The Scholar-Practitioner Model as a Basis for Promoting Researcher, Practitioner, and Educator Collaboration in Physical Science and Information Technology Graduate Education

Daniel R. Sewell, Ph.D.

Fielding Graduate University

Santa Barbara, CA

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Address correspondence to:

Daniel R. Sewell, Ph.D.
Associate Provost for Research
Fielding Graduate University
2112 Santa Barbara Street
Santa Barbara, CA 93105
email: dsewell@fielding.edu
phone: 805.898.2916
fax: 805.898.4186

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Fielding Graduate University, Santa Barbara, CA
dsewell@fielding.edu

Introduction

The knowledge domains of basic research in the sciences as well as applied research & practice domains including engineering, advanced information technology, and education are in modes of explosive growth. There is a strong need for, yet it is difficult to sustain, effective collaborations which would benefit the groups focused on each domain. Just as important is the need to integrate basic research, engineering and information technology practice knowledge, and education across each of the domains to benefit student learning and faculty development. One way of portraying these often disconnected domains is shown in Figure 1.

The Pan American Advanced Studies Institute for E-Science aims to facilitate development of a new generation of scientist engineers capable of integrating basic science, advanced information technologies, and engineering for the advance of science and education. In this paper, I call this effort Integrated Education, Scholarship, & Practice for Science, Engineering, & Information Technology (IESPSEI). The purpose of IESPSEI is to foster growth in the numbers of graduates attaining and using integrated knowledge that derives from the interaction between research in the physical sciences and practice in a variety of applied disciplines, especially engineering and information and communication technologies – to increase the numbers of what are called, in the social sciences, S*cholar-Practitioners*. The interaction of research, practice, and education creates the intersection domain that is called the Scholar-Practitioner space (Figure 2).

Scholar-practitioners work in their specific domains as well as the Scholar-Practitioner space to improve their own and others' work. The goal for these scholar-practitioners is to sustain, enhance, and produce new knowledge relevant to the transfer between and integration among research, practice, and education. For IESPSEI efforts, this is particularly important in the context of incorporating advances in engineering, computer science, information and communication technology (ICT), and other technologies[1].

In support of the IESPSEI goal, the Center for Internet Augmented Research & Assessment (CIARA), the Center for High Energy Physics Research and Education (CHEPREO), and the Americas Path Network (AMPATH) have provided various venues for the development of advanced infrastructure to support the conduct of and education in the sciences. In so doing they have used differing approaches to overcoming obstacles and moving towards sustained collaboration and integration among basic research, applied research & practice, and education related to science, engineering and information technology. For example, CIARA by co hosting PASI to "bring together approximately 40 scientists from the Americas, at the advanced graduate and postgraduate level, to learn about new ideas and developments in advanced networking technologies" and to foster "discussions among the participants [to] establish collaboration and new research initiatives for the 21st century" is directly supporting the IESPSEI goals (CIARA, 2004). In another example, CHEPREO has created educational outreach programs using Hestenes Modeling and Quarknet as a foundation for collaborative learning experiences shared by faculty, students, and local teachers from the community (see http://www.chepreo.org). Finally, AMPATH provides high performance networking to various institutions in North, Central, and South America supporting collaborative research and

educational opportunities that include modeling tools and Video-over-IP (see http://www.ampath.fiu.edu).

The IESPSEI goals and initial efforts already underway have a parallel in the social sciences where scientists, practitioners, and educators have struggled to develop models for collaboration and education that integrate across research, practice, and education. This work has been in development for over 30 years outside the mainstream of U.S. academia as exemplified by the work at Fielding Graduate University. Parallel to the work of Fielding and a few other non-traditional institutions of higher education, the Carnegie Foundation for the Advancement of Teaching set the stage for the growing mainstream acceptance of scholar-practitioner efforts by supporting a variety of initiatives which resulted in several significant publications exploring and calling for a change in views of scholarship in higher education (for example, Boyer, 1990; Boyer-Commission, 1998; Glassick, Huber, & Maeroff, 1997). This agenda has been advanced and this work has been further developed as evidenced by numerous research and application projects in the area often called the Scholarship of Teaching and Learning (SoTL) (Gray, Diamond, & Adam, 1996; M T Huber & S P Morreale, 2002; Hutchings, Babb, & Bjork, 2002; Hutchings & Shulman, 1999)[2].

As noted above, Fielding Graduate University has a 30-year history of integrating social science research, practice, and education to produce doctoral graduate scholar practitioners. In the past few years, members of the Fielding community have written about various elements of Fielding's innovative model of integrative doctoral education for scholar-practitioners. These have included explorations of learner characteristics (Barner, 2003), cognitive, personal, and behavioral factors in educational outcomes (McClintock & Stevens-Long, 2002), the role of graduate education in adult development (Stevens-Long & Barner, 2004), the Fielding learning

model (Schapiro, 2003), the nature of the scholar-practitioner (Sewell & DiStefano, 2002), as well as numerous summary articles published in edited volumes characterizing various aspects of distributed education for the scholar practitioner in ICT environments (DiStefano, Rudestam, & Silverman, 2004; Rudestam & Schoenholtz-Read, 2002).

Sewell & DiStefano (2002) reviewed the Fielding Model, the work of the Boyer Commission, the products of the SoTL research[3], and related social science research to produce an extended model of scholarship, the scholar-practitioner, and the role of basic research, research & practice, and education in the professional life of scientists, practitioners, and educators. Shapiro (2003) reviewed the Fielding Model, the history of the development of Fielding, and literatures related to pedagogy, andragogy, adult education, self-directed learning, and transformative learning to describe the characteristics, strengths, and limitations of the evolving Fielding learning model.

The Fielding Model as expanded by Sewell & DiStefano (2002) and further specified by Schapiro (2003), in his characterization of the learning model for the scholar-practitioner, is extensible to individuals and organizations in research, practice, and education in the physical sciences. In the rest of this paper, I describe the Fielding Model to include both the Scholar-Practitioner Model and the Learning Model. Then I apply the model to the domains of physical sciences and information technology research, application, and education to illustrate new paths of IESPSEI that should be explored. I conclude with a brief discussion of a significant driver of this effort and how successful development of IESPSEI efforts will facilitate a reduced divide and enhanced integrative and collaborative efforts among researchers in the physical sciences and practitioners consisting of technical research scientists, engineers, and educators to produce

both the "collision of ideas" necessary to yield learning success and "the container" to incubate a new generation of scientist engineers who will be scholar-practitioners.

The Fielding Model

The Fielding Model consists of four general components:

1. the Fielding Learning Model (Schapiro, 2003); the philosophical and theoretical foundations that determine the framework for the learning environment
2. the Fielding Scholar-Practitioner Model (Sewell & DiStefano, 2002); the philosophical and theoretical foundations that determine the lens through which all constituencies view each other
3. the Fielding Scholarship Model; a model of scholarship expanded beyond traditional views (Sewell & DiStefano, 2002) that creates a framework for institutional, departmental, and individual support of scholarly activities
4. the Fielding Delivery Model; the specific forms and/or activities through which 1-3 are implemented.

There are five key elements that shape the context of the Fielding Model. The Fielding Model is based on

1. a learner centered view of learning[4]; education in which learners' needs are important drivers of process and content in the learning process
2. a collaborative view of learning[5]; education in which faculty and students are co-learners, both bringing the full extent of their research-based and practice-based knowledge to the learning process – in support of the collaborative, learner centered views, historically, Fielding has used the term learner instead of student, for this paper, the terms learner and student are used interchangeably to maintain clarity

3. a distributed or distance free view of learning[6]; distributed education in which faculty and learners, through ICT and other means, are freed from the traditional norms often defined by the physical and temporal boundary parameters of institutions[7]
4. an adult learner view of learning[8]; education in which adult professionals' are viewed as peers as well as viewed as learners; and, their professional knowledge goals are central in the learning process
5. a transformational view of learning[9]; education in which the learner experiences a transformative process resulting in a radically different way of experiencing, understanding, explaining – knowing self, others, and domains of interest such that the transformed learner actively constructs and uses research and practice knowledge and is no longer a passive recipient of knowledge.

Within that context, and for the purpose of this paper, there are four ways of examining the Fielding Model. These are posed in the form of questions which are answered below. In examining the Fielding Model, one must know

1. what is done by and with the learner?
2. what is done by and with the faculty?
3. what is done by the approach, the institution, and/or the society to support the learner and the faculty?
4. what are the specific forms and/or activities through which 1-3 are implemented

What is done by and with the learner?

The learner seeking to develop as a scholar-practitioner has been described by Sewell & DiStefano (2002) in the following ways. The developing scholar-practitioner is typically

1. a self-directing learner, seeking to know more than the knowledge specific to one or a few relatively narrow disciplines
2. an experienced professional, seeking through scholarship to integrate knowledge resulting from a number of differing research-based and practice-based disciplines
3. a "distance-free" individual, seeking to learn in a distributed environment due to opportunities produced by current profession, current technologies, and widely dispersed potential sources of both research- and practice-based knowledge

so that the learner's experience will be maximized by an environment designed to facilitate self-directed, integrative scholarship in a distributed environment.

As described by Schapiro (2003, p. 154), the Fielding learning model for the nascent scholar-practitioner has nine characteristics, each of which constitutes a potentially evaluable dimension. The learning model is

1. more learner-centered than teacher-centered
2. more problem-focused than subject-focused
3. more inquiry-directed than answer-directed
4. more holistic than purely cognitive or rational
5. more experiential than purely didactic
6. more collaborative than competitive
7. more integrated than discipline-based
8. more constructivist than transmission-based
9. more person-centered than role-centered

so that individual or group learning experiences may incorporate a subset of the characteristics; and, the complete learning process incorporates all of the characteristics. The experiences occur, ideally, through a collaborative process imbued with

1. problem posing; creating problems for learning that employ factors relevant to practice, including case study methodology
2. dialogue; exploring problems in discussions incorporating both active listening and active participation
3. collective action; acting on the problem where action results from active participation to produce a collaborative decision/solution
4. reflective discourse; critical reflection through dialogue examining the problem process and outcome

and the goal that the successful learner who becomes a scholar-practitioner "applies scholarship to practice to develop and construct new knowledge that can inform their own and others' work in the world" (Schapiro, 2003, p. 153).

What is done by and with the faculty?

In the Fielding Model there is commitment to a faculty comprised of scholar-practitioners. Sewell & DiStefano (2002) describe three characteristics of the faculty scholar practitioner. The faculty scholar-practitioner is typically

1. an experienced practitioner integrating research, practice, and education
2. a combination of mentor, learner, guide, coach expected to break free of traditional "sage on the stage" models of academia to engage in collaborative learning processes with learners

3. a continual learner actively reflecting on research, practice, and education to develop new knowledge

This continually learning faculty scholar-practitioner is engaged in processes (adapted from Vaill, 1996) characterized by

1. self-direction in the pursuit of knowledge based on research and practice and relevant to the scholar-practitioner
2. exploration of knowledge potentials resulting from the intersection of research and practice and that are useful to the scholar-practitioner
3. practice enhancement using knowledge based on research and practice to enhance the activities of the scholar-practitioner
4. informing meaning to deepen the philosophical underpinnings of the work of the scholar-practitioner
5. multiple environmental influences to broaden the applicability of research and practice based knowledge for the scholar-practitioner
6. conscious reflection on both the research and practice products and the scholar-practitioner activities in each of the previous processes to further learning

From Schapiro (2003), with respect to the relationship between faculty and learners, faculty should maintain specific distinctions that define their role as collaboratively engaging learners in each learner's own

1. construction of personal meaning as opposed to being the sage, arbiter, and judge of academic worth
2. ownership of learning objectives as opposed to being the manager of a learning process

3. planning for learning followed by implementation of learning activities followed by evaluation and assessment of learning

And, faculty should recognize and collaboratively address the following with learners:

1. the extent of learning process and/or learning skill capability in learners
2. the extent of self-directedness disposition and capability in learners
3. the extent of critical reflection skill and capability in learners

When thinking about their general approach to working, faculty should recognize that learners will be moving through the following, often developmental, stages (adapted from Grow, 1991; Schapiro, 2003; Wang & Sarbo, 2004), where each learner may be dependent, followed by interested, followed by involved, followed by self-directed. In a broader sense, these learners may be constantly moving along four dimensions

1. from dependent to independent
2. from uninterested to interested
3. from uninvolved to involved
4. from other-directed to self-directed

and the faculty may be called on at different times to serve, correspondingly, as

1. coach or authority
2. guide or motivator
3. facilitator or equal participant
4. mentor or consultant

through a collaborative process incorporating, in different ways at different times

1. problem posing
2. dialogue

3. collective action
4. reflective discourse

And, the overarching philosophy that the faculty and student are collaborative learners as the student is becoming a scholar practitioner. This philosophy provides motivation, stimulus and a constant reminder that keeps the faculty in continual development as scholar practitioners themselves.

What is done by the approach, the institution, and/or the society to support the learner and the faculty?

Central to the success of the Fielding Model are the core elements defining how the learners and the faculty are supported in their endeavors by institutions, whether they be internal or external to Fielding. From Schapiro (2003), the Fielding learning model explicitly recognizes three core principles:

1. the primacy of the learner
2. the collaborative role of faculty and others in support of learners
3. the role of the broader social context in both the motivation of learners; and, in the objectives of learners

From Sewell & DiStefano (2002), the Fielding learning model incorporates an expanded model of scholarship characterized by three core principles:

1. the necessity of reflection; where every activity is an opportunity for critical reflection, evaluation, and subsequent learning
2. the necessity of action; where every issue is an opportunity to identify a problem, take an action, and evaluate the outcome for subsequent learning

3. the necessity of communication; where every learning is an opportunity to communicate with a community of practice; in Fielding from learning plans at program entry to dissertation at program completion, from knowledge area development to mentoring models to individual research

The six characteristics described above may be viewed as six core principles of the Fielding Model which guide institutional activities at all levels. To maintain these principles, according to Sewell & DiStefano (2002), the implementation of the Fielding Model, the activities of the institution, and the characteristics of the scholarly community should support the learner and the faculty by pursuing the following goals:

1. defining an inclusive model of student learning that incorporates principles relevant to learner centered orientations, collaborative efforts, and practitioner knowledge
2. expanding traditional models of scholarship to include knowledge processes and products generated by scholar-practitioners
3. developing venues for communicating and means for valuing the student and faculty products of scholar-practitioner efforts

Making the six core principles and three goals defining elements of an institution provides a wide range of opportunities for implementation. I turn now to the specific way in which this is done at Fielding.

What are the processes / activities by which the Fielding Model is implemented?

In general terms, what happens at Fielding is primarily a collaboration between faculty and learners, individually, in pairs, and in groups of varying sizes to set goals; and, to structure and facilitate experiences through which participants learn and during which participants develop, articulate, and apply criteria for assessment and evaluation. It is important to note that

there are no preset curricula, no predefined set of learning experiences, and no pre-established body of knowledge that learners are expected to master. Instead every learner develops an individualized program of study in a broadly defined content domain based on her or his practice experience, learning goals, and desires for scholar-practitioner development. In more specific terms there are three general sets of processes or activities in which every learner engages: 1) the learning process, 2) negotiating the curriculum, and 3) transformative experience. This and the following summary is adapted from Schapiro (2003).

The Learning Process. The learning process, occurs in the context of various possible relationships; different relationships will be in process at different times:

1. One to one relationships. These relationships may exist as student-faculty, mentee-mentor, or learner-assessor relationships.
2. One to many relationships. These relationships may exist as student-committee, student-group, or student-multiple faculty relationships.
3. Many to one relationships. These relationships may exist as online seminars, small group settings, or cluster meetings (regional meetings where individual faculty meet with students in their region).
4. Many to many relationships. These relationships may exist as large group meetings, especially at national sessions at which there are most faculty and many students attending.

Negotiating the Curriculum. The second process, negotiating the curriculum, consists of three specific processes, each of which has subsets of activities:

1. Planning learning. Every student develops a series of learning contracts including:

a. Learning Plan. Every student completes a Learning Plan which describes the general curricular and experiential path the learner plans to undertake. This is likely to evolve over time as the student evolves.

b. Knowledge Area. Every student plans, at minimum, the required number of Knowledge Area assessments. Each Knowledge Area plan outlines the intended scholarly explorations of a specified content domain. This serves as the basis for a Knowledge Area contract with a faculty assessor from which the student will produce three scholarly products that explore 1) the breadth of the domain, 2) the depth of some part of the domain, and 3) an applied product which demonstrates the integration of scholarly content, practitioner knowledge and action.

c. Comprehensive Exam. Every student plans and completes a comprehensive exam. With varying specifics for each school at Fielding, this process is one in which every learner is required to demonstrate comprehensive and scholarly integration and communication of knowledge. Learners are required to write one or more documents responding to specific questions. Across Fielding, the process has the following four goals:

    i. Integration and synthesis of knowledge across knowledge domains the learner has studied.
    ii. Integration of research, theory, and practice.
    iii. Critical reflection on identity as a scholar practitioner.
    iv. Communication of doctoral skills and wisdom.

d. Dissertation Process. Every student contracts for a dissertation via a dissertation proposal process. With slight variations for each school at Fielding, the Dissertation

Process, as in most doctoral institutions, is the capstone that pulls together everything that is required across all Knowledge Areas and the Comprehensive Exam. The significant difference at Fielding is that the dissertation is viewed as a means to generate new knowledge by exploring the intersection of theory, research, and practice constituting the "cutting edge" for the scholar-practitioner.

2. Learning activities. To implement and complete the planned learning, each student engages in an individualized combination of a) individual, independent learning activities, b) group learning activities through sessions and/or clusters, c) online seminars and other ICT-based learning activities, and d) unstructured/informal learning activities that may occur during any of the above.
3. Assessing/evaluating learning. Every student engages in participatory assessment/evaluation with every learning activity. Assessments/evaluations typically examine for a) doctoral-level quality of work, b) scholar-practitioner integrative demonstration of knowledge, and c) doctoral competencies and communication skills. The Knowledge Area assessments include evaluation by self and by faculty. The Comprehensive Exam includes evaluation by faculty not in defined mentoring relationship with the student. The Dissertation includes evaluation by self, committee, another student, and an external examiner, who is an expert in the field; and, who is not affiliated with Fielding.

Transformative Experience. The third process, transformative experience, is best portrayed as a series of processes co occurring with those previously described during which the learner moves from being someone for whom knowledge is something separate and apart from the individual to becoming someone for whom knowledge is something the individual owns and

uses or constructs for her or himself. As a result of this transformation, the learner is no longer a passive recipient of knowledge but is, instead, an active agent in the production and use of knowledge[10]. This is especially important for scholar-practitioners who must be responsible for integrating across many knowledge domains ranging from the most basic to the most applied, in order to generate new knowledge and even new forms of knowledge that can be useful to other researchers and practitioners.

The Scholar-Practitioner Model Applied to Physical Science and Information Technology Graduate Education

If one examines the Fielding Model as characterized above; and, if one's goal is to sustain, enhance, and produce new knowledge relevant to the transfer between and integration among research, practice, and teaching for IESPSEI efforts, especially to incorporate advances in engineering, computer science, information and communication technology (ICT), and other technologies; then one inescapable statement arises:

> The institution, organization, center, school, and/or department must define and commit itself to a scholar-practitioner oriented, research-practice integrative, distance-free learning model that demands and supports self-directed, action-based, collaborative, transformative efforts and results; and, that is embedded in the view that its self-reflective character will enable it to impact the broader scholarly, academic, and social context in which it resides.

This statement and the above-described model lead to implications and suggestions for any research and/or practice community considering such a commitment. Minimally there is a need to facilitate distance free or distributed collaborative learning relationships among groups of scientists, practitioners, and educators to focus on integration among and development of scholar practitioner knowledge. This is what CIARA, CHEPREO, and AMPATH, among others, have begun.

To advance the effort requires further support in two ways. One is to support and facilitate the various learning processes outlined above, in the Fielding Model, that will enhance integration of research- and practice-based knowledge for scholars, practitioners, and developing scholar-practitioners. The other is to push for and/or provide support for change in institutions (academic, scholarly, political, governmental) to shift the value-added dimension of scholarship from a basic research focus to an integrated research-practice focus. These are discussed in turn.

Supporting and Facilitating Learning

There are two aspects to supporting and facilitating learning in the Fielding Model. One has to do with the recognition of the interrelatedness of learning processes with research- and practice-based knowledge integration and education in a distributed or distance-free environment. The other has to do with directly supporting all the processes of the Fielding Model. Consequently, supporting and facilitating learning requires addressing both directly. The following discussion addresses some elements of each that may be particularly relevant to enhancing the collaborative potential of the physical sciences and information technology.

Research- & Practice-based Knowledge Integration and Education. This starts with combinations of experienced scientist, practitioner, and educator participants integrating research, practice, and education by seeking to integrate research & practice knowledge in a scholar-practitioner model. In so doing they are seeking knowledge beyond few relatively narrow disciplines in a broad "scholar-practitioner" space; and, using the knowledge to enhance applied practice, basic research, and the deeper conceptualization of what it means to be a scholar-practitioner.

In a general way the PASI conference is a beginning or general means of facilitating that kind of integration and education. One way of moving from a general to a more specific or

focused means would include the development of sustained learning-based scholar practitioner Communities of Practice (CoP). Each CoP consists of a small number of individuals from both the research-based and the practice-based disciplines of interest. For example, a small number of physicists, astronomers, computer scientists, engineers, ICT specialists, and other necessary practitioners would organize a CoP facilitated by an educator steeped in scholar practitioner and community of practice approaches. Within each CoP, the participants become co learners defining the scholar practitioner space and what it means to be a scholar practitioner in the context of their domains of expertise. An example of a question to address in the definition of the scholar practitioner space is, "*What is eScience?*" As numerous small CoPs are developed, then other means of sharing the scholar practitioner knowledge among various CoPs could be developed based, for example, on Learning Community models.

Distributed or Distance-free Learning. The participant learners are engaged in their various research, practice, and education processes in multiple environments and require knowledge from multiple other environments that broaden the potential knowledge for the scholar-practitioner. The multiple environments in which learners reside define a need to support all their efforts in distributed environments. The PASI experience provides an opportunity for face-to-face interaction among a group of researchers, practitioners, educators, and students with broad interests, who might never have interacted otherwise. As such, it is an example of one type of distributed learning possibility. At the same time that the participants are at PASI, they will be in constant e-connection to their respective home learning environments, therefore bringing the latest relevant knowledge into the experience – another type of distributed or distance-free learning.

To push this type of learning further, and into the future, it will be possible to build on the CoP approach to scholar practitioner development. The participants of each CoP will likely reside in different locations, have access to varying knowledge, and be comfortable with different educational processes. To support the work of a learner centered scholar practitioner CoP requires supporting a distributed learning model in which distance is no barrier. Multiple interaction approaches as well as multiple ICT approaches must be employed to support ongoing synchronous and asynchronous dialogue as well as periodic structured and unstructured learning experiences likely to be conducted virtually. Again, it will be desirable for an experienced scholar practitioner oriented educator to facilitate the process while the participants are defining the scholar practitioner space and becoming familiar with scholar practitioner oriented learning in a distributed environment.

Next we turn our attention to a subset of the various processes and activities involved in research- and practice-based knowledge integration and education in a distributed or distance-free environment. This subset will include the learning processes called self-directed learning, learner centered learning, active learning, and collaborative learning. These are discussed in turn with examples.

Self Directed Learning processes start with self directing learners in pursuit of new knowledge that goes beyond some number of relatively narrow disciplines. These learners are active learners who own their learning objectives and are responsible for planning, implementation, evaluation and assessment of learning. In addition to assessing process, these learners assess their own disposition, capacity, and capability in the effort to maximally enrich the process.

For example, in each of the CoPs, each participant defines objectives that clearly exist outside the realm of her/his own domain expertise. This is actually a starting place for PASI participants since each comes with learning objectives related to knowledge domains outside her/his area of expertise. Then through individual efforts and the collaboration of the community of practice participants undertake activities which move them toward the objectives. Subsequent to PASI, members of each CoP may work to help each other clarify both the implicit objectives with which they began and next steps to further those objectives. As time passes, and at specific intervals every participant should assess progress toward objectives and the development of her/his own capabilities; and, then reflect that to the CoP.

Learner Centered Learning processes start with the assumption of the primacy of the learner; consequently, are more person-centered than role-centered and are more learner-centered than teacher-centered.

For example, in the CoPs, the roles of teacher, researcher, computer technologist, engineer, student, and so forth are eliminated. Each participant must maintain the centrality of their own learning needs while respecting the same for other participants. No one in the CoP has a role as a leader, teacher, faculty, etc. All have an equally important voice in the CoP. This does not negate the fact that some individuals have information that others might need to learn. It enhances the potential that all have knowledge that others might need. Using CoPs in PASI to explore a question such as "*What is eScience?"* recognizes the fact that all participants have varying experience with and perspectives on eScience. As a consequence, all participants can participate in the question. This is an example of the attitude that needs to be taken at all levels of development of a CoP.

Active Learning processes are constructivist, experiential, inquiry-directed, problem focused, holistic, and grounded in personal meaning that grows out of practice experience.

For example, moving forward with the CoP model starting with the question of "*What is eScience?"*, the PASI experience provides a rich opportunity for supporting active learning by providing an inquiry-directed problem focused in personal meaning that grows out of personal experience. The CoP should provide focused, structured experiences in which all members can participate to create new and shared learnings in response to the focal question. For example, one way of starting such a process is by having each CoP work as a focus group in a facilitated discussion to explore the posed question. This can be followed up by future face-to-face or virtual sessions in which the focal or new questions can be explored.

Collaborative Learning processes engage the learners and faculty in one or more communities of practice to work collaboratively on problems while engaging in dialogue resulting in collective action and reflection; incorporating both active listening and active participation.

For example, moving beyond the initial PASI meeting, each CoP might develop different forms of collaboration among its membership; and, the collaborations might be aimed at different problems or different outcomes. However, the processes of each collaboration would still be the same, so, the critical issue would be for the CoP to develop methods for dialogue, action, and reflection. One outcome of the PASI might be for the conveners to develop a follow-up structure and support process to enable these.

Summary of Supporting and Facilitating Learning. There are many more elements of the Fielding Learning Model that could have been discussed to highlight potential for IESPSEI goals. These provide a direction and a focus and a specific suggestion for the future development

of researcher, practitioner, and educator collaboration in the scholar-practitioner space by taking a Community of Practice approach to addressing common problems with the goal of building interconnected relationships, experiences, and meaning.

Support for Change by Shifting the Value Added Dimension

To support and facilitate learning in the scholar-practitioner space; to support and facilitate the integration of researcher, practitioner, and educator knowledge; to support the continuing efforts of organizations like Fielding, CIARA, CHEPREO, and AMPATH, it is necessary to push for change within and across other institutions (academic, scholarly, political, governmental) in the perceived value of the products of such integrated efforts. Traditional models of scholarship (Figure 3) place a higher value on the products of basic research, consequently, a variety of rewards go primarily to those efforts. Sewell & DiStefano (2002) proposed a model of scholarship (Figure 4) centered on the value of learning across multiple dimensions and a matrix characterizing a broad set of scholarly products (Figure 5) which allow for value across all dimensions, not just basic research. Scholars, organizations, and institutions need to explore both the model and the matrix as a way of developing different scholarly products and criteria for evaluating them.

This PASI is one means for doing just that. By bringing together researchers across knowledge domains, as well as engineers and educators across research and technology domains to work on advancing eScience, the organizers are acting to equally value the knowledge that all have to offer. A next step would be for the members of the CoPs to work "both directions" by working collaboratively to produce scholarly products that exemplify the intersection of research, practice, and education **and** by carrying on

the effort back at their institutions. Transferring this knowledge is critical, not only to the advancement of eScience, but also to the advancement of science in general due to the growing necessity for collaborations due to increased needs for shared computing capacity (increasingly being called cyberinfrastructure) as well as increased overlap in the knowledge required to conduct scientific endeavors, and, finally, to help solve problems critical to the future of our world in physics, astronomy, biochemistry, ecology, and other areas that were dreams only a few years ago (Brown, 2003; Colwell, 2003; Newman et al., 2003).

Carrying the message back to their institutions would mean working actively toward defining an inclusive model of student learning that incorporates principles relevant to learner centered orientations, collaborative efforts, and practitioner knowledge. Examples of this have been described above in the context of the CoPs. Participants in the PASI should carry forward the CoP learnings to implement where possible and appropriate in their own laboratories and classrooms.

Carrying the message back to their institutions would also mean expanding traditional models of scholarship to include knowledge processes and products generated by scholar-practitioner. In the Sewell & DiStefano (2002) proposed matrix outlining the possible space of scholarly products that could be created and valued for any scholarly work including that of scholar-practitioners (see Figure 5), the gray boxes reflect knowledge spaces and subsequent knowledge products that are typically valued in traditional academic and other environments. Every other box in the matrix represents a potential knowledge space and subsequent products that could be valued. Participants in the PASI, with interests in advancing IESPSEI, should work toward the development of

scholarly products and venues that represent other spaces in that matrix; and, that are particularly relevant to the intersection of research and practice, science and technology, exploration and education[11].

Finally, carrying the message back to their institutions would mean developing venues for communicating and means for valuing the products of scholar-practitioner efforts. For example, one research and practice area that has grown rapidly over the past 20 years is called the Scholarship of Teaching and Learning (SoTL). A wide variety of researchers, educators, and other scholars and practitioners have been exploring the intersection of research and practice related to teaching and learning. It starts with the view that those who teach should reflect on their practice, produce useable knowledge that can further the efforts of other researchers and practitioners. In addition those who do research on teaching and learning should examine practice as well as the more circumscribed and narrow elements of teaching and learning. The development of SoTL has led to the creation of a number of peer-reviewed journals for SoTL-related work as well as varying degrees of advances in the research and practice related to teaching in a wide range of disciplines. This work is reviewed, summarized, and critiqued in an edited volume by Huber & Morreale (2002) and includes SoTL work in the Humanities, the Social Sciences, the Physical Sciences (mathematics, chemistry), and Engineering.

For IESPSEI efforts, to shift the value added component, in a way similar to the development of SoTL work, institutions or organizations should facilitate and support efforts to define activities, disciplines, publications, etc., that reflect the scholar practitioner orientation. Similarly, organizations could use the matrix developed by Sewell & DiStefano to define different sets of scholarly activities and products that

would be recognized in the organization or institution. As a result of the PASI, one focus of the CoP efforts could be to address the problem of what specific activities, disciplines, publications, etc. relevant to IESPSEI efforts might be like.

Conclusion

Knowledge Production, Research, and Practice

The rate of increase of knowledge production is fast and getting faster. This is true across disciplines ranging from basic science to information technology creation to commercial and business productivity (e.g., Moore, 1965). Basic researchers focus on creating the "next step" in knowledge production based on the best hypotheses generated by current knowledge. Knowledge generated by basic research is absorbed by practitioners and evolves quickly into new branches, categories, and even new forms of knowledge to which researchers have little access, especially since there is very little in our academic or commercial economies that encourages practitioners to produce their knowledge in a form that is consumable by others, especially scientists.

As a result of the increasing pace of knowledge production in both the scientific and the practitioner realms, networks representing this knowledge potentially are ever more richly interconnected and enmeshed. Practitioner knowledge is often tacit and usually not produced in a consumable form; and, researcher knowledge is produced and consumed by a wide variety of researchers and practitioners. Consequently, the knowledge that could arise from the connections in these networks is more likely to be generated by practitioners who are engaged in both worlds.

There is a tension among producers of research and theory based knowledge – the basic scientist, and producers of knowledge based on practice only – the practitioner. Scientist produced knowledge is often narrowly circumscribed by the limitations of epistemology and methodology. Practitioner-only knowledge is often narrowly circumscribed by being too local

and too grounded in an experiential knowledge base. Both are rich in their individual potential. When combined in interaction, the potential for new knowledge valuable to all domains is multiplied. The potential exists; whether that potential is realized for the benefit of all depends on taking a different approach to creating and valuing the efforts and the knowledge.

Knowledge Production and the Scholar-Practitioner

This rapidly growing web of knowledge requires Scholar-Practitioners embedded in both worlds to reflect, evaluate, transform, and generate the production of new knowledge and new forms of knowledge. As described in McClintock's summarization of the Scholar-Practitioner model, recent developments in methods, theories, and epistemologies foster "a more integrated basis for the dual facets of the scholar practitioner role" (McClintock, 2004, p. 395). Creating Scholar-Practitioners requires that academe and society value both the efforts and the products of scholar practitioner knowledge production. Fulfilling this goal for IESPSEI requires mindful and dedicated effort to apply the models described here.

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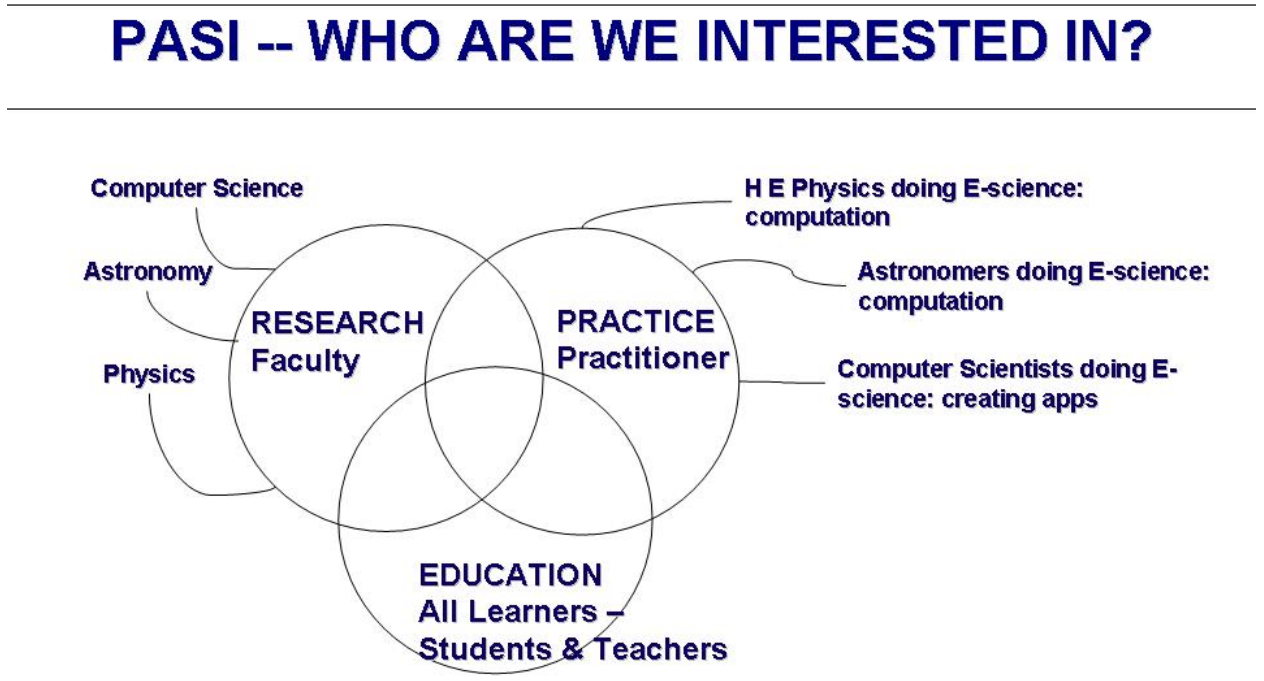


Figure 1. Research, Practice, and Education Domains

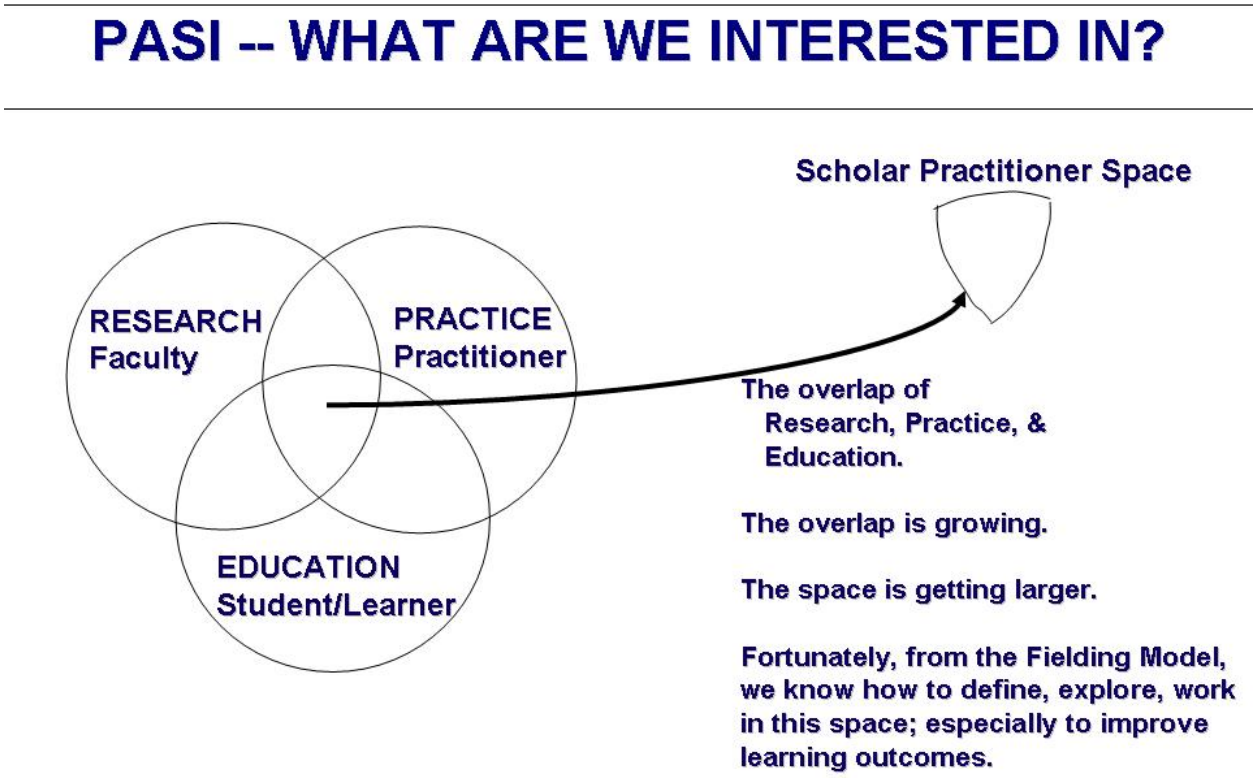
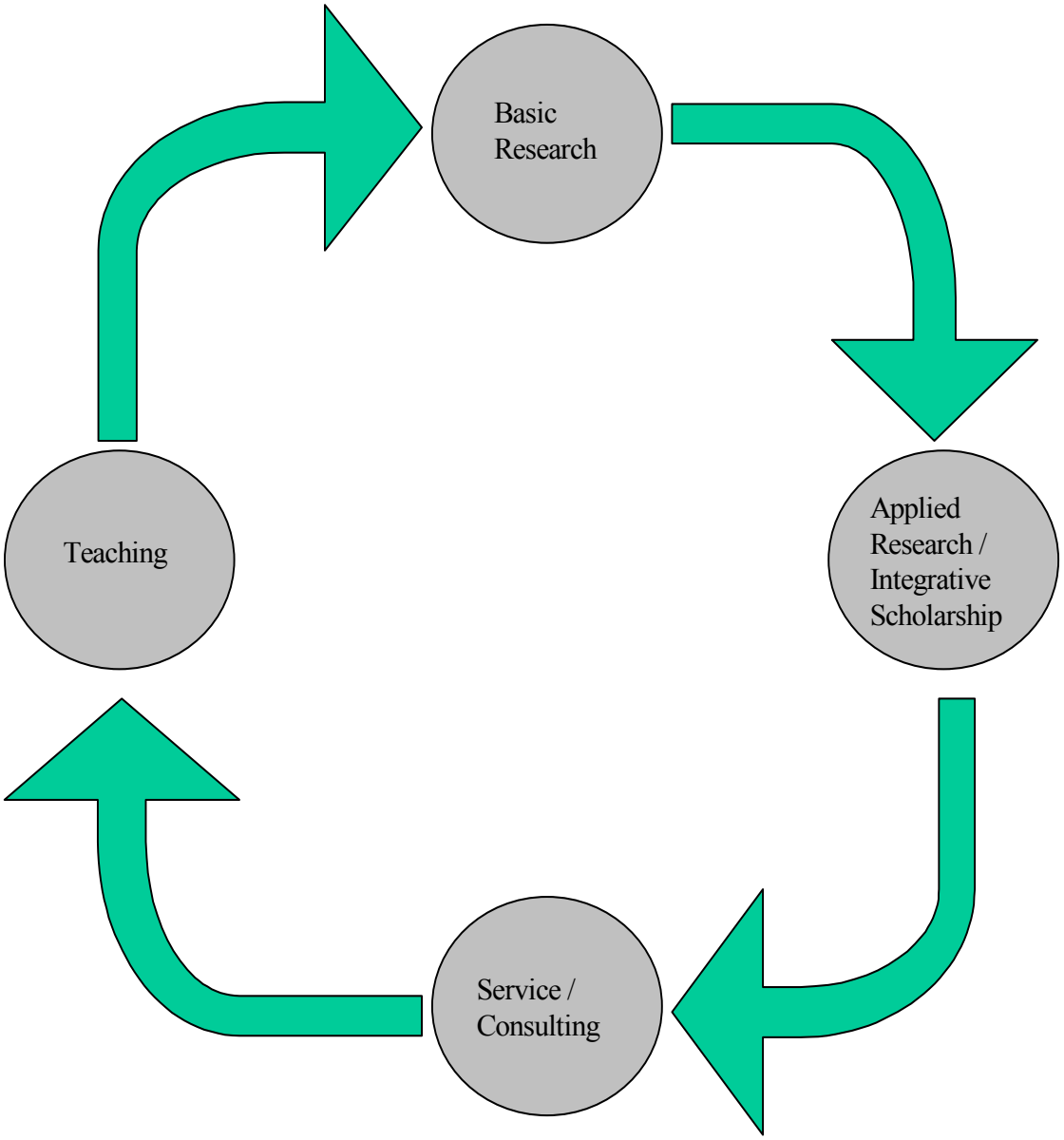


Figure 2. The Scholar-Practitioner Space

The Traditional Scholar

Traditional: Idealized view of how the Scholar engages in the four forms of scholarship to varying degrees with the highest form and the driving force being discovery in basic research

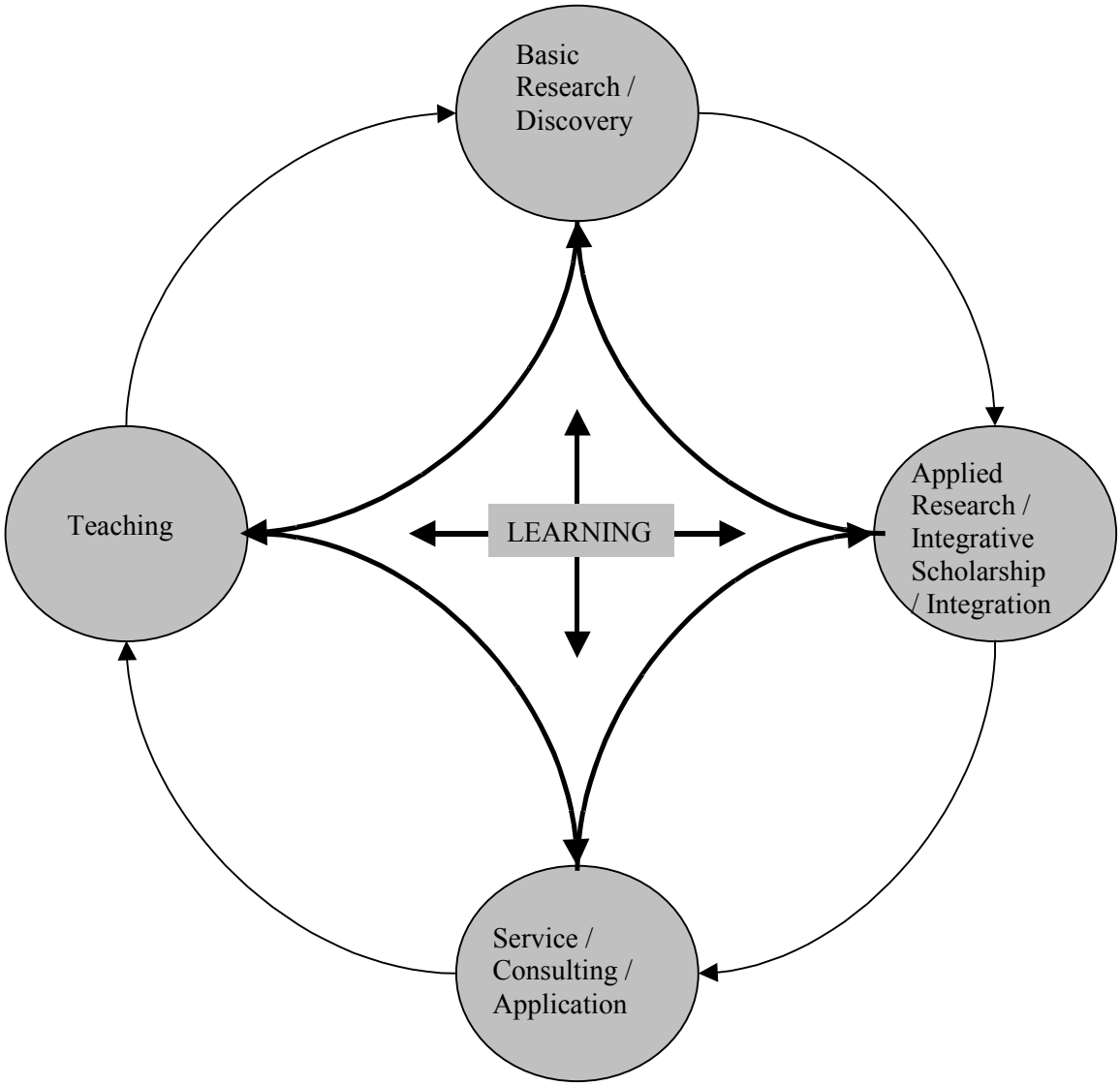


Adapted from Boyer (1990), Scholarship reconsidered: Priorities of the professoriate.

Figure 3. The Traditional Scholar.

The Scholar-Practitioner

Fielding: The Scholar-Practitioner engages in the four forms of scholarship to varying degrees and uses them to inform or provide feedback to one another to varying degrees.



Adapted from Boyer (1990), Scholarship reconsidered: Priorities of the professoriate.

Figure 4. The Scholar-Practitioner.

Form of scholarship *Continual learning process*	**Teaching**	**Discovery** (basic research)	**Integration** (applied research / multidisciplinary integration)	**Application** (consulting/service)
Self-direction (to know)	Learning about the self-directed interchange between faculty and student since students generate their own learning course.	Learning about the processes (or philosophies) underlying self-direction, especially in teaching/learning.	Learning about through integrating views of or doing applied research on self-direction process, potentially in any discipline.	Learning about application of principles, processes, practices to self-direction. Application experience brought to every aspect of education.
Exploration (to know how)	Learning about how teaching/learning works.	Learning about the processes (or philosophies) underlying knowing how.	Learning about through integrating views of or doing applied research on the exploration , potentially in any discipline.	Learning about application of principles, processes, practices to exploration.
Practice enhancing (to know what)	Learning about what teaching/learning practices work at the institution or elsewhere.	Learning about the processes (or philosophies) underlying any practice.	Learning about through integrating views of or doing applied research on practice, potentially in any practice discipline.	Learning about application of principles, processes, practices to any specific practice.
Meaning informing (to know why)	Learning about the goals, desires, etc impacting teaching/learning at the institution or elsewhere.	Learning about the processes (or philosophies) underlying meaning and its impact.	Learning about through integrating views of or doing applied research on the impact of meaning, potentially in any discipline	Learning about application of principles, processes, practices to meaning impact.
Multiply environmentally influenced (to know parameters)	Learning about the environmental influences impacting teaching/learning at the institution or elsewhere.	Learning about the processes (or philosophies) environmental influences.	Learning about through integrating views of or doing applied research on environmental influences, potentially in any discipline	Learning about application of principles, processes, practices to environmental influences.
Conscious reflective learning (to know about knowing)	Learning about what it means to teach/learn at the institution or elsewhere. Could also be where philosophies are explored.	Learning about the process of or exploring what it means to do or be engaged in basic research. Could also be where philosophies are explored.	Learning about through integrating views of or doing applied research on conscious reflective learning, potentially in any discipline	Learning about application of principles, processes, practices to conscious reflective learning.

Figure 5. An Expanded Model of Scholarship
(characterizing a large number of potential forms of scholarship).

Endnotes

[1] This is especially relevant in sciences where data collection and analyses require high speed / high bandwidth processors, networks, and combinations, such as in GRID, LambdaRail, or other advanced technology initiatives used for projects such as Laser Interferometry Gravity-Wave Observatory (LIGO), the Sloan Digital Sky Survey, the Large Hadron Collider (LHC) at the European Organisation for Nuclear Research (CERN, the European accelerator laboratory), and the National Virtual Observatory (NVO) (Brown, 2003; Colwell, 2003; Newman, Ellisman, & Orcutt, 2003).

[2] Within the IESPSEI community, there is already potential for contribution to and from the work in SoTL. The work through CHEPREO with the Florida International University College of Education to use Hestenes Modeling and QuarkNet as approaches to instruction is one example. The combination of local teachers, undergraduate students, and university faculty in these workshops to facilitate scientific discourse as well as attaining specific learning objectives serves as the foundation for an ongoing effort that can be evaluated for its progress in enhancing teaching skills, facilitating reflection on and improvement of the educational process, and contributing to the scholarly efforts of those involved. Exploration of the wide range of these efforts would undoubtedly produce many more examples.

[3] For a complete definition, discussion, and bibliography of work in SoTL, see (M T Huber & S P Morreale, 2002; Hutchings et al., 2002).

[4] For more on learner centered views see work by Knowles (1970; 1989; Knowles, Holton, & Swanson, 1998)

[5] For more on collaborative views of learning see work on learning communities in a variety of forms and settings (e.g., Hall, 2003; Hay, Hodgkinson, Peltier, & Drago, 2004; Lee & Cole, 2003; Spatig, Seelinger, Dillon, Parrott, & Conrad, 2005) and on communities of practice (Hildreth & Kimble, 2004; Wenger, 1998; Wenger & Snyder, 2000).

[6] Distance-free views of learning have been developing since the days of correspondence school; and, currently are most often called distance learning. The term distance learning; however, comes associated with considerable philosophical, political, and economic baggage. I encourage moving to the term distance-free as a way of indicating that we are talking about learning that is freed from any constraints that might have otherwise resulted because of distance between one learner and other learners or faculty.

[7] While acknowledging that many institutions are no longer completely defined by physical and temporal boundaries, it is clear that this mindset still impacts the philosophical and operational principles for many institutions, including students, faculty, and administrators.

[8] Adult learner views go back to (Lindeman, 1926); and, for more recent work, see Brookfield (Brookfield, 1984, 1991), Knowles (1970; 1989; Knowles et al., 1998), Merriam (1987; 1989; Merriam & Jones, 1983; Merriam & Yang, 1996).

[9] Transformational views of learning have been studied and promoted by Mezirow (1991) and examined by others (for example, Hicks, Berger, & Generett, 2005; Markos, 2004; Merriam, 2004; Schapiro, 2003; Whitelaw, Sears, & Campbell, 2004)

[10] In the context of work at Fielding, knowledge about and activities pertinent to the social justice mission of Fielding are often an element of this transformative process.

[11] As a postscript to the PASI, it should be noted that there were many discussions in which individuals talked explicitly about the focus on producing scholarly products particular to one discipline and the subsequent lack of time or venue for focus on intersection of the various domains.