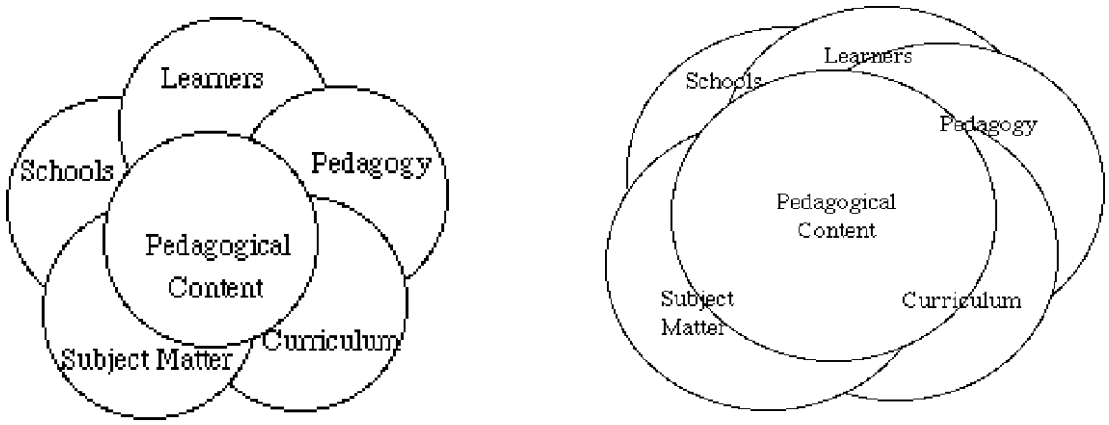

Figure 2. The Development of an Integrated Knowledge Structure

From a constructivist perspective, individuals are continually structuring knowledge and revising their structures of knowledge in response to differing contexts and new knowledge/perceptions. Consequently, it is important to note that the program does not view any of the domains of knowledge as completed outcomes upon a student's graduation from the program (see Development of an Integrated Knowledge Structure in Figure 2).

Rather, they must provide a basis for continued life-long professional development. Our program truly enhances the perspective of teachers as life-long learners and we do not view the knowledge structures of our teachers as completed and final at any point in their careers. The program continually strives to produce complex and integrated structures in each of these knowledge domains in a manner that is consistent with virtually all of the current reforms in education. Figure 3 demonstrates the on-going development of the integrated structure throughout the teacher's professional career that continually strives for a more complete integration of the structures in the teacher's thought processes.

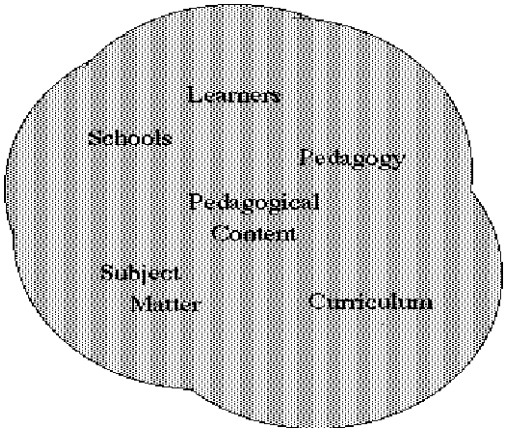

Figure 3. Continued Integration of the Teacher's Knowledge Structures.

Additionally, graduates from the program are able to use the aforementioned knowledge structures in an interrelated manner as they attempt to address and confront the multiplicity of decisions they need to make in the preactive, interactive and postactive phases of teaching (Westerman, 1992). Consistent with Shulman's original elaboration of pedagogical content knowledge, the knowledge developed by students enrolled in the program impact classroom practice and these same knowledge structures will impact subsequent learning of subject matter and knowledge of teaching. Beyond Shulman's model, the program fully recognizes that classroom practice itself influences a teachers' knowledge structure.

All students enrolled in the preservice program must complete BS degrees in their subject matter areas as they concurrently complete discipline-specific pedagogy courses as electives. What follows is an overview of how the 24 semester hour discipline-specific pedagogy courses align with the Program Framework.

The following 24 credit hours are taken as electives along with those courses required for each student's undergraduate academic degree. Course sequence is fixed across academic years. Students already possessing a subject matter degree still must take the required 24 credit hours for certification as a teacher.

Analysis of Classrooms (Practicum and Seminar): MSED 200/500 - 3 credit hours

Description: This course includes a two hour seminar on campus each week along with approximately five hours per week in an area school. This is an introductory course that provides students background in learning theory, motivation theory, classroom

management, aspects of effective teaching, critical classroom variables, and the school as a system.

Pedagogical Knowledge
Knowledge of Schools
Knowledge of Learners
Pedagogical Content Knowledge

Curriculum/Foundations: MSED 250/554/555 - 3 credits

Description: This lecture/discussion course focuses on history/sociology of education, rationales and goals of current reform efforts, curriculum design, development, and curriculum analysis.

Subject Matter Knowledge
Knowledge of Schools
Knowledge of Learners
Curricular Knowledge

Instructional Methods/Strategies I: MSED 300 – 3 credits

Description: Discussion/laboratory oriented course that focuses on instructional planning, implementation considerations of various teaching methods, development of instructional activities, and assessment of student learning. Students are also provided with opportunities to practice instructional skills in peer teaching lessons.

Subject Matter Knowledge
Pedagogical Knowledge
Knowledge of Learners
Curricular Knowledge
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Inquiry/Problem Solving Experience: MSED 320/538 - 3 credit hours

Description: Mathematics and science teachers gain in-depth knowledge of scientific inquiry and problem solving through experiences with active researchers in science and mathematics. The course provides students with opportunities for reflection on aspects of inquiry/problem solving, and nature of science/mathematics. Provides background for student development of instructional materials focusing on inquiry/problem solving and nature of science/mathematics.

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Informal Education Practicum and Seminar: MSED 350/540 - 3 credit hours

Description: Students spend approximately five hours per week in an informal education venue (e.g., museum, aquarium, zoo) along with a two hour on-campus course per week. This course will help students develop an understanding of the roles informal institutions can plan in math/science achievement and the ability to develop instructional materials that capitalize on these community resources.

Subject Matter Knowledge
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Instructional Methods/Strategies II: MSED 400 - 3 credit hours

Description: Follow-up course to Instructional Methods/Strategies I with a strong focus in various advanced instructional models such as inductive, deductive, synectics, inquiry role development, and cooperative learning. Assessment of student learning in these contexts is also addressed. Students will have several opportunities to practice instructional models in peer teaching lessons.

Subject Matter Knowledge
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Curricular Knowledge
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Professional Internship: MSED 450 - 6 credits

Description: Capstone experience in which students assume continuous teaching responsibilities in at least three classes in an area school. Students will spend a full semester in the area school under the supervision of a classroom teacher and university supervisor. A total of 15 weeks will be spent in schools between the two required courses. The field experience is divided into two courses so students who wish can officially graduate in May, a university date that precedes the completion of the public school calendar year.

Subject Matter Knowledge
Pedagogical Knowledge
Knowledge of Schools
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Specific Program Outcomes

The reader is again reminded that, although the program uses "domains of knowledge" as a label for preservice teachers' learning outcomes/competencies, what is sought are performance-based competencies developed through active experiences in classroom settings with secondary students. Upon completion of the aforementioned program, candidates will demonstrate their knowledge of the stated domains of knowledge by:

- the development of integrated and in-depth subject matter knowledge in topical areas directly relevant to teaching content specialty (**Subject Matter Knowledge**)

- the successful development of instructional materials and plans that are consistent with research on teaching and provide students with an environment supportive of learning and emotional development (**Pedagogical Knowledge**)

- successfully working within the school and community in a manner that fosters community and state instructional goals (**Knowledge of Schools**)

- development and implementation of instructional materials and plans, as well as informal interactions with students, that are consistent with current cognitive and social theories on student learning and personal development for regular as well as special needs students (**Knowledge of Learners**)

- appropriate selection of instructional/curriculum materials relative to local, state, and national curriculum goals and reforms, and exhibited ability to analyze and revise materials so that they are consistent with appropriate curriculum goals (**Curricular Knowledge**)

- successful development and implementation of instruction that represents current subject matter to students in a form that promotes in-depth understanding and ability to apply knowledge to new and unique situations (**Pedagogical Content Knowledge**)

It is important to note that all aspects of preservice teachers' knowledge and abilities are evaluated with respect to the needs of ALL secondary school students. In particular, program participants will be expected to develop those skills and knowledge necessary to meet the needs of students regardless of ability, ethnicity, gender, or socioeconomic status.

References Guiding Program Development and Supporting Discipline-Based Teacher Education

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Empirical Research Specific to Science

Magnusson, S. J., & Palincsar, A. S. (1995). Learning environments as a site of science education reform, *Theory into Practice,* 34(1), 1-8.