

**A Cybernetic Systems Model of Teaching and Research Production:
Impact of Disciplinary Differences**

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A Cybernetic Systems Model of Teaching and Research Production: Impact of Disciplinary Differences

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Colleges' and universities' core teaching, research, and service goals are accomplished by their faculty members. Students' learning and development are enhanced through teaching, new knowledge is produced from research, and service contributes to the growth of communities, both outside and inside the academy. For more than one hundred years, observers in the United States (US) have debated whether faculty roles enhance each other or conflict, particularly the roles of teaching and research. An analysis of fifty articles about the link between teaching and research published between 1890 and 1938 in major American magazines found that authors (who included administrators, journalists, policy makers, and professors) of more than half the articles believed that faculty attention to research hurt teaching. Opinions expressed in the remaining articles were almost evenly divided between those who argued that teaching hampered research and those who took a middle ground (Bowman, 1938). The debate continues throughout the academy across national boundaries, as this conference attests. National and state policy makers, college and university administrators, and faculty are concerned with the best way to organize individual faculty work, departments, institutions, and entire national systems for maximum research productivity and teaching effectiveness.

Identifying "the best way" is complicated by many factors. My charge for this paper was to focus in particular on one factor: how disciplines and departments affect the relationship between teaching and research. Academics do not generally see themselves as comprising a single unified profession. Many are as likely – or more likely -- to identify themselves as members of disciplinary professions (physicists, political scientists, historians) as they are to identify themselves as staff at their employing college or university (Clark, 1983). Dramatic disciplinary differences in approaches to teaching (Neumann, Parry, & Becher, 2002) and the conduct of research (Becher, 1989) affect links between teaching and research.

Reviewing empirical research about disciplinary effects on teaching-research linkages, however, reveals that scholars conceptualize "teaching," "research," and the ways they may or may not be linked in several different ways. Some focus on the antecedents to these aspects of faculty work, including the organizational contexts that foster or inhibit linkages and individual faculty characteristics, such as dispositions, skills, and motivations, that affect their ability to engage effectively in teaching, research, or both. Other authors focus on teaching and research as processes, and either consider specific ways to infuse teaching with research, such as scholarship of teaching or inquiry-based learning, or consider the ways and the extent to which faculty already jointly produce teaching and research. Other scholars correlate measures of products, specifically student ratings of teaching effectiveness and numbers of research publications. Some have also explored evaluation of and rewards for faculty teaching and research products.

Investigating existing empirical data about disciplinary effects for each of these various ways of conceptualizing links between teaching and research led me to wonder about another set of relationships: those between the antecedents, processes, products, evaluation, and rewards for teaching and research. Better evidence is needed about these linkages in order to craft meaningful policy at national, state system, institutional, and departmental levels to foster effective processes and useful products of teaching, and research, and some combination of both.

The Production of Teaching and Research as a Cybernetic System

In this paper, I place the issue of disciplinary effects on teaching and research relationships in the context of a cybernetic systems model for producing learning and new knowledge. A cybernetic system is composed of interdependent parts, and it maintains and regulates itself by adjusting to internal flows of information and to information that flows in from the environment (Scott, 2003). Organizational theorists frequently use the metaphor of a heater-thermostat combination to explain how organizations function as cybernetic systems. Without some sort of mechanical regulator, a heater would continue to heat a room unabated. A thermostat programmed to switch off the heater once the surrounding air reaches a pre-set temperature ensures the room does not become uncomfortably hot. The interconnection of the heater and the thermostat, together with the program that dictates when the thermostat sends the signal to the heater to switch on or off, forms the inner loop of a double-loop cybernetic system. The inner feedback loop applies given decision rules allowing the system to adjust to differences in degree (Argyris, 1982). Different people, however, have differing perceptions of what is “comfortably” warm. One person wearing layers of clothes who comes into a room in which the thermostat has been set by another person who prefers to wear shorts during the winter will likely reset the thermostat to a lower temperature, especially if the bundled up person is also the one who pays the fuel bills. This outer feedback loop determines whether it is appropriate to change the rules that control the inner loop operating levels (Argyris, 1982).

I apply this double-loop learning cybernetics systems metaphor to the production of new knowledge and learning in higher education, as shown in Figure 1. The inner loop is considerably more complex than a simple heater-thermostat combination. It starts with how individual faculty members’ characteristics influence the ways they conduct teaching and research activities. Those activities result in desired outcomes of student learning and new knowledge. The desired outcomes are rarely measured, however. Instead, the easy-to-measure approximations of numbers of publications and student ratings of teacher performance are commonly accepted as equivalent to the desired outcomes. Variables such as reviewers’ and editors’ tastes intervene between what is produced in the lab or the field and publications. Similarly, variables such as students’ characteristics, taste, and effort intervene between instructor-student interactions and students’ perceptions of good teaching. Nevertheless, department heads and promotion and tenure committees primarily evaluate faculty performance based on the measured outcomes. More often than not, faculty members’ teaching and research efforts are evaluated as distinct and separate rather than as integrated. Information from evaluation feeds forward to individual faculty members in the form of rewards and recognition for their performance. Rewards, in turn, influence individual faculty motivation, and the cycle of the inner loop begins again.

This cycle of individual characteristics, activities, outcomes, evaluation, and rewards exists within and is influenced by institutional, disciplinary, and national contexts. National and state funding and other policies for higher education, competing governmental priorities, and variation in public demand for learning opportunities influence the numbers, missions, and priorities of colleges and universities. Similarly, but to varying degrees, research agendas across the disciplines are driven by public and corporate demand for economic development, public health, or aesthetic pleasure. This information from the environment feeds forward into the inner loop, affecting faculty motivation, activities, and the way their work is evaluated. The outer loop continues as aggregated evaluations of faculty work provide information to those who make policy at national, state, and institutional levels. Such data is used to inform new decisions about higher education funding and other policies, and the cycle of the outer loop begins again.

Disciplinary influences on teaching-research relationships

In this section, I review evidence from empirical research about each component of the double-loop learning model, particularly as it relates to the impact of disciplinary differences.

National context

The current national context for higher education in the United States places apparently competing pressures on public colleges and universities to do more research as well as more teaching. Funding plays a major role in driving college and university behavior. The primary sources of revenues for four-year public colleges and universities in the United States are tuition and fees, appropriations from state governments, federal funding (including grants, contracts, and appropriations) and private gifts, grants, and contracts. In recent years, the relative share of revenues from state appropriations has steadily decreased, and institutional reliance on tuition and federal funding has increased (NCES, 1997). As research expenditures grew throughout the 1980s, so also did the number and types of institutions spending money on research. More and more institutions considered “second tier” competed successfully with the largest and most highly rated universities for federal research dollars (Geiger & Feller, 1995). Leaders concerned with science in the United States from industry, the executive branch of government, Congress, and higher education groups expressed concern that this dispersion of research among ever more institutions would not only undermine the quality of new knowledge produced, but would also hurt the instructional mission (Geiger & Feller, 1995). Even within the public research university sector, research expenditures increased 141 percent while the number of faculty increased only 10 percent between 1980 and 2000. During this same time period, student enrollments at these institutions increased 11 percent (Geiger, 2004). Federal funding for research varies widely by discipline, with the life sciences reaping the major share, followed by the physical sciences, with the social sciences far behind. Humanities disciplines receive almost no federal funding for research.

Even as state appropriations for general funds (think instruction) are dropping, student demand for instruction is increasing. Enrollments soared in public institutions across the United States since 2000 as the traditional college-age population increased and a stagnating national economy sent older students back to the classroom in search of skills that might enable them to find reasonable employment (Rooney, 2002). Again, disciplinary differences emerge because demand is increasing for degrees in such fields as computer and information sciences and

communications technologies and decreasing in such fields as mathematics and engineering (NCES, 2003).

Within a national context where institutions derive substantial revenues from governments and public prestige from the research done by their faculty, state policies implemented during the 1990s that involved small-scale inducements to improve teaching or regulations directing faculty to spend more time on their teaching had varying, but overall little effect on faculty efforts to foster student learning across different types of institutions. Disciplines (such as physics, engineering, or business) able to secure external funding in the form of government grants for research or industrial contracts can afford to pay less attention to policies specifically designed to regulate or reward faculty teaching than disciplines, such as English literature, which have access to few outside resources (Colbeck, 2002).

Academic contexts

The faculty members responsible for addressing these pressures for more research and more teaching work within overlapping academic contexts of their institutions and their disciplines. Differences in institutional missions and governance may shape faculty members' opportunities to link teaching and research. Faculty behavior is less likely to be controlled by formal bureaucratic rules in research universities than in comprehensive universities (Clark, 1987). In research universities, faculty tend to be treated like professionals who set their own work agendas and participate in setting organizational direction and purpose (Finkelstein, 1984). In comprehensive universities, faculty are treated more like employees and are therefore held more accountable for expected work than research university faculty (Clark, 1987).

Disciplines vary in the degree to which there is consensus about theories, methodologies, techniques and problems to be addressed (Braxton & Hargens, 1996). In high consensus disciplines, knowledge is perceived as cumulative, and concerned with universals, quantification, and discovery (Becher, 1989). Research in high consensus disciplines is characterized by collaboration, competition for recognition and funding, clearly defined intellectual boundaries, and gate keeping of those boundaries by a powerful elite (Becher, 1989). Teaching in these fields often requires little preparation time for large lectures and labs and is designed to enhance logical reasoning (Neumann, Parry, Becher, 2002). Low consensus disciplines consider knowledge as recursive; scholars use new lenses to explore intellectual territory already mapped by others. Knowledge is also concerned with particulars, qualities and understanding (Becher, 1989). Research in low consensus disciplines is characterized by weak boundaries, independent research efforts, and tolerance for unusual ideas or methods (Becher, 1989). Teaching in low consensus fields involves curriculum open to interpretation and debate, much preparation time, small problem-based classes, and is designed to foster critical thinking, analysis, synthesis and personal growth (Neumann, Parry, & Becher, 2002).

Most faculty teaching and research occurs within academic departments, the place where institutional and disciplinary contexts intersect. Departments provide identity and community to disciplinary researchers and teachers, link disciplinary communities with college and university organizations, and conduct basic college and university administrative functions. Studies about the impact of research on student learning from the perspective of students at the department level indicates there may be a positive relationship. Students at a single university in the United Kingdom, for example, perceive more benefits than disadvantages to studying in departments that are ranked by

the Research Assessment Exercise (RAE) as performing quality research (Lindsay, Breen, & Jenkins, 2002). A study that investigated the relationship between research climate (operationalized as grant applications, grants received, percent of active researchers, and dean's rating) and teaching climate (operationalized as deans' rating, student ratings, and average student-faculty contact hours in and out of the classroom) in disciplinary departments in a single US research university found little correlation. Senior undergraduate students' self-reported learning gains were greatest, however, whose majors were in departments that rated highly on both research climate and teaching climate. In contrast, self-reported learning gains were lowest in departments that rated highly in teaching but low in research climate (Volkewin & Carbone, 1994). Neither study, however, investigated the influence of disciplinary differences on students' self-reported learning gains.

Individual characteristics

When selecting faculty, departments choose individuals whose dispositions, skills, and motivation complement and fit well with existing staff. Individual faculty members' characteristics affect their ability and willingness to be effective teachers and good researchers. Some researchers have theorized that the activities of teaching and research require similar or differing personality traits. Thus, high levels of research productivity might be associated with either high or low student ratings of faculty members as demonstrating intellectual curiosity, organization skills, self-discipline, and supportiveness in the classroom (Friedrich & Michilak, 1983). Organization skills may enhance both research and teaching performance, according to a study of faculty in a single liberal arts college (Friedrich & Michilak, 1983). In his (1987) meta-analysis of 29 studies relating teaching and research productivity, however, Feldman found little empirical research relating traits to both research and teaching, and the little available data were inconclusive. At most, he concludes that being supportive of others may be negatively associated with research productivity and positively related with student perceptions of teaching effectiveness. Some scholars have speculated that the trait of being sociable or extraverted is also likely to be positively associated with teaching effectiveness but not with research productivity (see Feldman, 1987). If such a correlation were investigated empirically, the relationship would likely vary by discipline because much research is done collaboratively in the sciences but in isolation in the humanities (Colbeck, 1998; Kyvik & Smeby, 1994).

Scholars, including Marsh (1987), who have investigated the relationship between teaching and research have also hypothesized that general ability should have positive effects on both teaching effectiveness and research productivity. A test of this hypothesis with faculty at a single Australian university found no significant relationship between self-ratings of teaching or research ability and outcomes (Marsh & Hattie, 2002).

Motivation, the energy that moves people toward the achievement of goals, is usually invoked by those investigating academic work as a variable to explain why faculty pay more attention to either research or teaching. When motivation is investigated as a predictor of faculty behavior or productivity, researchers typically analyze teaching and research separately or set the two faculty roles in opposition to each other. Surveys, for example, ask faculty to state whether their primary interest is either teaching or research. Analysis of responses to this question on national surveys between 1960 and 1988 showed that the percent of faculty who said they were more interested in research than in teaching has been steadily increasing. In response to a similar question on a 1988 survey, a higher percent of English faculty said they were more interested in

teaching than chemistry or psychology faculty (Blackburn & Lawrence, 1995). In their more complex structural equation model investigating the impact of self-reported ability, motivation, and time on research productivity and teaching effectiveness, Marsh and Hattie (2002) found that neither of their distinct constructs for research motivation and teaching motivation (defined as satisfaction and primary goal) had significant association with the outcomes measured. Their sample was too small, however, to explore disciplinary differences.

Activities

Individual faculty bring their dispositions, skills, and motivation to their conduct of their work roles. Many scholars and administrators consider teaching and research as separate and often competing activities. Others have investigated the extent to which faculty simultaneously accomplish teaching and research goals. Reformers also advocate for linking teaching and research by doing research about one's own teaching or by teaching students by engaging them in research.

Most analyses of the relationship between teaching and research that consider time use depend on self-reported estimates. The National Survey of Postsecondary Faculty in the US in 1998 found that on average across all types of institutions, humanities faculty spent a greater percentage of their time on teaching than social sciences and natural sciences faculty (81.9, 71.6, and 62.4 %, respectively). In contrast, natural science faculty spent more time on research than social sciences and humanities faculty (26.9, 12.5, and 3.5 %, respectively) (NCES, 2001). At least two problems plague such time reports. First, investigators who have compared individuals' time diaries to their self-reports of time allocation find that people tend to overestimate the time it takes to do some activities and underestimate time spend on others (Juster & Stafford, 1991). Second, because such reporting forms define work roles as mutually exclusive, faculty are unable to report the amount of time their activities fulfill teaching and research goals at the same time (Romney, 1971; Yucker, 1984). In interviews, however, faculty describe various links between their teaching and research. In a study of faculty opinions about the mutual influence of research and teaching at Norwegian universities, 67 percent of humanities faculty, 59 percent of social scientists, and 47 percent of natural scientists felt their research had a meaningful impact on their teaching at the undergraduate level. Similarly, humanists (45%) and social scientists (42%) were also more likely than natural scientists (26%) to say that their undergraduate teaching had positive impact on their research. Across all three fields, almost 90 percent or more faculty said there were positive associations between their research and teaching of students at the Ph.D. level (Smeby, 1998). Nevertheless, faculty self-reports of time to teaching and research as separate activities have been used to show that research productivity is positively influenced by increased time spent on research and decreased time spend on teaching (Feldman, 1987; Hattie & Marsh, 1996).

A contrasting line of research involves a few studies that investigate the percent of time faculty accomplish teaching and research goals at the same time. A faculty work analysis conducted at the University of California asked faculty to estimate the proportion of time each work activity contributed to any one or more institutional "outputs" or goals. Results showed that, on average, faculty work activities contributed to more than one institutional objective nearly 40 percent of the time (University of California, 1970). The dean of liberal arts at Arizona State University recently implemented a workload system, asking faculty to report time

spent on activities that integrated teaching and research, research and service, and service and teaching, in addition to time spent on activities that exclusively served teaching, research, or service goals. Humanities, social science, and science faculty respondents to a pilot workload survey reported that they integrated teaching and research 12.9, 16.8 and 18.0 percent of the time, respectively (Krahenbuhl, 1998).

I documented similar overlaps between faculty work roles when I conducted structured observations of twelve physicists' and English professors' work activities at two universities; one research and one masters level (Colbeck, 1998). By observing faculty actually at work over more than 1000 hours, I documented many periods when faculty engaged in integrated activities that fulfilled more than one goal. The English faculty integrated research and teaching, on average, 19.8 percent of their work time at the masters level university and 13.5 percent of the time at the research university. The physicists integrated teaching and research 18.7 and 22.5 percent of the time at the masters level and research universities, respectively. An example of teaching and research integration occurred when an English professor read and analyzed a novel for class discussion, knowing that he was scheduled to present a conference paper about the novel's author in two months. A week later, the professor used his class notes when drafting his conference presentation. A physicist integrated teaching and research when he explored the next steps on a research project with undergraduate and graduate student members of his research team over lunch at the student union.

I have just completed another observational study of nearly 650 hours of faculty work at two different research universities involving thirteen English and chemistry faculty, most of whom were assistant or associate professors, and seven of whom were women. Participants in my 1998 study were all male full professors. Table 1 shows that, on average, this second group of faculty engaged in activities that simultaneously accomplished teaching and research goals 15.5 percent of their work time. The average for English literature is quite low because two of the six English literature faculty integrated teaching and research less than one percent of the time they were observed for the study. Interviews revealed that such fragmentation of roles was typical for one faculty member, but not for the other.

Table 1: Average Percent of Work Time Faculty Integrated Research with Teaching by Discipline

Research Integrated with:	Chemistry	Literature	All in sample
RESEARCH TRAINING	15.7	1.5	10.2
With Graduate Students	11.1	1.2	6.5
With Undergraduate Students	3.4	0.3	2.9
With both Graduate and UG	1.3	0	0.8
CLASSROOM TEACHING	5.2	4.8	5.3
With Graduate Students	5.1	0.6	3.6
With Undergraduate Students	0.1	4.2	1.7
TOTAL RESEARCH/ TEACHING INTEGRATION	20.9	6.3	15.5

Percent of integration varied by discipline according to whether the faculty member was preparing for or actually teaching in the classroom or whether the teaching involved training students to conduct research. Chemists spent much more time training students in the process of conducting their own research than did English literature faculty. Similarly, the percent of integration varied by the level of student taught. Chemists integrated research with classroom teaching more for their graduate classes while English literature faculty integrated research more with their undergraduate classroom teaching. The results of the observations of US faculty are similar to what Smeby (1996) learned from Norwegian faculty from interviews and surveys. He found that more teachers in natural sciences, medicine and technology than social sciences or humanities say that research supervision was integrated with their own research and that humanists are more likely than natural scientists to turn a lecture into a publication.

The scholarship of teaching is a specific way of linking teaching and research, and is variously known as action research, or teaching as research. It was identified as one of four valid arenas of scholarship by Boyer (1990); the three other scholarships are discovery, application, and integration. Since 1990, many have tried to specify exactly what the scholarship of teaching might be. One such attempt by Hutchings and Shulman (1999) describes four interrelated components: a public account of teaching that involves inquiry about student learning in a manner subject to peer review and amenable to adoption or adaptation by others. Similarly, a new national Center for the Integration of Research, Teaching, and Learning (CIRTL) considers “teaching-as-research” as one of its three pillars for improving undergraduate education in the sciences, technology, engineering, and mathematics in the US. Teaching-as-Research, according to the CIRTL website (2003), “involves the deliberate, systematic, and reflective use of research methods to develop and implement teaching practices that advance the learning experiences and learning outcomes of students and teachers.” CIRTL efforts are just now getting underway, so there is as yet no research evidence about the time involved in actually doing teaching-as-research, nor about its impact on desired outcomes. There are hundreds of articles about scholarship of teaching, but most of them are accounts of how individual instructors benefited from engaging in meaningful inquiry about their students’ learning. Here again, systematic analysis across institutions and disciplines is needed about the time costs and learning benefits. Healy (2002) argues that multiple discipline-specific scholarships of teaching must be developed to gain credibility and status for the endeavor and to ensure that the complementarity between teaching and research is appropriate for each knowledge domain.

Another mode of linking teaching and research for the purpose of improving classroom teaching is variously known as inquiry-based teaching, case-based teaching, or problem-based learning. As described by Jenkins, Breen and Lindsay (2003), this approach focuses on motivating students by helping them learn “about and through research” in the classroom (p. 56). Neumann (1994) also describes a tangible connection between teaching and research that borders on inquiry-based teaching when it involves teaching students useful techniques derived from the instructor’s own research as well as class assignments that emulated research activity. Inquiry-based teaching is necessarily grounded in the disciplines, as instructors teach the principles, methods, and recent findings in their fields and students have opportunities to actually conduct research. This approach was implemented in several medical schools across North America in the 1980s and 1990s as problem-based learning (PBL), and has been implemented in undergraduate curricula as well.

Desired outcomes: New knowledge and student learning

In the best of all possible worlds, time spent on research would yield important and ultimately useful new knowledge, and time spent on teaching would result in students' learning and development. Integration or synergy between research and teaching should also enhance the quality of the new knowledge, student learning, or both. Furthermore, the teaching-research link should be time efficient and cost effective. The line around the box for "Desired Outcomes" in Figure 1 is dotted because there is not yet sufficient empirical evidence of actual research quality or student learning, of how teaching-research linkages affect these desired outcomes, or of the time cost involved.

An initial challenge for research in this area will involve finding new ways to assess the quality of the knowledge produced, or the incremental learning achieved solely as a result of a specific classroom or out-of-classroom experience. A second challenge will involve demonstrating empirically any marginal improvement of new knowledge or learning produced as a result of cross-fertilization between teaching and research. The third challenge will be comparing the costs and benefits of any improvements in research quality or learning derived from linking teaching and research with processes that keep accomplishment of the two activities separate.

Although counts of publications are typically used as evidence of research quality, sheer numbers are not necessarily a good foundation for that judgment. Across disciplines, norms vary for the length, frequency, nature and co-authoring of publications (Becher, 1989). In the sciences, publication is frequent, articles are short, and collaboration abounds. In the humanities, scholars produce fewer, longer publications, and seldom collaborate. Norms in the social sciences range from natural science to humanities publishing patterns. Some research about publication across the disciplines attempts to compensate by weighting publications by length or numbers of authors, but weighting systems also vary widely. Some researchers deliberately chunk their findings into the "least publishable units" to increase their numbers of publications; they know that simple numbers mean more than quality for attaining rewards and recognition (Owen, 2004). Except for faculty testimony in interviews (Colbeck, 1998; Robertson & Bond, 2001; Smeby, 1996), there is as yet no empirical evidence showing how, if at all, the quality of research may be enhanced or diminished by linkages with teaching.

Assessing student learning is also problematic within, as well as across, disciplines. Within disciplines, students may be gaining in content knowledge, skill development, abilities to apply or integrate knowledge, and as well as developing attitudes about future learning (Colbeck, et al., 2001). Net learning gains in any of these domains, except occasionally content knowledge, are seldom systematically assessed beyond the individual course. Furthermore, disciplinary fields differ in the domains of learning emphasized (Lattuca & Stark, 1994). Of the various ways that research and teaching may be linked, problem-based learning (PBL) is the only one for which there is systematic empirical evidence of student learning gains. Meta-analyses of the effects of PBL on medical students' learning found that PBL students gained less content knowledge (although they remember what they have learned longer), but gain more in skills and perform more effectively on clinical examinations than students receiving traditional lecture-style instruction (Albanese & Mitchell, 1993; Dochy, Segers, Van den Bossche & Gijbels, 2003).

Interviews with students in computer engineering, psychology, and physiotherapy reveal there are disciplinary differences in the ways students make sense of knowledge and learning in PBL learning environments (Dahlgren, 2003).

Intervening variables

Several variables intervene between teaching and research as activities, achievement of their desired outcomes, and the measures most frequently used as proxies for research quality and student learning: numbers of relevant outlets for publication, taste of reviewers, and student characteristics.

Disciplines and subdisciplines vary in the number of journals and other outlets for academic publication, resulting in varying levels of opportunity for publishing research results. Braxton and Del Favero (2001) used the four types of scholarship defined by Boyer (1990) to compare the relative impact (as determined by frequency of citation) of articles published in various types of journals across several disciplines. They found that articles focusing on scholarship of discovery in hard science discipline journals had far higher impact scores than similar articles in humanities and social science journals. Articles focusing on the scholarship of teaching were also cited more frequently in hard science education journals (such as *Journal of Chemical Education* and *Academic Medicine*) than articles in journals about teaching in the social sciences and humanities (such as *Teaching Sociology* and *Communication Education*). Regardless of discipline, however, the impact score for journals focusing on the scholarship of teaching was far lower than for those focusing on the scholarship of discovery.

Whether attempting to publish findings from scholarships of discovery, integration, application, or teaching, authors must also satisfy the taste of reviewers and editors. Peer review is not a fail-safe guarantee that only the highest quality research gets published. As Kaufer and Geisler assert, academic writing, is “less an agent of intellectual change than a vehicle for maintaining social stability in the face of change” (1989, p. 289). Not only may innovative ideas be rejected, those who would be published learn to tailor their research to fit current disciplinary norms and expectations. A former editor of a higher education journal noted that “there are definitional values reflected in the review process that are in addition to the more specific observations of a manuscript’s qualities. These broader meanings are not lost upon authors” (Silverman, 1993, p. 510).

Students’ ratings of faculty members’ performance in the classroom provide the data most often used to assess teaching effectiveness. Student ratings of instructors’ overall teacher effectiveness varies by discipline; students rate instructors in the humanities and fine arts more highly than instructors in the sciences, math, and engineering (Feldman, 1978; Cashin, 1990). Furthermore, ratings of teachers vary by course characteristics such as class size and course level, by instructor characteristics such as rank and gender, and by student characteristics such as gender and whether the student is taking the course as an elective or a requirement. The pattern of relationships between these characteristics and teacher ratings also varies from discipline to discipline (Franklin & Theall, 1995). Thus, students’ characteristics and taste intervene between faculty members’ teaching efforts, students’ actual learning, and the ratings they assign to their teachers.

Measured outcomes

As previously mentioned, investigators who have attempted to determine whether there is some measurable correlation between teaching and research quality typically measure teaching effectiveness by student ratings of formal classroom instruction and research productivity by numbers of publications. Most of these studies were conducted at one or only a few institutions and included relatively small (less than 300) samples of faculty. To attain more comprehensive results applicable to more faculty, two meta-analytic studies synthesized the results of multiple studies. In 1987, Kenneth Feldman analyzed the combined results of twenty-nine studies of the relationship between teaching effectiveness and research productivity, and found a very small (0.12) positive correlation. A meta-analysis conducted by John Hattie and H. W. Marsh in 1996 analyzed the combined results of fifty-eight studies, and found an even smaller (.06) positive correlation between teaching effectiveness and research productivity. Both Feldman and Hattie and Marsh found that the relationship was greater for social sciences than for the natural sciences where there was no relationship, positive or negative. Feldman, however, found a slightly more positive relationship between teaching effectiveness and research productivity in the humanities than did Hattie and Marsh.

Faculty evaluation

The outcome measures of research productivity and teaching effectiveness described above are also used for evaluating faculty for annual raises and for promotion and tenure. Faculty members' perceptions of how their institutions define and evaluate roles affect the ways they do their work. In one study, those faculty who perceived that teaching evaluations had especially strong influence on their rewards spent more time on teaching than their colleagues. Similarly, faculty who perceived that evaluations of research had stronger influence on their rewards than evaluation of teaching spent more time than their colleagues on research (Dornbusch, 1979). In contrast, Huber (2001) documented the cases of junior faculty in literature, engineering, and chemistry who built their tenure dossiers around their integration of teaching and research. Theirs were "edgy cases," but they did attain tenure, signaling hope for faculty who follow.

It is likely that the more institutional evaluations and rewards separate faculty activities and products into mutually exclusive categories, the less faculty will enrich their teaching with their research, or inform their research with lessons learned from engaging with students. On the other hand, joint production of teaching, research and service can be documented in integrated workload reports (Colbeck, 2001; Krahenbuhl, 1998). Figure 2 illustrates a form that might be used to cross reference faculty teaching, research, and service activities with the institutional goals addressed by those activities.

Faculty rewards

Organizational context may contribute to competition between teaching and research when evaluation and reward policies systematically fragment the two roles. Using data from a 1988 national survey of postsecondary faculty, Fairweather (1996) found that faculty at all types of four-year institutions in the US were rewarded more for their numbers of publications than for the amount of their teaching. According to Fairweather, "faculty rewards emphasize the discreteness, not the mutuality, of teaching and research" (1996, p. 110). Natural science

faculty, who experience greater pressures – and greater rewards – for securing external funding for their research activities than humanities faculty, also report spending less time on teaching than their colleagues in the humanities. Social science faculty are, on average, in between the two extremes in terms of securing external funding and teaching time. The inner loop of the cybernetic system model closes and the cycle begins again as rewards affect faculty motivation to spend time and effort on research, perhaps at the expense of teaching.

Feed Forward to National Context

Data about time allocation and measured teaching productivity and teaching effectiveness outcomes also feed forward in the cybernetic system's outer loop to national and state higher education policy makers. One recent example of how policy makers use such information to attempt to adjust rules used to control the inner loop was provided by the state of Ohio. The Ohio legislature passed a bill in 1993 requiring public college and university faculty to increase the time they spent teaching by ten percent. Ohio lawmakers' concerns about faculty workload stemmed from two issues: large deficits in the state budget and the growing public perception that state universities were neglecting undergraduate education. The second concern appeared substantiated by faculty workload data. A comparison of aggregate 1990 and 1980 faculty workload data showed that the time faculty reported they spent on teaching had declined by ten percent in ten years. The workload mandate was designed to restore these apparent reductions (Colbeck, 2002). This policy assumed fragmentation of and competition between teaching and research.

In contrast to the state of Ohio, the National Science Foundation offers an example of providing incentives to encourage faculty and their employing institutions to consider fostering stronger links between teaching and research. In addition to demonstrating intellectual merit, for the past few years, proposals submitted to the National Science Foundation (NSF) must also demonstrate the "broader impact" of the proposed activity (NSF, 2002). The first of five broader impact criteria is "How well does the activity advance discovery and understanding while promoting teaching, training, and learning?" As a consequence, principal investigators are scrambling to find ways to show reviewers how their proposed research will advance teaching and learning. In addition, NSF is funding two postsecondary Centers for Teaching and Learning that associate research with education in the sciences, technology, engineering, and math. The mission of one of those centers, the Center for Integration of Research, Teaching and Learning (CIRTL) has as its mission the development of "a national faculty in the sciences, technology, engineering, and mathematics that include implementing and advancing effective teaching practices for diverse student audiences as part of their professional careers." These and other policies, such as incentives for faculty who include undergraduates as members of their research teams, encourage teaching and research integration for faculty in the science and social science disciplines that are the target of NSF funding.

Conclusions

Analyzing the production of teaching and research in the context of a cybernetic systems model highlights areas where more research is needed to inform policy making at national, state, institutional, and departmental levels about faculty work. Although many faculty say that their work "merges in a seamless blend" (Clark, 1987), data collection, evaluation, and reward

procedures and policies actually promote fragmentation of teaching and research and reinforce the perception that faculty must make choices continually between competing priorities. Exploratory research with small samples, however, shows that faculty members already engage in activities that simultaneously accomplish teaching and research between 15 and 20 percent of their time, on average. The amount of integrated time varies by the type of teaching (classroom-related or research training) and by discipline. Systematic and widespread evaluation of faculty work as an integrated whole is needed to determine how much the process of faculty work is actually integrated across all types of institutions and disciplines.

Additional key questions that should be addressed to inform policy making about faculty work include:

- Under what conditions does integration (joint production) of teaching and research enhance the quality of new knowledge produced by faculty?
- Under what conditions does integration of teaching and research improve student learning in terms of gains in content knowledge, skills, application and integration of knowledge, or attitudes toward future learning?
- To what extent is integration of teaching and research associated with increases in publications or student ratings of instruction?
- How does faculty engagement in the scholarship of teaching (also known as teaching as research) affect student learning in terms of gains in content knowledge, skills, application and integration of knowledge, or attitudes toward future learning?
- How does faculty engagement in the scholarship of teaching affect faculty members' approach to the development of new knowledge?
- How does faculty engagement in the scholarship of teaching affect overall faculty allocation of time?
- To what extent is engagement in scholarship of teaching associated with increases in publications or student ratings of instruction?
- How does faculty engagement in inquiry-based teaching (also known as problem-based learning) affect student learning in terms of gains in content knowledge, skills, application and integration of knowledge, or attitudes toward future learning?
- How does faculty engagement in inquiry-based teaching affect faculty members' approach to the development of new knowledge?
- How does faculty engagement in inquiry-based teaching affect overall faculty allocation of time?
- To what extent is inquiry-based teaching associated with increases in publications or student ratings of instruction?
- How does evaluation of faculty work as an integrated whole affect the ways and the extent to which faculty link teaching and research?
- To what extent does variation in discipline or institutional type affect all of the above?

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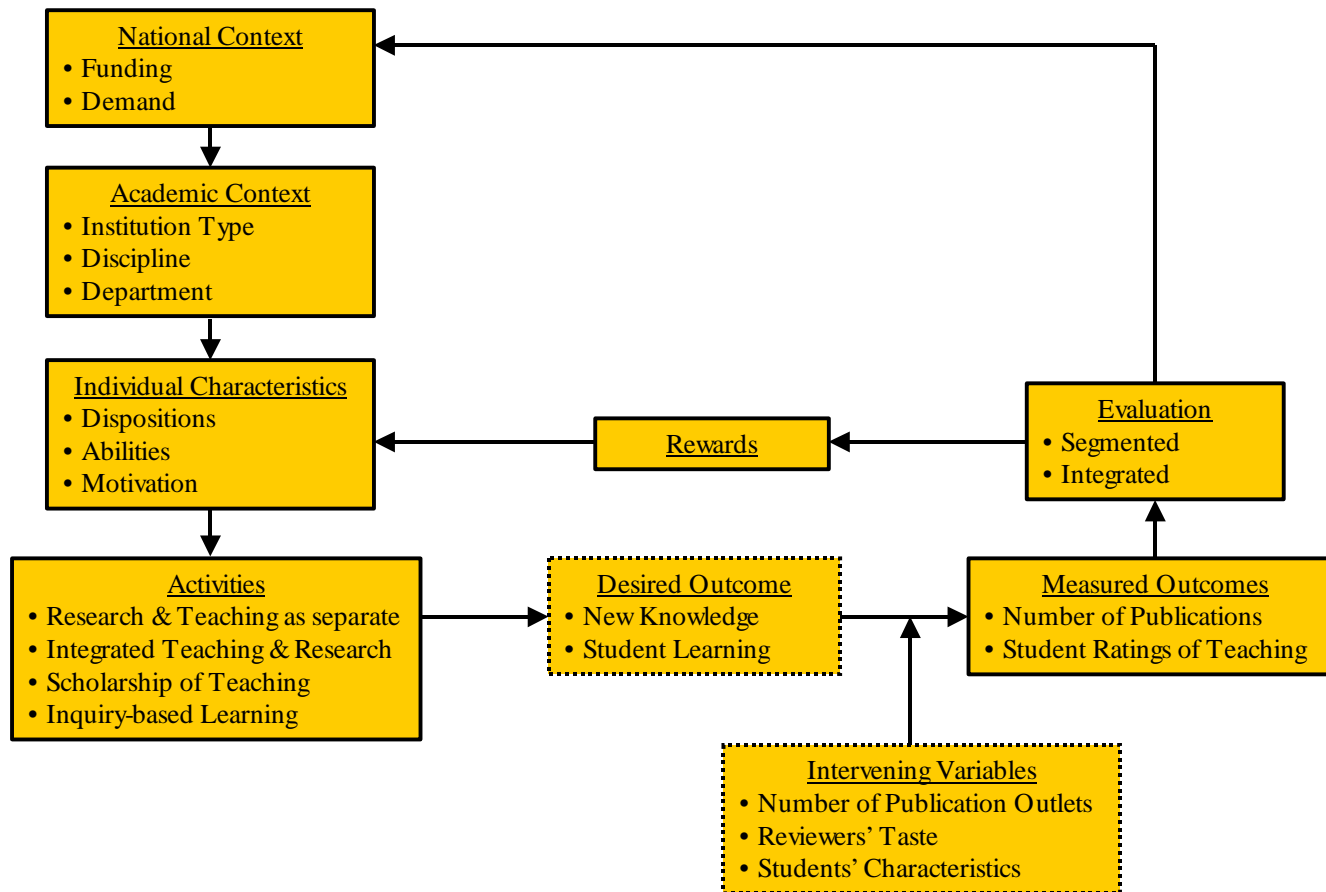


Figure 1. Forces Affecting Links Between Teaching and Research: A Double Loop Learning Model

Figure 2: Workload Report Form that Cross-references Faculty Activities with All Relevant Institutional Goals

FACULTY WORKLOAD REPORT		
ACTIVITIES	HOURS/ WEEK	INSTITUTIONAL GOALS
<u><i>TEACHING</i></u>		% of time spent on teaching activities that also: ___ advanced development of new knowledge/arts ___ contributed to growth of university, professional, or non-academic community
Classroom instruction		
Preparation		
Grading		
Individual instruction		
Course development		
Meetings / memos		
TEACHING ACTIVITY TOTAL		
<u><i>RESEARCH</i></u>		% of time spent on research activities that also: ___ enhanced registered students' development ___ contributed to growth of university, professional, or non-academic community
Inquiry		
Scholarly development		
Logistics/grant work		
Writing/presenting		
RESEARCH ACTIVITY TOTAL		
<u><i>SERVICE</i></u>		% of time spent on service activities that also: ___ enhanced registered students' development ___ advanced development of new knowledge/arts
Administrative service		
Professional service		
Community service		
SERVICE ACTIVITY TOTAL		
<i>TOTAL HOURS/WEEK</i>		

Source: Colbeck, 2001