DOCUMENT RESUME

ED 476 058 RC 023 793

AUTHOR	Harmon, Hobart L.
TITLE	Interdisciplinary Research for Teaching and Learning Mathematics in Rural Schools: Considerations for Creating a Mathematics and Vocational Education Research Agenda. Working Paper.
INSTITUTION	Ohio Univ., Athens. Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics.
SPONS AGENCY	National Science Foundation, Arlington, VA.
REPORT NO	WP-9
PUB DATE	2003-03-00
NOTE	37p.; Paper presented at the ACCLAIM Research Symposium (McArthur, OH, November 3-6, 2002).
CONTRACT	NSF-0119679
AVAILABLE FROM	For full text: http://kant.citl.ohiou.edu/ACCLAIM/ rc/rc_sub/pub/3_wp/Harmon9.pdf.
PUB TYPE	Opinion Papers (120) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC02 Plus Postage.
DESCRIPTORS	*Educational Research; Higher Education; *Interdisciplinary Approach; *Mathematics Education; *Research Methodology; Rural Education; *Vocational Education
IDENTIFIERS	*Research Trends

ABSTRACT

This paper provides a foundation for researchers in mathematics education and vocational education (now commonly called career and technical education) to begin exploring an interdisciplinary research agenda that will create new knowledge and innovations for living and working in rural areas in the 21st century. The need for interdisciplinary research is discussed, followed by definitions of interdisciplinarity. Lattuca's typology of interdisciplinary scholarship is presented, in which the nature of interdisciplinarity in teaching or research is defined by the type of question motivating it. The evolution of research methods in mathematics education over the past 25 years is outlined, moving from strictly quantitative methods to qualitative studies and multiple perspectives focused on students' learning processes. Trends in vocational education research would also seem to accommodate the conduct and characteristics of interdisciplinary research. Integration of disciplines may not be the defining characteristic of effective interdisciplinary research. Questions that transcend disciplines or that have no compelling disciplinary basis characterize true interdisciplinary research. Interdisciplinary research faces barriers based in traditional academic structures. Yet, various types of institutional support exist for conducting interdisciplinary research. Moreover, entities outside academia, including funding organizations and businesses, are increasingly influencing the research agenda. Five considerations are outlined for creating an interdisciplinary research agenda that links rural mathematics education and vocational education in meaningful ways. (Contains 32 references) (TD)

Appalachian Collaborative Center for Learning, Assessment and Instruction in Mathematics

Working Paper Series

Interdisciplinary Research for Teaching and Learning Mathematics in Rural Schools: Considerations for Creating a Mathematics and Vocational Education Research Agenda

Working Paper No. 9

Hobart L. Harmon
Education Consultant
March 2003

ACCLAIM's mission is the cultivation of *indigenous leadership capacity* for the improvement of school mathematics in rural places. The project aims to (1) understand the rural context as it pertains to learning and teaching mathematics, (2) articulate in scholarly works, including empirical research, the meaning and utility of that learning and teaching among, for, and by rural people, and (3) improve the professional development of mathematics teachers and leaders in and for rural communities.

ACCLAIM

ACCLAIM Research Initiative
All rights reserved

Address: 210A McCracken Hall
Ohio University
Athens, OH 45701-2979

Office: 740-593-9869
Fax: 740-593-0477

E-mail: howleyc@ohio.edu
Web: http://acclaim.coe.ohiou.edu/

Funded by the National Science Foundation as a Center for Learning and Teaching, ACCLAIM is a partnership of the University of Tennessee (Knoxville), University of Kentucky (Lexington), Kentucky Science and Technology Corporation (Lexington). Marshall University (Huntington, WV), University of Louisville, and Ohio University (Athens, OH).

This material is based upon the work supported by the National Science Foundation Under Grant No. 0119679. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Interdisciplinary Research for Teaching and Learning Mathematics in Rural Schools: Considerations for Creating a Mathematics and Vocational Education Research Agenda

By

Hobart L. Harmon, Ph.D.
Education Consultant
3699 Richardson Road
Timberville, VA
E-mail: hharmon@shentel.net

Paper presented at the
ACCLAIM Research Symposium
Ravenwood Castle, McArthur, Ohio

November 3-6, 2002

Interdisciplinary Research for Teaching and Learning Mathematics
in Rural Schools: Considerations for Creating
a Mathematics and Vocational Education Research Agenda

Introduction

As a former executive assistant to a state superintendent of schools and a vice-chair of a state rural development council, I found few solutions to most problems were possible if a disciplinary lens guided one's thinking. In fact, discipline-oriented "turf" issues consumed enormous amounts of energy when seeking to build partnerships that could best serve rural schools and their communities.

For example, historically vocational education has been important to preparing citizens in rural areas for a lifetime of work in predominantly blue-collar occupations. Academics were usually associated with those few students in public schools that anticipated a career in some profession, usually outside the rural community. Today, however, rural communities are becoming less dependent on natural resource-based economies. Preparing for life's work requires higher levels of achievement in core academic skills such as mathematics, especially if students desire preparation for technician-level (previously "vocational") skills.

To say simply that all students need "advanced" academic skills (and a bachelor's degree) fails to recognize how most rural citizens can prepare to successfully live and work in a rural place – an individual choice most any public school in rural America would profess to value. Rather, we might do better to say that virtually all who would remain in rural communities today and seek to participate in the local economy must obtain additional education beyond high school, but less than a baccalaureate degree, while leaving the doors formal education open to those who, once in the workplace, aspire to professional positions and careers.

Since the mid-1980s school improvement advocates of varying points of view have shared a support for integrating vocational and academic education in public schools. Both "camps" (i.e., vocational and academic educators) have sought to work together in Tech Prep, School-to-Work and other education reform initiatives. Even Rural Systemic Initiatives, sponsored by the National Science Foundation, in which this author has been significantly involved for several years, advocate their intent to enhance the workplace competitiveness of rural youth. "Vocational" and "academic" disciplines are important, yet their greatest potential for most rural communities lies in their unique interdisciplinary value for preparing citizens to live and work in a rural area.

Researchers have an opportunity and obligation to foster changes in educational practices based on empirical evidence. This paper provides a foundation for researchers in mathematics education and vocational education (now commonly called career and technical education) to begin exploring an interdisciplinary research agenda that will create new knowledge and innovations for living and working in rural areas as we enter the 21st Century.

Why an Interdisciplinary Research Approach

We now live in a world guided by knowledge production and innovation. As a society, America hopes to remain atop the heap of developed nations by exploiting knowledge and technology gains. This national aspiration likely will not only bring tremendous change in the expected work life of rural Americans (such as, in the elimination of blue collar "manual" labor), it also promises to redirect the role and practice of research in academia.

Those who would effectively exploit knowledge to solve problems need to take part in generating that knowledge. Discovery and application thus become more closely integrated. In a dynamic and socially distributed system with feedback loops, markets set new problems more or less continuously. For example, Rheinberger (1995) predicts boundaries of basic research and medical applications will be inverted. The opportunistic ideology of medical application and goals-directed research will produce keys for attacking fundamental problems in other areas, such as developmental biology, protein folding and function, and the brain (Gibbons, 1994).

Metaphors of knowledge shift in turn. Gibbons et al. (as cited in Weingart & Stehr, 2000) suggest organizations that carry projects at the forefront of science, technology, and high-value enterprises act like a spider web:

> Connections are spun continuously, with growing density and connectivity. Problems in genetics, electronics, mathematics, and physics possess an intrinsic intellectual interest nourished by the research and practical interests of other users. Older terms—applied science, technological or industrial research, technology transfer, strategic research, mission-oriented research, research and development—are no longer adequate. In the linear model, science led to technology and technology satisfied market needs. In many advanced sectors of science and technology today, however, knowledge is being generated *in* the context of application. New social contracts between industry and academe make 'interchange' a more appropriate word than 'transfer.' A greater number of scientists, moreover, are working on problems outside traditional specialists and entering into new social arrangements. (pp. 14-15)

Definitions of a "good" scientist and science become more pluralistic. Problem solvers, problem identifiers, and strategic brokers are working with knowledge resources held in government laboratories, consultancies, and other businesses. Skilled "boundary riders" must "beat the boundaries" in order to relocate science into productive and localized forms. Weingart and Stehr (2000) maintain "management in higher education are beginning to operate in a parallel mode" (p.15).

Advances in high technology and international competition are creating new descriptors of knowledge, such as "collaboration," "competitiveness," "problem solving," "systems," "complexity," "and "interdisciplinary." Problem complexity, economic competition, costs of instrumentation and facilities, the desire to transfer knowledge rapidly to application, and the interchange of applied and basic research are increasing the legitimacy of hybrid organizations and modes of knowledge production (Weingart & Stehr, 2000, p.15).

As these new commercial strategies and the structures they create intersect with traditional university departments, they foster changes in organizational values, structure, and culture. Scientific debate and discourse is no longer limited to scientists; increasingly it enters the public political discourse and popular discourse (Stehr and Ericson, 1992, p. 196). The need to address complex problems now requires governments to make decisions that, in time, will bring greater control of science way from scientific institutions and into the hands of non-scientists. Elzinga (1985) coined the term "epistemic drift" to describe this sort of shift from a world in which institutions have autonomy to exercise control over themselves and their reputations to one in which institutions are governed by external regulation.. Finally, as interdisciplinary work becomes the norm, the likelihood it will involve at least one party who does not work at a university also increases (Fuller, 1995, p. 204).

Defining Interdisciplinary Research

Bechtel (1986, p. 43-44) defines interdisciplinarity – the conscious crossing of disciplinary boundaries in the pursuit of knowledge as an "ongoing process for discovery," not an attempt to systematize what is already known. The real benefit, Salter and Hearn (1996) contend, is not necessarily in subject matter or new journals and publications. Interdisciplinarity is a set of dynamic forces for rejuvenation and regeneration, pressures for change, and the capacity for responsiveness. It is the necessary "churn" in the system. Interdisciplinarity entails knowledge negotiation and new meanings, not one more stage in "normal" science.

There is a danger, though, in perceiving interdisciplinarity and innovation as isolated events at the single moment of their inception. "They [i.e., interdisciplinarity and innovation] continue throughout the circulation, diffusion, elaboration, revision, codification, and appropriation of new ideas, and their incorporation into intellectual and social life. Social practices and their material bases generate openings for ideas that lead to development of newer practices that help, in turn, to institutionalize new ideas" (Goldman, 1995, p. 212).

In the last quarter of the twentieth century, scholars could take for granted the role of academic disciplines in college and university life. Most did not think about how disciplines influenced the daily work life of college and university faculty and shaped their views of how knowledge is created and advanced. Academic departments that followed disciplinary lines provided a seemingly logical arrangement of scholarly activity. Disciplinary associations served to connect scholars to one another and to advance their given disciplines. Over time, however, it became clear that departments and disciplines had some drawbacks.

Disciplines are powerful, but they constrain ways of knowing. As conceptual frames they delimit the range of research questions that are asked, the kinds of methods that are used to investigate the phenomena, and the types of answers that are considered legitimate (Becher, 1989; Kuhn, 1970, 1977). Research generally supports this conceptualization, demonstrating close ties among the attitudes, cognitive styles, and behaviors of groups of faculty within disciplines – as well as the character of the knowledge domains in which faculty work (Becher, 1989; Biglan, 1973a, 1973b; Donald, 1983, 1990; Jacobson, 1981; Lodhl and Gordon, 1972; Price, 1970; Shinn, 1982). The exponential growth of knowledge in the twentieth century revealed how disciplinary cultures and perspectives could discourage inquiries and explanations that extended beyond disciplinary boundaries.

As disciplines grow, they also become more complex. Today many disciplines are comprised of small communities of scholars who coalesce around shared interests, methods of inquiry, or both. *Many* faculty within particular disciplines no longer share similar areas of interest, methods, or even epistemological perspectives (Becher, 1987). In 2002, members of the American Educational Research Association (AERA) could chose from almost 150 Special Interests Groups to represent their scholarly interests.

Gaps are widening between those who adhere to traditional approaches to knowledge and those who argue that these approaches are misguided and misleading. The quantitative-qualitative cross currents in the social sciences and the increased use of poststructuralist theories in the humanities and social sciences are two obvious examples of how different perspectives can disrupt disciplinary relations (Lattuca, 2001).

The border crossing of early interdisciplinarians was largely *instrumental*: it was motivated by the need to solve a given problem using borrowed theories, concepts, or methods. Early disciplinarians were also fewer in number and generally acted as trespassers who crossed disciplinary boundaries but rarely tried to demolish them. By contrast, many of today's interdisciplinary scholars are more revolutionary in their ideas and ideals and are eager to interrupt disciplinary discourse and to challenge traditional notions of knowledge and scholarship.

In the sciences and related professional fields, such as engineering and medicine, interdisciplinarity largely remains instrumental. There is also a good deal of instrumental interdisciplinary work in the social sciences and humanities and in professional fields such as education, business, and social work. Increasing numbers of faculty in the humanities and social science, however, are pursuing interdisciplinary work with the specific intent of deconstructing disciplinary knowledge and boundaries (Lattuca, 2001).

In studying 38 faculty members doing interdisciplinary work across 16 fields of study and four institutions, Lattuca concludes, "it became clear that as interdisciplinarity has evolved, it has outgrown its own definitions. The traditional conceptualization of interdisciplinarity as the integration of disciplinary perspectives conceals the disciplinary critique that drives much interdisciplinary scholarship today" (Lattuca, 2001, p.4).

The Centre for Educational Research and Innovation (as cited in Lattuca, 2001) offers one accepted definition of *interdisciplinary*:

> Interdisciplinary – An adjective describing the interaction among two or more different disciplines. This interaction may range from a simple communication of ideas to the mutual integration of organizing concepts, methodology, procedures, epistemology, terminology, data, and organization of research and education in a fairly large field. An interdisciplinary group consists of persons trained in different fields of knowledge (disciplines) with different concepts, methods, and data and terms organized into a common effort on a common problem with continuous intercommunication among the participants from the different disciplines. (Lattuca, 2001, pp.17-18)

This definition focuses on integration and is a broader notion than team research or collaboration. The definition assumes a disciplinary basis for interdisciplinarity, but does not exclude *postmodern interdisciplinarity*, in which disciplines themselves are tangential to the mode of inquiry. It also recognizes a wide range of interdisciplinary work, suggesting that interdisciplinarity exists on a continuum. At one end is informal communication; at the other end is such formal collaboration as research or teaching teams comprising faculty from different disciplines (or without self-proclaimed disciplinary homes, in the postmodern case).

Lattuca (2001) maintains that theorists distinguish one discipline from another by the type of questions considered legitimate to ask. Similar types of interdisciplinarity may be best distinguished by the kinds of questions asked. Faculty interviewed by Lattuca noted how learning another discipline or disciplines had expanded the range of research questions that they could ask and answer. But the faculty did not simply learn to ask new kinds of disciplinary questions; instead they identified interdisciplinary questions. As one faculty member noted:

> I hope what interdisciplinarity does for colleagues and for students is that something it does for me, that is, opening minds and making the question more important than the mode of answering them. When I think about graduate students, for example, I think that one of the things that interdisciplinary work can do for graduate students is show them that research is not about taking a particular

way of analyzing data and making publishable articles out of it. It's actually about answering questions or about thinking about how you would go about answering questions even if you can't answer them. The questions become really, really important. (Lattuca, 2001, pp. 81-82)

Table 1 shows Lattuca's profile of the different types of interdisciplinary scholarship and related questions each addresses (Lattuca, 2001, p. 81). Table 2 compares her four types of interdisciplinary scholarship with categories previously described in the literature (Lattuca, 2001, p.114).

Table 1. Types of Interdisciplinary Scholarship

Type of Scholarship	*Teaching*	*Research*
Informed Disciplinarity	Disciplinary courses informed by other discipline(s)	Disciplinary questions requiring outreach to other discipline(s)
Synthetic Interdisciplinarity	Courses that link disciplines	Questions that link disciplines
Transdisciplinarity	Course that cross disciplines	Questions that cross disciplines
Conceptual Interdisciplinarity	Courses without a compelling disciplinary basis	Questions without a compelling disciplinary basis

Interdisciplinarity has often been described as borrowing. Research approaches that borrow methods have been called *method interdisciplinarity*, or *instrumental interdisciplinarity*. A broader term for approaches that borrow either theories or methods is *cross-disciplinary*. However, these approaches are not considered to be true forms of interdisciplinarity and should be considered *pseudo-interdisciplinarity* according to Heckhausen (as cited in Lattuca, 20001, p. 114). Newell (1998, p. 533) contends that "...any approach that does not attempt to integrate disciplines or that draws insights from other disciplines while viewing them through the lens of the original discipline are forms of *partial interdisciplinarity*."

In her proposed typology, Lattucca (2001) maintains that it is the nature of the question asked that defines the approach. Instrumental and cross-disciplinary approaches could be informed disciplinarity if the question asked is disciplinary in nature, since borrowing alone is not sufficient for interdisciplinarity. However, if a synthetic, transdisciplinary, or conceptual interdisciplinary question motivates borrowing, the resulting project would be considered interdisciplinary.

Based on her interpretation of informants' accounts, Lattuca (2001, p. 112) maintains that questions that are merely informed by references to other disciplines are not interdisciplinary questions, but disciplinary ones. She claims that there are three types of interdisciplinary questions:

1. *Synthetic interdisciplinarity questions* that bridge disciplines and therefore cannot be answered completely by a single discipline;
2. *Transdisciplinary questions* that are applicable across disciplines and therefore transcend a single disciplinary identity; and
3. *Conceptual interdisciplinarity questions* that have no compelling disciplinary basis.

Lattuca (2001) concludes that interdisciplinarity is not merely a process or product, but a defining element of a project:

> We can determine a project's interdisciplinarity or disciplinary nature by looking at the question that has motivated it. Additional information about approaches and methods to be used to answer the question, the audience(s) involved, and the epistemological commitments of the instructor(s) or researcher(s) may also assist in making an initial determination. (p. 118)

7

Table 2. Comparison of Interdisciplinarity Typology and Previous Categorizations

Typology	Previous Category
Informed Disciplinarity	- Instrumental interdisciplinarity - Pseudointerdisciplinarity - Cross- disciplinarity - Partial interdisciplinarity
Synthetic Interdisciplinarity	- Instrumental or cross-disciplinarity that is motivated by an interdisciplinarity question - Multidisciplinarity - Partial interdisciplinarity - Conceptual interdisciplinarity
Transdisciplinarity	- Transdisciplinarity - Cross-disciplinarity
Conceptual Interdisciplinarity	- (True) interdisciplinarity - Critical interdisciplinarity - Full interdisciplinarity

Defining "interdisciplinarity" appears analogous to any attempt to define "what is rural" or what is "rural education." The answer depends greatly on the context of experiences and traditions or values held by those asked the question. Similarly, traditions of research guide those seeking to frame questions that direct studies focused on the teaching and learning of mathematics in rural schools and their communities. Understanding these traditions is necessary not only for "asking the questions" in ways that value interdisciplinary research as noted by Lattuca (2001), but also in making the results of research meaningful to the context of rural schools and their communities.

Traditions and Trends in Mathematics Education Research

Describing the evolution of research methods in mathematics education as represented over the 25-year history of the *Journal for Research in Mathematics Education*, Schoenfeld (1994) argues that, as a field, mathematics education is reaching the point where we can acknowledge the complexity of some of the phenomena we wish to explain, such as metacognition, beliefs, and cognitive apprenticeship. "But we do not have standard methods with which to do the explaining. Indeed, a large part of our work over the *JRME's* second quarter century will be to create such methods—to craft methods to capture phenomena we think important, in ways that are informative, replicable, and reliable" (p.708). The origins of mathematics education lie jointly in mathematics and psychology – in mathematics for a grounding in the content being studied, and in psychology for the tradition of disciplined inquiry into the workings of the mathematical mind (Kilpatrick, 1992).

For three-fourths of the 20th Century, inquiry became increasingly "scientific" (ostensibly objective and rigorously quantified). According to Schoenfeld (1994), "The result was a rather single-minded focus on quantification and experimentation – the kind of data that could be analyzed statistically. Education researchers borrowed empirical methods such as 'treatment A versus treatment B' designs and factor analyses from the physical and experimental sciences" (p.699). In reviewing 10 years of problem-solving studies (1968-77), Schoenfeld (1981) concluded there was too great a reliance on statistics, and a deep look at process was being avoided. He argued: "Statistics are valuable in their place. They can suggest hypotheses in preliminary studies and help to test them in well-designed experimental studies. But if we want to understand what goes on in people's heads when they solve problems (and I assume we do!), we have to watch them solving problems" (p. 389-90). By the end of the first decade (1964-74) of the *Journal for Research in Mathematics Education*, researchers in mathematics education began to look outside their profession for ideas and methods, particularly information-processing (later to coalesce into cognitive science).

Through the 1980s and into the 1990s, the character of the field changed radically. There was a shift from an emphasis on *product* – correlations of "abilities" and other variables with performance – to an emphasis on *process*, which sought correlations between "strategies" and performance. As the field's conception of mathematical thinking expanded, one saw more descriptive studies of strategy used, and then studies of metacognition and of beliefs. With this came a shift in research methods to include the reporting of clinical interviews, process and simulation models, field observations, and participant observations. This new focus could be characterized as teacher knowledge and behavior, according to Schoenfeld (1994). Research sought to elaborate, clarify and better understand the complex web of circumstances shaping the professional life of a teacher in a classroom.

The time was right for a major paradigmatic change. The study of the mind was once again seen to be possible – and prestigious and scientific as well. With the renewed interest in constructivism came a host of previously uncommon research methods. Schoenfeld notes: "Psychologists and educational researchers rediscovered 'mind' – that thinking was no longer a dirty word that had been banished from the lexicon by the behaviorists but once again the object of legitimate inquiry" (Schoenfeld, 1994, p. 707).

Moreover, work in AI (Artificial Intelligence) and related fields (e.g., cognitive science) produced a host of methods that were clearly "scientific." As the field came to recognize the complexity of the issues it faced, it came as well to recognize the value of multiple perspectives and approaches. In short, educational researchers emerging from a methodological straitjacket proceeded to open a Pandora's box of opportunities and problems (Schoenfield, 1994).

In reviewing the book, *Mathematics Education as a Research Domain: A Search for Identity* (1998), King and McLeod (1999) note that several chapters make clear that mathematicians are not the only group to work with, draw from, and influence mathematics education research. Psychologists, sociologists, philosophers, curriculum developers, practicing teachers, and other researchers in education all have an interest in (and often opinions about) mathematics education research. Many authors throughout the two volumes comment on how mathematics education researchers often adopt and adapt research methods, as well as criteria for evaluating these methods, from other disciplines. Along with methods and criteria, mathematics education researchers increasingly embrace the epistemological perspectives and research paradigms of these other disciplines.

These authors note how the research paradigm has changed in mathematics education:

> In the 1960s our senior researchers in mathematics education started their careers working in an academic environment that promoted the scientific paradigm, with its predictions, quantitative methods, and hypothesis testing. In the 1980s the emphasis on problem solving in mathematics education was accompanied by a corresponding emphasis on cognitive science in research in mathematics education. Subsequently, a shift in focus to social aspects of learning has led to an emphasis on social constructivism in many of the most influential research projects in the United States. (King & McLeod, 1999, pp. 230-231)

King and McLeod (1999) also note the lack of attention in the two-volume book to shifts in the research paradigm. Issues of equity in mathematics education were becoming more prominent.

In an article characterizing the didactics of mathematics education as a scientific and scholarly discipline, Niss (1999) notes:

> A major portion of research done during the last couple of decades has focused on students' *learning processes and products* as manifested on the individual, small group, and classroom levels, and as conditioned by a variety of factors such as mathematics as a discipline; curricula; teaching; tasks and activities; materials and resources, including text books and information technology; assessment; students' beliefs and attitudes; educational environment, including classroom communication and discourse; social relationships amongst students and between students and teacher(s); teachers' education, backgrounds, and beliefs; and so forth. (p.11)

Today, we know a lot about the possible mathematical learning processes of students and about how these may take place within different areas of mathematics and under different circumstances and conditions. We also know a lot about factors that may hinder, impede or simply prevent successful learning (Niss, 1999).

In a meta-analysis to identify trends in research in mathematics education Lee, Ozgun-Koa and Rehner (1999) report research topics conducted in 1995-1997 reflect changes of interests in mathematics education that support trends Niss illustrated. Mathematical concepts and instructional techniques were the most researched subjects for all three years.

Niss (1999) suggests we have learned two lessons, which he calls *super-findings*. He maintains:

> If we want to teach mathematics, with satisfactory or desirable results, to students other than the few who can learn mathematics without being taught, or the even

> fewer who cannot learn mathematics irrespective of what and how they are taught, two matters have to be kept in mind at all times:
>
> 1. We have to be infinitely careful not to jump to conclusions and make false inferences about the processes and outcomes of students' learning of mathematics. Wrong or simplistic assumptions and conclusions are always close at hand.
>
> 2. If there is something we want our students to now, understand, or be able to do, we have to make it the object of explicit and carefully designed teaching. Because of 1., there is no such thing as guaranteed transfer of knowledge, insight and ability from one context or domain to another. Transfer certainly occurs and can be brought about, but if it is to take place in a controlled way it has to be cultivated. (pp. 21-22)

Lastly, Lester and Wiliam (2000) examine the evidential basis for knowledge claims in mathematics education research and conclude:

> The relation between knowledge claims and evidence involves more than simply establishing a logical connection between the two. Instead, the relation is determined, in large part, by a set of beliefs, values, and perspectives operating in the context in which the empirical data are being assessed. How researchers go about convincing others of the claims they make and how they defend their claims on ethical and practical grounds are, only in part, matters of marshalling adequate contextualized evidence embedded in sets of beliefs and theories. Indeed, convincing others is also a matter of persuading them to accept the values the researcher holds about he objects and phenomena being studied as well as about the very purpose of research itself. (p. 136)

During the past decade researchers have presented a phenomenal body of research that has radically shifted educators' thinking about the art of teaching mathematics for understanding and have done a superb job of documenting the pedagogical limits of traditional practice (Carnine & Gersten, 2000). We have a much better sense of critical issues in professional development and of variables and issues that are critical for students and teachers. According to these researchers, "We now need to build upon this base using rigorous controlled studies. This type of research is, in our view, especially critical in understanding approaches that are truly effective for students with significant problems in learning mathematics. We need not only to conduct more experimental studies but also to ensure they are of the highest quality" (Carnine & Gersten, 2000, p.142).

Traditions and Trends in Vocational Education Research

As I explored the trends and traditions of research in mathematics education through one of the discipline's most prestigious journals: the *Journal for Research in Mathematics Education*, I now turn to a similar journal in vocational education: the *Journal of Vocational Education Research* (*JVER*) published by the American Vocational Education Research Association.

In assuming the new role as editor of *JVER*, Rojewski (1997) reviewed the past, present, and future directions of the journal. Rojewski reviewed 160 articles published in the *JVER* during the 10-year time period of 1987-1996. Approximately two-thirds of all published articles reflected a quantitative research paradigm, with slightly more than 10 percent being qualitative in nature. Primary topics of published articles reflected models that reflect the extant literature in the field (Ertel & Neveu, 1987) to those that reflect the needs or priorities of various stakeholders (Lynch, Schmidt, & Asche, 1988; Phelps & Hughes, 1986; Rojewski, 1991; Schmidt, Lynch, & Frantz, 1988; Way & Rossman, 1994). Also, articles reflected new or alternative paradigms that restructure traditional frames of reference (Pratzner, 1985), or plot a research course for vocational education which is consistent with the emerging liberal education hypothesis (Lewis, 1990).

Rojewski chose to use the research framework proposed by Ertel and Neveu (1987) to identify major topics or issues addressed by past research published in the *JVER*. They proposed a six-phase research planning cycle that examined the development and evaluation of both *policy* and *program*. (See Table 3)

Table 3. Policy and Program Development/Evaluation Considerations and Topics

Considerations	Priority Areas	Study Topics
Policy Development & Evaluation	1. Content/area analysis	- Emerging occupations and labor market - Basic academic skills - Academic and vocational education integration - Identification of occupational competencies
	2. Student-focused considerations	- Special student population - Program equity and access - Attitudinal or motivational issues
	3. Career timing or sequencing considerations	- Career choice behavior - Guidance and counseling practices - Concurrent academic and occupational preparation activities - Age/grade level considerations - Lifelong learning programs
Program Development and Evaluation Considerations	1. Location/siting considerations	- Cooperative business-education ventures - Comprehensive vs. regional vocational schooling - Work study programs - Changing roles of secondary and postsecondary vocational programs and institutions
	2. Instructional methodology	- Specific instructional techniques - Assessment of academic achievement - Efficacy of individualized, competency-based, technology-based instruction - Establishment of standards of excellence
	3. Articulation/generalization	- Program evaluation studies - Establishment of research and

		funding priorities - Pre-service and in-service teacher preparation - Longitudinal studies to enhance vocational education

Rojewski (1997) consequently identified several trends in research topics. Two research categories –articulation/generalization and content/area analysis – comprised over 60 percent of all published articles in the *JVER* during the 10-year period. A steady increase in content/area articles occurred in the most recent five years of the period. Efficacy of instructions methods decreased markedly in the recent years, with only one article being published in the most recent five years of the period. Thirteen articles (out of 83) focused on instructional methods during the first five years of the period. Only four articles were published on timing/sequencing during the most recent five years of the period, compared with 10 articles during the first five years of the period.

Rojewski (1997) also determined that authors from eight institutions – all major research universities – represented the most frequent contributors (and presumably the greatest influence on the field) to the *JVER* during the 10-year period. The eight institutions were University of Minnesota, Virginia Tech, University of Georgia, Ohio State University, University of Illinois, University of Wisconsin-Madison, University of Missouri-Columbia, and Pennsylvania State University. A total of 86 distinct institutional affiliations were identified.

Wonacott (2000) found the body of vocational education research to be large and complex, with a diffuse focus on topics ranging from the essential nature of vocational education and its role in society to the individual details of specific occupational programs. Wonacott found, however, that most research seeks to answer one form or another of a fundamental question: How can we best prepare youth and adults for the workplace of today?

Comprehensive national and international research programs typically attempt to ask and answer larger forms of that question. Change in the workplace greatly influences research themes in the United States, guided by the skills workers need for the changing workplace and how vocational education should address them. For the most part, other research focuses on the specifics of occupational areas in vocational education, with noticeable examples being studies on attitudes toward agricultural education and teaching strategies in business education. Calls for further research are particularly common.

Quantitative methods play a major role in research in vocational education. Other methods recommended include action research, reflective practice, and critical theory/critical research. Barrett, Hovels, Den Boer, and Kraayvanger (1998) suggest a complementary combination of quantitative and qualitative research on the returns to vocational education and training. Looker and Dwyer (1998) recommend alternatives to the linear pathways research model for education-to-work transitions. Other research approaches used include Delphi survey, concept mapping, context-input-process-product, action research, and action reflection learning, with case studies by far the most common.

The U.S. Department of Education, Office of Educational Research and Information also supports a National Research Center for Career and Technical Education that arguably influences trends and methods of research in vocational education. Titles of current projects or activities in the National Research Center for Career and Technical Education (NRCCTE) include:

1. *Alternative Teacher Certification Strategies for Career and Technical Education Teachers: Assuring Quality at the Secondary School Level*

2. *The Community College and Beyond: A Longitudinal Analysis of Postsecondary Education and Employment Outcomes for Tech-Prep Participants and Non-Participants*

3. *An Examination of Four Curriculum Integration Models Impact of School-to-Work and Career and Technical Education on Student Achievement, Transition, and Labor Market Entry*

4. *Influence of Industry Sponsored Credentials in the Information Technology Industry*

5. *New Designs for Career and Technical Education at the Secondary and Postsecondary Levels*

6. *Preservice Development: From Data to New Designs*

7. *The Relationship of Career Development Interventions to the Positive Student Outcomes: A Multilevel Analysis*

8. *Theoretical and Practical Research on Dissemination: Developing a ResearchProgram for Studying and Evaluating Dissemination Efforts*

9. *What Makes It Work: Examining Successful Career and Technical Education Efforts in High Poverty Schools and Community Colleges Engaged in Educational and Whole School Reforms*

Themes of research in vocational education have varied over the years. In her presidential address at the American Vocational Education Research Association Conference, Redmann (1998) reviewed the topics the association's presidents addressed in the first 30 years, starting in 1967. Redmann noted that three major themes were recurring and have maintained their timeliness through the decades: (1) the relevance of vocational education research to a wider world, (2) the organization of research efforts and dissemination of research findings, and (3) issues related to maintaining a vision of the future for vocational education research. Table 4 provides a synopsis of the key themes addressed by former *AVERA* presidents, as categorized by the three recurring major themes Redmann described.

Table 4. Themes in Addresses of *AVERA* Presidents

Major Recurring Theme	Illustrative Presidential Themes
1. Relevance of Vocational Education Research	Discipline, not funding source, should set the research agenda (Cheek, 1987)
	Obligation to correctly identify client base and tailor research to meet needs (Miller, 1994; Moore, 1992)
	Priorities arise from nation's problems (Magisos, 1981)
	Economic development that maximizes human resource potential (McCage, 1982)
	Respond to skills and knowledge demands imposed by workplace (Pucel, 1995)
	Prepare individuals to meet challenges of the future technological society (Wall, 1972)
	Prepare workers to demonstrate a broader range of skills at higher levels of competence for a lifetime of learning (Finch, 1991)
	Provide transferable work skills to adapt to the demands of a changing workplace (Ley, 1987)
	Address interplay between technology and social change related to families (Wall, 1972)
	Address moral values as important educational outcomes (McCracken, 1990)
2. Organization and Dissemination of Research Efforts and Findings	Barrier to significant research is placing grater emphasis on the research process than on the product (Moore, 1992)
	What drives important research studies are important problems, not paradigms (Miller, 1994)
	Ideas and concepts are the first requisite for good research; research without important ideas is busy work (Cheek, 1988 citing Hamlin, 1966)
	Much vocational education research is fragmentary in nature, not cumulative for valid generalizations (Kievit, 1975)
	Produce programmatic research by a process of combining deductive and inductive methods of inquiry as a synthesis (Lee , 1971)
	Concentrate on an important area continuously over a period of years (Copa, 1980; Finch 1993)
	Formation of interdisciplinary or multidisciplinary research teams to undertake a broad research agenda and strengthen the research base (Cheek, 1987; Finch, 1993)
	Formation of links with researchers and practitioners outside the discipline to provide interdisciplinary qualities and new ideas (Asche, 1985)

Major Recurring Theme	Illustrative Presidential Themes
	Use a combination of quantitative and qualitative research methodology (Hillison, 1989)
	Conduct rigorous and disciplined evaluations studies (Warmbrod, 1976)
	Research results are not getting into the hands of practitioners (Cheek, 1987; Miller, 1994)
	Consider dissemination of results as part of initial research proposal (Smink, 1984)
	Use technology in dissemination efforts (Budke, 1988)
3. Vision for the Future of Vocational Education Research	Growth in research after World War II due to growth in statistical methods, advent of computer, and federal funding (Morrison, 1973)
	Decentralization of funding sources will continue into the future (Redmann, 1998)
	Unify the scope of past, present and future research and reduce fragmentation (Cheek, 1987)
	Foster a commitment to scholarship and publication that goes beyond the superficial level of building one's own vita (Cheek, 1987)
	Encourage a greater utilization of a variety of research methods, both quantitative and qualitative (Cheek, 1987)

Traditions and trends of research in mathematics education and vocational education appear under significant transition. These trends also seem to accommodate the conduct and characteristics of interdisciplinary research.

Characteristics of Interdisciplinary Research

Lattuca's study (2001, pp. 166-167) revealed several characteristics of the interdisciplinary process. Interdisciplinary work required the usual academic activities of reading, talking with colleagues, and collaborating. Faculty conducting interdisciplinary work read more widely than they did when doing disciplinary work. More preparation time was required to do interdisciplinary work. Collaborations also required more and longer timelines so bumps could be smoothed out.

Faculty doing synthetic interdisciplinary work that combined two or three disciplines limited their reading to these disciplines. Faculty doing informed disciplinary and conceptual interdisciplinary work generally read more broadly regardless of type of strategy. Faculty usually had lengthy engagements with the material of other disciplines. Reading was almost always supplemented by conversations with campus and off-campus colleagues.

Faculty doing interdisciplinary work valued highly the specialized meetings, institutes, and campus forums as sources of information and contacts and as sounding boards for new ideas. Collaborations may have been more serendipitous than planned, with faculty in the sciences more purposefully seeking out collaborations with particular disciplinary or technical expertise. (Faculty in the social sciences and humanities rarely used this strategy.)

Faculty in research collaborations usually negotiated issues of content and methods before agreeing to collaborate; fundamental beliefs are therefore not contested. Interdisciplinary research, however, forced faculty to confront their assumptions about knowledge and the ways in which it was pursued.

Supportive Context for Interdisciplinary Research

Admittedly, numerous barriers exist to those who seek to conduct interdisciplinary research. The barriers the literature frequently cites include the discipline itself, academic department configurations, and institutional traditions reflected in promotion and tenure decisions. Based on her study of four institutions, Lattuca (2001) notes:

> The height of a barrier, of course, is in the eye of the beholder. Faculty who are determined to pursue interdisciplinary research and teaching projects may see possibilities where others see pitfalls. But perhaps departmental, institutional, and disciplinary contexts are not now – or may never have been – as hostile to interdisciplinarity as reported. (p.252)

What context supports conducting interdisciplinary research? Administrative support is usually viewed as structural or financial support. Joint appointments signal an institution's openness to interdisciplinarity. The institution may encourage departments to share faculty to work on teams or other collaborate arrangements that are conducting significant interdisciplinary projects. Funding for graduate and undergraduate programs and special projects are barometers of support at the institution. Faculty announcements listing experience or training in the conduct of interdisciplinary research sends a strong signal of support. Recognition by the department and or institution of faculty whose work in interdisciplinary research results in conference papers, articles, and books reflects a supportive context.

Institutional support also includes incentives for faculty to attend workshops, institutes and conferences where they can deepen their knowledge of content and meet colleagues with interests and experiences in interdisciplinary research. Special seminars may be co-sponsored by several departments that bring to campus a person highly recognized for interdisciplinary research. An institution's grants office may provide assistance in identifying funding for interdisciplinary research. Department chairs can solicit ideas for interdisciplinary forums from faculty members and graduate students. Institutions may also create flexible interdisciplinary spaces where faculty can find temporary or second homes more supportive of interdisciplinary work. These places are particularly important to allow faculty interested in interdisciplinary research a place to grow, outside the purview of antagonistic faculty.

External influences such as funding agencies and sponsors can push an interdisciplinary agenda. And the institution could support research that examines interdisciplinary work on campus, investigating both facilitators and barriers of such research on campus or in partnership with key institutional stakeholders.

Considerations for an Interdisciplinary Research Agenda

While the context of support for interdisciplinary research may differ greatly on a college or university campus and within disciplines, research traditions and trends in mathematics education and vocational education suggest that windows of opportunity exist for interdisciplinary research. No one discipline should be expected to create new knowledge or innovations that address significant societal and educational problems prevalent in public schools today. Addressing many of the complex school improvement and student achievement issues, particularly in rural schools and their communities, will require collaborative partnership approaches to research.

The following five considerations might serve as a catalyst for creating an interdisciplinary research agenda that links mathematics education and vocational education in meaningful ways.

1. Avoid the quicksand of trying to define interdisciplinarity. Seek first to understand the significant problem to be addressed and clarify the contributions each discipline can make toward the creation of new knowledge.
2. Emphasize research questions that offer opportunities to create new knowledge or innovations considerate of public and political discourse regarding improvement of

student achievement in mathematics for living and working in a high-tech, knowledge-driven society.

3. Include dissemination strategies in the research agenda that will foster interests in individuals, institutions, and organizations seeking recognition for providing new ideas or innovations.

4. Establish timelines that enable researchers to read, network and cultivate an understanding of the other disciplines or specialties important to project success.

5. Advocate research that acknowledges the significant value of qualitative methods, but focus intently on more rigorous experiments or quasi-experiments for evaluating programs and practices in rural schools that will build confidence in educational research among policymakers and educators.

Summary and Concluding Thoughts

Mathematics education and vocational education are relatively young disciplines. A review of the significant journal in each field also suggests considerable "churning of the waters" is occurring as writers within the disciplines review the past and attempt to project a future consistent with major changes in society.

Quantitative research methodologies have dominated the two disciplines. However, in recent years long-standing research traditions have been challenged. Qualitative research approaches are becoming more prevalent as researchers have sought to investigate in more depth the evolving and complex phenomenon or issues that characterize public education today. Interdisciplinary research approaches are being recommended among the methodologies for addressing these important issues.

While defining interdisciplinarity can be cumbersome, how the research questions are asked can reveal the extent to which two or more disciplines are being effectively integrated. Integration alone, however, may not be the defining characteristic of effective interdisciplinary research at an institution or in a project. Lattuca (2001) offers a new typology based on her study of four institutions and 38 faculty members involved in interdisciplinary research projects.

Interdisciplinary research continues to face traditional barriers: academic department configurations, institutional traditions reflected in promotion and tenure decisions, and the discipline itself. Yet individual faulty members often can find institutional support for conducting interdisciplinary research. Moreover, numerous entities outside the respective disciplines, including key funding organizations, are increasingly influencing the research agenda.

Of particular concern today is the need to conduct research that provides definitive evidence of "what works" in educational policy and practice for improving student achievement (Slavin, 2002). While some researchers may argue that a narrow focus on public school accountability (i.e., student test scores) has unduely restricted the research agenda, others welcome the increasing recognition that better research and scholarship can bring to educational decision-making. Interdisciplinary research can be one of the desirable approaches to scholarship that creates new knowledge or innovations. Five considerations for creating a research agenda are listed in this paper. And, as one astutue observer notes:

> We must judge scholarship on the basis of its contribution to the advancement of knowledge. Any other evaluation privileges the discipline over the enterprise and diminishes both the scholarship and the community that produces it. (Lattuca, 2001, p. 266)

7

Perhaps, too, it is this same mindset that will enable the results of interdisciplinary research between and among mathematics education and vocational education researchers to advance a meaningful research agenda for rural schools and their communities.

References

Barrett, A., Hovels, B., Den Boer, P., & Kraayvanger, G. (1998). *Exploring the returns to continuing vocational training in enterprises*. Thessaloniki, Greeece: European Centre for the Development of Vocational Training. (ERIC Document Reproduction Service No. ED 422 508)

Becher, T. (1987). The disciplinary shaping of the profession. In B. R. Clark (Ed.), *The academic profession: National, disciplinary, and institutional settings* (pp. 271-303). Berkeley: University of California Press.

Becher, T. (1989). *Academic tribes and territories: Intellectual enquiry and the cultures of disciplines*. Bristol: PA: The Society for Research into Higher Education and Open University Press.

Biglan, A. (1973a). The characteristics of subject matter in different academic areas. *Journal of Applied Psychology, 57*(3), 195-203.

Biglan, A. (1973b). Relationships between subject matter characteristics and the structure and output of university departments. *Journal of Applied Psychology 57*(3), *204-13*.

Bechtel, W. (1986). The nature of scientific investigation. In W. Bechtel (Ed.), *Integrating Scientific Disciplines* (pp. 3-52). Dordrecht, Netherlands: Martius Nijhoof.

Carnine, D., & Gersten, D. (2000). The nature and roles of research in improving achievement in mathematics. *Journal for Research in Mathematics Education, 31*(2), 138-143.

Donald, J. G. (1983). Knowledge structures: Methods for exploring course content. *Journal of Higher Education, 54*(1), 31-41.

Donald, J. G. (1990). University professors' views of knowledge and validation processes. *Journal of Educational Psychology, 82*(2), 242-249.

Elzinga, A. (1985). Research, bureaucracy, and the drift of epistemic criteria. In B. Wittrock & A. Elzinga (Eds.), *The University Research System* (pp. 191-200). Lund, Sweden: Research on Higher Education Program.

Ertel, K.R., & Neveu, F.R. (1987). Vocational education research planning. *Journal of Vocational Education Research, 15*(3), 1-17.

Fuller, S. (1988). *Social epistemology*. Bloomington, IN: Indiana University.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The New Production of Knowledge* London: Sage.

Goldman, H. (1995). Innovation and change in the production of knowledge. *Social Epistemology, 9*(3), 211-232.

Jacobson, B. (1981). Collection type and integration type curricula in systems of higher education. *Acta Sociologica, 24*(1-2), 25-41.

Kilpatrick, J. (1992). A history of research in mathematics education. In D. Grouws (Ed.), *Handbook for research on mathematics teaching and learning* (pp. 3-380). New York: Macmillan.

King, K. D., & McLeod, D. B. (1999). Coming of age in academe. *Journal for Research in Mathematics Education, 30*(2), 226-234.

Kuhn, T. (1970). *The structure of scientific revolutions*. (2nd edition, enlarged). Chicago: University of Chicago Press.

Kuhn, T. (1977). *The essential tension*. Chicago: University of Chicago Press.

Lattuca, L. R. (2001). *Crating interdisciplinarity: Interdisciplinary research and teaching among colleges and university faculty*. Nashville: Vanderbilt University Press.

Lee, H., Ozgun-Koca, S., & Rehner. (1999). *Research trends in mathematics education, 1995-1997*. In Kelly M. Costner and Michelle K. Reed (Eds.). MSaTERS: Mathematics, Science, and Technology educators and researchers of The Ohio State University. Proceedings of the Annual Spring Conference (3rd). Columbus, OH, May 15. (ERIC Documents Production Service No. ED 438 166)

Lester, F., & Wiliam, D. (2000). The evidential basis for knowledge claims in mathematics education research. *Journal for Research in Mathematics Education, 31*(2), 132-137.

Lewis, T. (1990). Toward a new paradigm of vocational education research. *Journal of Vocational Education Research, 15*(2), 1-30.

Lodhl, J. B., & Gordon, G. (1972). The structure of scientific fields and the functioning of university graduate departments. *American Sociological Review, 37*(2), 57-72.

Looker, E. D., & Dwyer, P. (1998). Rethinking research on the education transition of youth in the 1990s. *Research in Post-Compulsory Education,* 3(1), 5-23.

Lynch, R. L., Schmidt, B. J., & Asche, F. M. (1988). Determining priorities for vocational education research through use of a nominal group technique. *Journal of Vocational and Technical Research, 5*(1), 13-27.

Newell, W. T. (1998). Professionalizing interdisciplinarity: Literature review and research agenda. In W. H. Newell (ED.), *Interdisciplinarity: Essays from the literature* (pp. 529-563). New York: College Entrance Examination Board.

Niss, M. (1999). Aspects of the nature and state of research in mathematics education. *Educational Studies in Mathematics, 40*, 1-24.

Phelps, L. A., & Hughes, R. P. (1986). The unfinished agenda: Some implications for research in secondary vocational education. *Journal of Vocational Education Research, 11*(2), 51-72.

Pratzner, F. (1985). The vocational education paradigm: Adjustment, replacement, or extinction? *Journal of Industrial Teacher Education, 22*(2), 6-19.

Price, D. (1970). Citation measures of hard science, soft science, technology, and non-science. In C. Nelsen & D. Pollock (Eds.), *Communication among scientists and engineers* (pp. 3-22). Lexington, MA: D. C. Heath and Company.

Redmann, D. H. (1998). Recurring themes in *AVERA* presidential addresses: The first 30 years. *Journal of Vocational Education Research, 23*(1), 1-12.

Rojewski, J. (1997). Editorial: Past, present, and future directions of the *JVER*. *Journal of Vocational Education Research, 22*(3), 141-148.

Rojewski, J. W. (1991). National perspectives on future directions for research in vocational special needs education. *Journal of Vocational Education Research, 16*(2), 53-73.

Rheinberger, H. J. (1995). Remarks on epistemic practices. In P. Weingart (Ed.), *Greenziiberschreitungen in der Wissenschaft (Crossing Boundaries in Science), ZiF* (pp.168-182). Interdisciplinary Studies 1. Baden-Baaden: Nomos.

Salter, L., & Hearn, A. (1996). *Outside the lines: Issues in interdisciplinarity research*. Montreal: McGill-Queen's University Press.

Schmidt, B. J., Lynch, R. L., & Frantz, N. R. (1988). An analysis of priorities for vocational education research and development. *Journal of Vocational Education Research, 13*(2), 3-18.

Schoenfeld, A. (1981). Review of John G. Harvey and Thomas A. Romberg's *Problem-solving studies in mathematics. Journal for Research in Mathematics Education,12,* 386-390.

Schoenfeld, A. (1994). A discourse on methods. *Journal for Research in Mathematics Education, 25*(6), 697-710.

Shinn. T. (1982). Scientific disciplines and organizational specificity. In N. Elias, H. Martins, & R. Whitley (Eds.), *Scientific establishments and hierarchies* (pp. 239-264). Dordrecht: Reidel.

Sierpinska, A., & Kilpatrick, J. (1998). *Mathematics education as a research domain: A search for identity.* Dordrecht, The Netherlands: Kluwer.

Slavin, R. E. (2002). Evidence-based education policies: Transforming educational practice and research. *Educational Researcher, 31*(7), 15-21.

Stehr, N., & Ericson, R. (1992). The culture and power of knowledge in modern society. In N. Stehr, & R. Ericson (Eds.), *The culture and power of knowledge: Inquires into contemporary societies* (pp. 3-29). Berlin: Walter de Gruyter.

Way, W. L., & Rossman, M. M. (1994). The interrelation of work and family: A missing piece of the vocational education research agenda. *Journal of Vocational Education Research, 19*(2), 1-24.

Weingart, P., & Stehr, N. (2000). *Practising interdisciplinarity.* Toronto, Canada: University of Toronto Press.

Wonacott, M. E. (2000). *Vocational education trends.* (Trends and issues alert no. 15). Columbus, OH: ERIC Clearinghouse on Adult, Career and Vocational Education (ERIC Document Reproduction Service No. ED 440 298)

NOTICE

Reproduction Basis

X This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").