DOCUMENT RESUME

ED 414 187		SE 060 935
AUTHOR	Spadano, Joseph W.; Zeidler, Dana L.; Chappell, Michaele F.	
TITLE	Advancing Ownership of Understanding and Responsibility through Homework in Mathematics Education.	
PUB DATE	1997-00-00	
NOTE	27p.; Paper presented at the Annual Meeting of the Pi Lambda Theta International Education Leadership Association (40th, San Diego, CA, July, 1997).	
PUB TYPE	Guides - Non-Classroom (055) -- Speeches/Meeting Papers (150)	
EDRS PRICE	MF01/PC02 Plus Postage.	
DESCRIPTORS	*Educational Change; Educational Philosophy; Elementary Secondary Education; Home Study; *Homework; Learning Theories; *Mathematics Education; *Student Centered Curriculum; Teaching Methods	
IDENTIFIERS	*Teacher Centered Instruction	

ABSTRACT

Philosophical traditions have a pedagogical impact on how educators willingly or unwittingly conduct themselves. This paper presents an analytic review of two contrasting educational philosophies and their corresponding learning outcomes. Questions are raised concerning the schism that exists between teacher-centered and learner-centered educational orientations, and their implications to concepts central to education such as ownership of understanding and responsibility. An argument is presented as to how a rationale policy of homework may be able to bring about goals consistent with current reform initiatives without radically altering curriculum or pedagogy. (Contains 47 references.) (Author/NB)

Advancing Ownership of Understanding and Responsibility through Homework in Mathematics Education

Joseph W. Spadano
Mathematics Department
Westford Academy
Westford, Massachusetts 01886-2921

Dana L. Zeidler
Science Education
College of Education
University of South Florida
Tampa Bay, Florida 33620-5650

Michaele F. Chappell
Mathematics Education
College of Education
University of South Florida
Tampa Bay, Florida 33620-5650

Advancing Ownership of Understanding and Responsibility through Homework in Mathematics Education

ABSTRACT

Philosophical traditions have a pedagogical impact on how we willingly or unwittingly conduct ourselves as educators. This paper presents an analytic review of two contrasting educational philosophies and their corresponding learning outcomes. Questions will be raised concerning the schism that exists between teacher-centered and learner-centered educational orientations, and their implications to concepts central to education such as ownership of understanding and responsibility. Finally we present an argument of how a rational policy of homework may be able to bring about goals consistent with current reform initiatives, without radically altering curriculum or pedagogy.

INTRODUCTION

A continuum of educational orientations may be operationalized by its corresponding instructional methodologies. Two educational orientations, teacher-centered and learner-centered, are juxtaposed within the context of understanding for the purpose of examining the impact these two pedagogical positions have on student learning and belief systems. The extreme case of each position (toward the ends of the continuum) provides us with distinctive regions where a discussion of educational orientations exposes stark contrasts. While in practice the activities of these educational orientations often become blurred, involving central tendencies on the pedagogical continuum, research (Goodlad, 1984) suggests that the teacher-centered educational orientation is the predominant pedagogical paradigm.

The purpose of this paper is to raise a question central to these educational orientations: "Who owns the understanding?". In teacher-centered classrooms, the ownership of understanding belongs to the teacher and is something shared with their students. In this classroom, the students learn by accepting this transfer of knowledge, in a non-evidential sense, and rely on the teacher for verifying their resultant belief systems. In the learner-centered classroom, the student is an active agent, central to the learning process and gains ownership of understanding by developing an evidential belief system.

The teacher-centered educational orientation is often associated with label of "teacher-as-expert", while the learner-centered one is designated by "teacher-as-facilitator". The pedagogy of teacher-as-facilitator is not new to the school of education. Its pedagogical roots are evident in Socratic inquiry. Yet, the absence of its pedagogical presence in contemporary classrooms poses a professional development nightmare. In the wake of intense reform initiatives (AAAS Project 2061, 1990; NCTM Standards, 1989; 1991; 1995) to implement a student-centered orientation of learning with an emphasis on problem solving skills, how will teachers receive the training necessary to implement the recommended changes? The issue may be change itself. Research (Hall & Loukes, 1979;

Jackson, 1971; Orlich, 1989; Schlecty, 1990; Zaltman, Florio, & Sikorski, 1977) abounds with issues of change, uncovering teachers' difficulty, reluctance, and fear of change. It seems necessary to examine alternative and more realistic ways of inducing change without radically altering curriculum or pedagogy.

We believe that the desired change can be advanced through a homework policy, developed from problem solving theory, that is consistent with learner-centered principles. Research (Spadano, 1996) suggests that a "Homework Model" may provide an unobtrusive means of addressing reform initiatives in mathematics classrooms. Failure to incorporate an appropriate homework model will result in, at best, pretentious lip service to current reform initiatives and, at worst, a noticeably stagnant inability of teachers to design and provide instructional strategies and learning environments for the individual needs of their students. Furthermore, failure to recognize the importance of homework, in relation to the learner-centered classroom, deprives the classroom teacher of the opportunity to fully implement the philosophical, psychological, and pedagogical benefits of autonomous learning, responsibility, and ownership of understanding.

FAITH AND DEED

The expected outcome of education is knowledge. A subset of this outcome is learning from teaching, where the means to the ends of knowledge are instructional methodologies. The teacher-centered, social behaviorist's pedagogical perspective (e.g.: Johann Herbart [1776-1841]; Wilhelm Wundt [1832-1920]; Edward Thorndike [1874-1949]) of transferring generalized knowledge through pre-determined, outcome-based objectives is not conducive to extending knowledge. Their theoretical framework is satisfied with content coverage, when mastery of objectives through skillful use of algorithms has been accomplished and measured by criterion-referenced exams. In this mastery learning approach the analysis of outcomes precedes the learning experience. The learner-centered, experientialist orientation (e.g.: Friedrich Froebel [1782-1852]; Francis Parker [1837-1902]; John Dewey [1859-1952]) is less restrictive with respect to pre-determined objectives or expected outcomes. Without strict adherence to pre-determined outcomes there are no limits to what knowledge results and learning becomes individualized. The "social behaviorist" is satisfied when "learning" has occurred while the "experientialist" pursues a deeper "understanding", constantly working in the student's zone of proximal development (Vygotsky, 1978). The traditional, social behaviorist classroom student has faith in what the teacher knows and believes what the teacher teaches. The progressive, experiential classroom student constructs an ownership of understanding by deed and believes what experience teaches (See Figure 1).

CONTINUUM OF EDUCATIONAL ORIENTATIONS

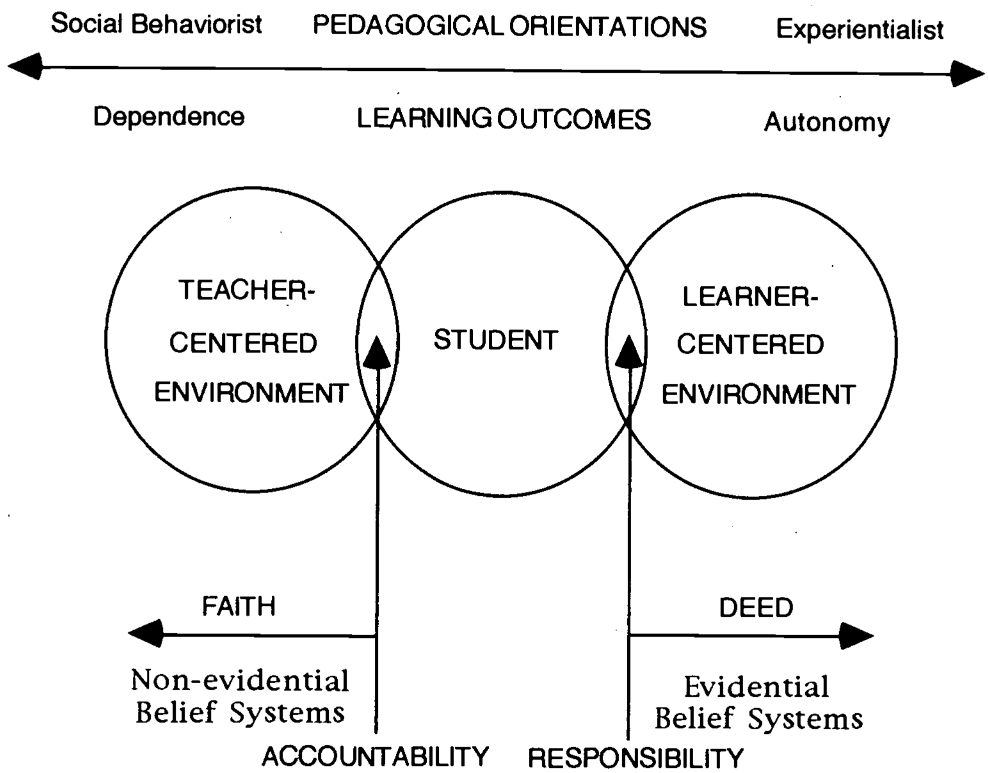

Figure 1: CONCEPTUAL ANALYSIS: Instructional Methodologies

In short, the debate between social behaviorist (with their adherence to measurement, precision, efficiency, and mechanical technique) and experientialist (with their child-centered, democratic, effective, problem-solving orientation) pitted formal science against investigative science. The social behaviorist sought controls through generalized knowledge by credentialed experts while the experientialist explored, through inquiry with others, for insights into experiences that may not yet be known (Schubert, 1986).

Round Multiple Learning Styles in Square Learning Environments.

Do teachers in today's classrooms try to fit round pegs into square holes? Gardner (1983) has collected many supporters of his theoretical perspective of multiple intelligences and perhaps alerted or reminded teachers that students (in fact, people in general) learn differently. Perhaps instead of the teacher selecting the "way" students learn, students themselves should direct and advance their particular learning style, thus insuring an appropriate match of learner and learning style. The social behaviorists cannot relinquish the learning process to the student since their corresponding framework depends on the transfer of the teachers' knowledge to their students. The experientialist framework is conducive to the pupil becoming the teacher since the teacher is also a participant in the learning process.

Thorndike (1903) and Dewey (1902; 1929) each believed that education should be elevated to a science. Yet, philosophically their inquiry in and study within the domains of curriculum and pedagogy are diametric. Consider the answers to these three questions, eternally fundamental to the science of education, from both the social behaviorist and experientialist perspectives: "What do you know?", "How did you come to know it?", and "How do you know you know it?". The responses may be the same for the first question but will be quite different for the last two. To question two, the student from the social behaviorist classroom would answer, "My teacher taught it to me.", while the experientialist classroom student would say, "By doing it.". The answer to the third question from the social behaviorist perspective might very well be, "I got an 'A' on my test.", and from the experientialist perspective, "It works.", or, "I proved it.".

Efficient or Effective Pedagogy:

Algorithmic Learning or Conceptual Understanding?

Often associated with these educational orientations is the debate of whether teachers should teach the algorithms of concepts or have students derive algorithms with their understanding of the concept. "Faith" would argue that efficient use of time is the deciding factor in giving the student the algorithm and understanding the concept is something that will develop if the student is able and genuinely interested in learning its derivation. This efficient use of time allows students to be introduced to many other algorithms and indoctrination to more algorithms is more knowledge. We hesitate to call this teaching and would distinguish it as <u>indoctrination</u>. This is a term that Green (1971) contrasts against teaching, in the context of beliefs. Indoctrination develops belief systems non-evidentially (faith) while teaching does so evidentially (deed or reason). The difference is not necessarily in the ends of beliefs, but rather the means by which they are developed. "In short, even though the beliefs one holds are true, one cannot be said to know they are true, if they are believed in this non-evidential fashion" (p. 299). "Deed" believes that if students explore a concept, discover a pattern or relationship, and derive a corresponding algorithm, that it is understanding owned by the student. Ownership of understanding may require more <u>time</u> but is justified by the experientialist's belief that it is effective learning. "Faith" believes that teaching the skillful use of algorithms is efficient learning. However, "To focus simply upon securing a right solution without understanding the nature of mathematical operations is the mathematical equivalent of indoctrination" (Green, 1971, p. 303). Parenthetically, we should point out that while we believe depth of study to be important, we know of no research which asserts its preference over breadth in establishing a knowledge base. The central question for educators to raise is, "What kind of learning do we wish to teach?".

The issue is really learning itself. There is no determinant that students in teacher-centered classrooms are learners because student activity is covert. "Deed" will argue that passivity is not natural or conducive to learning. Activity, or learning from experience, involves the student in the learning process and is overt. "Deed" believes that learning from experience is natural because it is how we tend to learn, in general. In both orientations learning involves sensory perceptions. In the experiential classroom there are, arguably, more senses involved. Learning in the social behaviorist model is often transferred from the teacher to the student by lecture and drill with an emphasis on skills (Goodlad, 1984), but what is involved in learning from experience? Shulman (1989) points out there are two obvious (yet possibly difficult to achieve) requirements - knowing what you did and identifying the consequences. Learning from experience requires careful attention to trials and their resultant errors. Trial and error can be very frustrating to learners, especially young learners. They can easily exhaust possible means in search of desired ends, or reach their desired ends while forgetting which means were used. In the social behaviorist classroom, the teacher chooses the shape of the lesson and, by so doing, efficiently directs the "way" in which students learn. The inefficiency of the experiential orientation, or the learner-centered classroom, is often considered to be the enormous quantity of mistakes students make in constructing understanding. However, it is precisely during mistakes where proponents of the experiential model claim that students (in fact, people in general) actually begin to understand. The experientialist adds that their model of teaching naturally corresponds to the "way" students learn. Dewey (1957, p. 279) defends this perspective stating, "Few men would purchase even a high amount of efficient action along definite lines at the price of monotony, or if success in action were bought by all abandonment of personal preference". If the difference between faith and deed is learning efficiently or effectively, then as a teacher, ask yourself this question, "Would I rather learn efficiently or effectively?".

Are there particular schools that favor faith or deed? College preparatory schools with their strict dependence on the outcomes of SAT scores are generally associated with the social behaviorist model of teaching while vocational education is often thought to espouse an experientialist one. Each association is determined primarily by the activities and teaching methods used in the classroom. Vocational courses differ from academic courses because vocational course students are about twice as likely to have used some kind of instrument, tool or equipment, and computer than academic course students. In addition, vocational teachers are more likely to administer a performance test or assess a student's portfolio than academic teachers since occupational skills are significantly more likely to contribute to a vocational student's grade. Interestingly, homework is much more likely to be assigned in an academic class (95%) than in a vocational class (59%) (Heaviside, 1994).

AUTONOMY AND RESPONSIBILITY

The purpose of education, as proposed by the great philosophers of Western traditions (e.g., Plato, Bacon, Hobbes, Descartes, Spinoza, Locke, Rousseau, Kant, Hegel and others), is to enable the development of the individual and society. Undeniably, the philosophical mission of preparing students to become responsible citizens advances this purpose of education. What are the criteria for developing responsibility in the learner? There are learners that are not autonomous and learning can certainly take place without learner autonomy. However, our claim, for teachers to consider, is that there exists a region of responsibility that is created only through "deed" when the learner is autonomous. The autonomous learner is independent and self-governing, and this freedom is essential in developing responsibility. This region stands in stark contrast to the region of accountability which is teacher-driven and exacts, as its cost, "faith" from the student. As we suggest in Figure 1, without autonomy the learner cannot become responsible.

Nowhere are mathematics learners more autonomous than during homework. It is during homework that learners reinforce content and internalize concepts. Homework also provides an opportunity for learners to isolate points of confusion as they construct an ownership of understanding. Polya (1988, p. 1) underscores the importance of autonomy by stating that the "student should acquire as much experience of independent work as possible". Does merely assigning homework mean that teachers are providing a window of opportunity for students to act responsibly? Not necessarily. Mathematics teachers spend a great deal of class time going over homework (Schoenfeld, 1985). This raises speculation about the reasonableness of the homework, the quality of the lesson which preceded the homework, or perhaps the students' accustomed dependence on the teacher for presenting solutions to the homework. If the student is accustomed to relying on the teacher for reviewing the homework, the learner is not autonomous and responsibility is not advanced.

Accountability or Responsibility?

This is a point where another schism between the social behaviorist and experientialist occurs. What motivates a student to do homework? The fundamental principle of the social behaviorist's stimulus-response framework is control. Behavior in S-R theory is controlled by rewards. In the social behaviorist classroom, the student is motivated to do homework because of a grade. Success in a social behaviorist classroom is measured by an accounting of student rewards (grades). Students motivated by rewards are not being taught responsibility. Grading, as a motivator, holds students accountable for doing homework, and increases their dependence on the teacher's quest for accountability. Does the grade a student receives measure their responsibility? Responsibility can be the source or cause of behavior, but in this case the grade controls the behavior. This is more appropriately described by accountability. Accountability can explain behavior but cannot be the source or cause of the behavior, it must rely on a mediating factor, in this case grades, which associates the causal relation.

In the experientialist classroom, evaluation of progress involves multiple assessments through portfolios of student work. The student, their parents, peers, and teacher can all become involved in the assessment strategy. There are several types of assessment formats, some of which are; Journals: which give the teacher insights into student understanding, Research Projects: individual or group, Performance:

demonstrations of student abilities, and Problem Solving: non-routine problems that challenge curiosity and creativity. The student is responsible for providing input into what will be included in their portfolio, which should document their mathematical growth. Success in an experiential classroom is measured by the growth of the student. It is very difficult to put a grade on such an individualized basis.

HOMEWORK'S ROLE IN MATHEMATICAL PEDAGOGY

A brief overview of characteristic studies provides an evidentiary base from which our final pedagogical claims will be derived. A more thorough report of homework (Spadano, 1996) and its place in mathematics education will further support our claims.

Homework: Policy or Curriculum?

In the Los Angeles Unified School District (1990), policy guidelines for assigning homework are provided as a part of the lesson planning and instruction of mathematics and science electives. Although the guidelines are general and their interpretations may vary somewhat from teacher to teacher the appearance of a homework philosophy is purposeful. The guidelines suggest ends but are unclear as to the means to be used to reach those ends. For example, "Daily homework assignments are important resources for teachers in helping students learn" (p. 24). No one would deny this as an appropriate end, but by which means does this become accomplished? Consider these additional statements: "Students should not be given homework assignments they have not been taught how to do; When appropriately assigned and explained by the teacher, homework becomes the responsibility of the student to understand" (p.24). Inasmuch as this view of homework is clearly teacher-centered, accountability and indoctrination result, not responsibility and understanding. The teacher produces dependence and faith as learning outcomes. This is contrary to the kind of student responsibility that develops from deed in the autonomous learner.

The Cleveland Collaborative for Mathematics Education (C2ME) used homework as the curriculum. The C2ME intended to change the role and status of teachers of mathematics. "This curriculum was characterized by directed lessons with coverage of content held to the minimum...Homework is the mathematics lesson" (Bruckerhoff, 1989, pp. 43-44). In this project the definition of homework has changed. It is something done in class from the beginning bell to the ending bell as well as at home. Bruckerhoff suggests that the homework curriculum helps students learn mathematics, but was concerned with what kind of mathematics was being taught and how it was being learned.

Sequential mathematics for grades 9-11, which extends the integrated K-8 curriculum, governed by the New York City Board of Education, interweaves algebra, geometry, logic, probability, statistics, and trigonometry. The lessons involve a motivational activity, generally related to the students' experiences (Bresnan, 1985). This activity appears to have an experientialist flavor, developing critical thinking skills through applications, and performance objectives, however the homework is primarily drill and practice designed to reinforce the specific goals and objectives.

The New York City Board of Education (1987a; 1987b) has produced materials from workshop sessions which include, homework planning and review to maximize student learning, designed for new teachers of mathematics. The emphasis is on planning and significance of homework with regard to instructional goals. This material suggests that careful consideration be given when assigning homework. The type of consideration is left to the teacher to determine.

Homework: Teaching or Learning

Bloom (1981) suggests that evaluation can be used to improve learning. The evaluation (homework, quizzes, tests, etc.) is the motivating factor for the student to do their work. This is referred to as "teaching by testing". Posamentier and Stepelman (1990) concur that extrinsic motivation induced by the expectation of a quiz is a useful factor in the learning process, but caution that this should not be done for punitive reasons and should be used sparingly to determine the level of mastery of a particular homework assignment. Motivation from sources external to the student is also derived from teachers' practices of collecting and grading homework. Columba and Dolgos (1993) are also among the many who espouse the social behaviorist perspective to homework. They present a "drill-and-review" process in which students take daily quizzes and then correct each other's work.

The rationale used by teachers relative to grading homework varies from teacher to teacher. Some teachers do not grade homework but give credit to the student for attempting to accomplish it. The grading of homework is often the motivation for the student doing the homework. However, as Ropp (1992, p. 536) points out, "collecting homework takes it away from the student and makes mountains of paper work for the teacher". Ropp's solution to the "homework dilemma" is to use a homework scorecard where students receive a '5' for a complete assignment (not necessarily a correct one), a '1' for an incomplete assignment, and a '0' for no attempt at all. "Although a perfect score on a test may be difficult to achieve, a perfect homework score is possible for all students" (p. 536). Notice here that students can get a perfect homework grade for just attempting it, yet their test scores will not necessarily reflect their doing the homework. This homework policy holds students accountable for attempting the assignment. It does not hold the student responsible to do homework to gain ownership of understanding or improve test scores.

Stanulonis (1992) uses a similar scorecard to record homework. One difference being that the students keep track of their grades as well as the teacher. She believes this method is a motivational technique and teaches responsibility. We hesitate to think that responsibility is being taught. Perhaps she is teaching accountability since responsible students do not need to be grade-motivated to do homework.

Marquis (1989) reminds us that problems should be carefully chosen with a purpose in mind. When teachers assign "page 32, 1-31 odd", for example, they may be "sending a message to students that no thought was given to the selection of particular problems, implying that none are particularly essential, important, or meaningful" (p. 423). In addition, she recommends that a system of accountability motivates and interests students because of its variety. This system includes collecting and grading random homework assignments, giving frequent quizzes, and giving open-notebook quizzes. The idea behind this frequent quiz and test strategy is one where the student is rewarded for doing the homework. The grades are the motivating factor. Grades as motivators to do homework, that extend to include frequent evaluations based on the homework, are often interpreted as measuring learning. "Good" grades are often associated with "good" learning. This is the "teaching by testing" method in all its glory.

It seems clear that homework is a part of how teachers expect students to learn mathematics. If the activity of a mathematics classroom exposes students to a concept, and examples of exercises which apply an algorithm to the concept are demonstrated by the teacher at the chalkboard, homework becomes a culminating event. In the 15-30 exercises which are assigned for homework, students repetitively invoke the algorithm of the day to master the concept. Using this mastery learning approach there is a concentrated focus on that particular algorithm, as it relates to the concept, with little connection made to last week's or yesterday's concept. This approach to teaching is algorithmic and establishes field dependence. This is not problem-solving, it is exercise-solving. This is the social behaviorist's homework perspective, not the experientialist's. It appears to be the dominant use of homework but is it the best use?

Spending more time teaching is more time available for influencing learning. The more time students spend in school appears to directly affect learning. Research (Goodlad, 1984) shows the amount of time spent on a given subject (particularly core subjects like mathematics and science) is a powerful factor in learning. Is spending more time on homework beneficial to learning?

Data (OERI, 1986) on the time spent on mathematics instruction and homework were collected from 20 countries. Japanese students ranked first in all mathematics content areas. Regarding homework, 95% of the Japanese teachers represented that their students did less than three hours of homework per week, while 83% of the United States teachers believed that their students did greater than three hours of homework per week. In addition, 12% of United States students did not do homework, in contrast to only 3% of Japanese students not doing homework.

In a comparison of mathematics instruction in Tokyo and Hawaii schools, Lai and Whitman (1988, p. 6) reported that "Hawaii teachers spent three times the amount of time explaining homework than did Tokyo teachers." This dramatic difference in time spent reviewing homework could be attributed to different interpretations or meanings of homework. The "Juku (after school) class that about 50% of the Tokyo students attend" (p. 7) was not considered to be homework.

Time spent on learning seems to be dramatically different between Asian students and American students. Stephenson (1983) conducted a study of school achievement in Japan, Taiwan, and the United States. In his comparative study, he asked the students' mothers if luck, ability, or effort were the critical factors underlying achievement. He reports that Asian mothers said effort while U.S. moms said ability (Hard work leads to success?).

FLOTSAM AND JETSAM

Questions always arise when reviewing the literature as to what we wish to salvage from it and what should be jettisoned. At this point we then cautiously attempt to deduce or infer the "open questions". We have seen many uses of homework in the review of the literature, but what about homework for enrichment, or enhancement of understanding? Can homework extend learning to include specific areas of individual or group interests? What about homework as research, as an advanced organizer or as a means of discovery? It appears that considering such questions will require careful thought and visionary perspectives for the future of education. The literature surrounding the varied philosophical approaches of assigning, correcting, and assessing homework confuses the purpose, relevance, and importance of homework. The literature tells us much about homework and responsibility by telling us very little. Minor, if any, attention is devoted to homework as a vehicle for developing autonomous learners. The bulk of the literature is devoted to how the teacher, not the student, conducts reviews of homework. Therefore it is quite clear, from the lack of literature, that there is virtually no homework model which addresses the development of student responsibility. The literature tells us very little about homework in an experiential setting. The primary focus of homework appears to be reinforcing content through drill and practice. The current philosophical state of homework does not develop student responsibility, it develops student dependence. The student learns very quickly in the mathematics classroom that attempting to do homework is sufficient, since credit is given for effort, not understanding, and whatever effort is made, the teacher will go over the homework questions in class. This allows or teaches students to attempt just enough to get credit for doing the homework and it teaches students nothing about their self-governing control in gaining ownership of understanding. The student also learns that homework is not likely to be collected and meaningfully evaluated, removing purpose and importance from doing the homework. The teacher should reflect on the question, "Why are there so many questions on the homework?", and determine the answer.

Virtually no reference to homework regarding learning styles was discussed in the literature. The noticeable absence of the "homework-learning style" relationship is puzzling. If learning styles are admittedly as multiple as there are learners, why not gear the homework assignment to each type of learner? People learn differently, so why not adapt the homework to match the individual's learning style? If management is a concern of not fully implementing multiple teaching styles to accommodate multiple learning styles in the classroom, perhaps it would be appropriate to capitalize on homework as an opportunity to match the learner to their learning style.

RATIONAL RUMINATIONS: A LOOK FORWARD

Recent education reform initiatives (AAAS Project 2061, 1990; NCTM Standards 1989; 1991; 1995) suggest that curriculum should be based on an experientialist philosophy advanced through instructional techniques involving inquiry, problem-solving, discovery, and conceptual application. This represents a shift from the traditional teacher-centered classroom to one which is learner-centered. This pedagogical shift positions the student as an active agent central to the learning process and repositions the teacher as a facilitator of knowledge. Questions immediately surface. Is it sometimes necessary to teach just an algorithm, and not the concept, because the conceptual understanding does not exist? Regardless of which pedagogical orientation of schooling a teacher assumes, is it possible to teach an algorithm without understanding its essence? In other words, is it possible to conduct an experiment which demonstrates a phenomenon, get predictable results, explain the phenomenon with a mathematical formula, and yet, not be able to deduce the phenomenon's cause or reason?

Although Newton did not conceptually understand gravity he was able to quantify its actions (Significance unnecessary to mention!). This example of algorithm, not understanding, is paradoxical. Can we ignore physical intelligibility for the sake of mathematical description? Newton merely had a rule of computation and elevated it to a law of nature. Providing the mathematical description in the absence of the physical mechanism concerned great contemporary scientists and mathematicians, like Huygens and Leibnitz, who criticized Newton's accounts. Yet there are many mathematical algorithms standing alone and indefensible because we lack a complete physical understanding of its related concept. As Kline (1985, p. 122) states, actually what we have found since Newton's day is "that our best knowledge of the physical world is mathematical knowledge". This suggests that it is unnecessary to have conceptual understanding in order to teach applications of mathematical algorithms.

Given this scenario, one wonders if the social behaviorist's grip on mathematical pedagogy is so strong that the experientialist model will, at best, be rarely utilized. Perhaps it is because the social behaviorist's short term gains satisfy so quickly and the return on an investment in experientialism, although it may be greater, is not as quick to reward. It is also possible that teachers may not understand the importance of developing the habits of a mathematical mind through an evidentiary belief system. For example, teachers who teach that any non-zero number divided by zero is undefined must encourage and be prepared to answer the question, "Why?". Dependence on algorithms, like dependence on calculators, is only useful if the answers they provide are reasonable to the problem-solver. The "reasonableness" of an answer can only be derived by a measure of ownership as it pertains to autonomous understanding.

Autonomous learning, by definition, is individualized, independent, and self-governing. Yet, to some degree, the teacher will always be a hindrance to student independence and will measurably control or govern the learning process. Can there truly be autonomous learning in this abrogated context? Consider mathematics students to be farm oxen and homework their yoke. Is the yoked oxen independent and self-governing? No more, one would possibly argue, than the "homeworked" students. Yet if the oxen foresee the consequences of the yoke to be harvest, as the students see homework to be understanding, and identify themselves with the realization of its possibilities, they act autonomously (Dewey, 1957).

Capitalizing on learner autonomy through a homework policy which is sensitive to education reform initiatives, the teacher becomes a **learning manager**. A learning manager is not necessarily the primary source of knowledge. With individualized, on-going assessment through regular homework assignments, a learning manager has the opportunity to diagnose student needs, identify and select appropriate learning objectives, select and organize learning experiences, and measure students' progress toward the learning objectives (Tyler, 1950). This unique assessment of progress identifies student needs, returning the learner manager to the beginning of the teaching-learning cycle.

Homework's ubiquitous presence as an educative product is a proclamation of its importance to the educative process. From this it follows that credit or blame for student achievement may be due, in part, to homework. Homework has its place in each educational orientation (See Figure 2). For the social behaviorist, homework serves as drill and reinforcement of the prescribed criteria, helping students gain mastery of behavioral

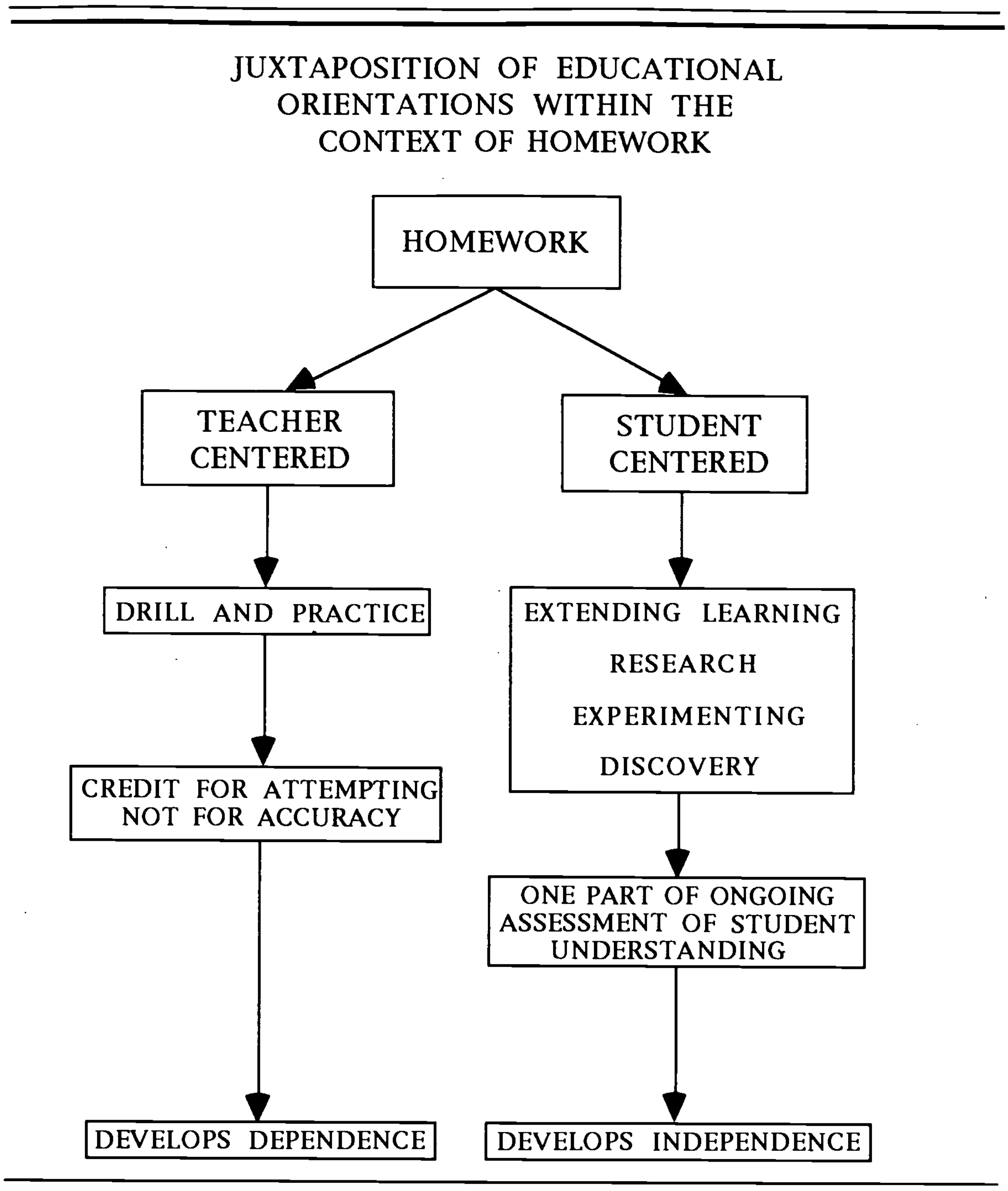

Figure 2: Homework's Role in Educational Orientations

objectives. Students often ask their teacher, "Is this right?", verifying the control of the teacher, as the owner and authority of knowledge, and the students' dependence on the teacher for confirmation of understanding. The experientialist uses homework to initiate and develop independence helping students gain ownership of understanding. The student develops a belief system that is compared not only to the teacher's but also to their peers.

Cognitive psychology and mathematics education research (Case & Bereiter, 1984; Cobb & Steffe, 1983; Davis, 1984; Hiebert, 1986; Lampert, 1986; Lesh & Landau, 1983; Schoenfeld, 1987) suggests that learning occurs when students actively collect new information and construct their own meanings. In mathematical terms, this means actively connecting prior knowledge to new knowledge, experientially, developing mathematical belief systems. Teachers using a learner-centered homework model, which can be utilized by social behaviorists or experientialists without radically altering curriculum or pedagogy, are able to recognize the importance of homework in relation to the philosophy of the learner-centered classroom. Homework should be purposefully challenging and develop problem-solving strategies. High expectations, regarding the quality of homework, should be modeled, established, and its integrity should not be compromised. Homework should exploit multiple learning styles to actively engage students in the discovery and application of concepts. Assessment of homework should enable teachers to diagnose students' needs and design learning activities to satisfy those needs. Homework should enable the growth of student responsibility by capitalizing on learner autonomy and develop belief systems as students construct an ownership of understanding. Homework discussion, in class, should make connections within and across disciplines, as well as provide opportunities for students to interact, demonstrate competency, or exhibit work. To avoid the students becoming dependent upon the teacher for solutions to the homework, the homework reviews should only focus on isolated points of homework confusion identified by the students.

If a homework model is to serve responsibility and understanding then it must have a plan. Adapting Polya's (1988) plan for solving problems in, "How to Solve It", these necessary conditions can be satisfied. The Homework Model identifies four salient phases in solving homework problems and requires students to be active participants in the problems' solutions. With this plan, or Homework Model, students are expected to identify and isolate points of homework confusion into one of four areas: (1) understanding the problem; (2) devising a plan to solve the problem; (3) executing the plan to effect a solution; and (4) checking the solution. If students are confused with a homework problem they are responsible for communicating their specifically isolated point of confusion during the Homework Model review, thereby capitalizing on their autonomy (independence and self-governance). Students are expected to "Go through the principal parts of your problem, consider them one by one, consider them in turn, consider them in various combinations, relating each detail to other details and each to the whole of the problem" (p. 33). Students must realize that in solving a problem they should work from a problem state to a solution state. Students should find that working from the problem state to the solution state often involves a series of subgoals which are necessary in reaching the solution state. The application of Polya's plan is consistent with developing the kind of belief systems and dimensions of autonomous deeds that structure students' ownership of understanding. The important pedagogical aspect, during the Homework Model review, is that the teacher manage the learning process by allowing the student to precisely communicate their points of homework confusion. This places a reasonable share of the work to solve the problem on the students. It also enables teachers to specifically diagnose students' needs and design learning experiences to satisfy those needs by questioning, prompting, and providing hints or suggestions to clarify the confusion to allow the <u>student</u> to continue solving the problem. With the Homework Model, students quickly realize that simply "attempting" the homework problems will not suffice and that the purpose of homework is to advance understanding. When students begin to sense that understanding is their responsibility, they become learners, actively taking control of the learning process. This "promotes students' confidence, flexibility, perseverance, curiosity, and inventiveness" (NCTM, 1991, p. 104).

Conclusion

Often in education, we, in theory, attempt to justify a particular pedagogical philosophy using a syntax that reflects a peculiar order of constructed social reality. Accountability, responsibility, authentic assessment, teacher-centered, student-centered, and constructivism are terms (among others) that reflect that syntax in recent years. Yet often the theory is molded as much by external constraints (spatial, temporal, physical, and contextual), as it is by its own internal ideology. Richardson (1990, p. 34) suggests "Buried beneath the apparent 'plain speak' are metaphoric, theoretical, and empirical traditions, which position and deepen the text for the social scientist." Is the dominant teacher-centered pedagogical justification fabricated by inflexible scheduling and curricula, or have we the freedom to exercise our practice because of our theoretical beliefs? Recent education reform initiatives suggest a pedagogical shift from teacher-as-owner-of-knowledge to teacher-as-facilitator-of-knowledge. This reform is radical change and will not likely take place in most of our educational classrooms; it opposes the change dynamics of human nature and conventionally-embedded tradition. However, a "whisper" of change, through careful attention to homework, is quite possible. Subtle change, coupled with teacher education that is aligned with the philosophy and principles of the learner-centered classroom, is more likely to accomplish what radical reform rhetoric cannot.

REFERENCES

AAAS (1990). Science for all Americans: Project 2061. New York: Oxford. [American Association for the Advancement of Science].

Bloom, B.S., et al. (1981). Evaluation to improve learning. New York: McGraw-Hill Book Co.

Bresnan, M., et al. (1985). Sequential mathematics course II. New York City Board of Education, Division of Curriculum and Instruction, Brooklyn, N.Y.

Bruckerhoff, C.E. (1989). Teachers on the board: The Cleveland collaborative for mathematics education. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.

Case, R. and Bereiter, C. (1984). From behaviorism to cognitive development. Instructional Science, 13, 141-158.

Cobb, P. and Steffe, L.P. (1983). The constructivist researcher as teacher and model builder. Journal for Research in Mathematics Education, 14, 83-94.

Columba, L. and Dolgos, K.A. (1993). Tips for beginners. Mathematics Teacher, 86 (5), 378-379.

Davis, R.B. (1984). Learning mathematics: The cognitive science approach to mathematics education. Norwood, N.J.: Ablex.

Dewey, J. (1902). The child and the curriculum. Chicago: The University of Chicago Press.

Dewey, J. (1929). The sources of a science of education. New York: H. Liveright..

Dewey, J. (1957). Human nature and conduct. New York: The Modern Library.

Gardner, H. (1983). Frames of mind: The theory of multiple intelligences. New York: Basic Books.

Goodlad, J. (1984). A place called school: Prospects for the future. New York: McGraw-Hill.

Green, T.F. (1971). A topology of the teaching concept. Studies in Philosophy and Education, 3 (4), 284-320.

Hall, G.E. and Loukes, S. (1979). Teacher concerns as a basis for facilitating and personalizing staff development. In A. Lieberman and L. Miller (Eds.), Staff development; New demands, new realities, new perspectives. New York: Teachers College Press.

Heaviside, S. (1994). Public Secondary School Teacher Survey on Vocational Education. National Center for Education Statistics, Washington, D.C.

Hiebert, J. (Ed.). (1986). Conceptual and procedural knowledge: The case of mathematics. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Jackson, P.W. (1971). Old dogs and new tricks: Observations on the continuing education of teacher. In L.J. Rubin (Ed.), Improving in-service education: Proposals and procedures for change. Boston: Allyn and Bacon, 19-36.

Kline, M. (1986). Mathematics and the search for knowledge. New York: Oxford University Press.

Lai, M.K. and Whitman, N.C. (1988, April). A comparison of mathematics instruction in Tokyo and Hawaii junior high schools. Paper presented at the Annual Meeting of the American Educational Research Association, Washington, D.C.

Lampert, M. (1986). Knowing, doing, and teaching mathematics. Cognitive and Instruction, 3, 305-342.

Lesh, R. and Landau, L. (Eds.) (1983). Acquisition of mathematics concepts and processes. New York: Academic Press.

Los Angeles Unified School District (1990). Investigations in math and science AB: A course of study for grades 7-12. (Report No. SC-974). CA: Office of Secondary Instruction.

Marquis, J. (1989). What can we do about the high D and F rate in first-year algebra? Mathematics Teacher, 82 (6), 421-425.

NCTM (1989). Curriculum and evaluation standards for school mathematics. Reston, VA.

NCTM (1991). Professional standards for teaching mathematics. Reston, VA.

NCTM (1995). Assessment standards for school mathematics. Reston, VA.

New York City Board of Education. (1987a). Computers in the biology classroom. (Report No. Curric.-06-8010-40). Brookline, NY: New York City Board of Education.

New York City Board of Education, NY. (1987b). New teachers mathematics staff development, junior high school. Brookline, NY: New York City Board of Education, Division of Curriculum and Instruction.

OERI Bulletin (1986, December). Time spent on mathematics instruction and homework by Japanese and U.S. 13-year-old-students. Washington, D.C.: Center for Education Statistics.

Orlich, D.C. (1989). Staff development: Enhancing human potential. Needham Heights, MA: Allyn and Bacon.

Polya, G. (1988). How to solve it: A new aspect of mathematical method. Princeton, N.J.: Princeton University Press.

Posamentier, A.S. and Stepelman, J. (1990). Teaching secondary school mathematics: Techniques and enrichment units. New York: Macmillan Publishing Company.

Ropp, C. (1992). Tips for beginners: Solving the homework dilemma. Mathematics Teacher, 85 (7), 536-537.

Richardson, L. (1990). Writing strategies: Reaching diverse audiences. Newbury Park, CA: Sage Publications, Inc.

Schlecty, P.C. (1990). Schools for the twenty-first century. San Francisco: Jossey-Bass.

Schoenfeld, A.H. (1985). Mathematical problem solving. San Diego, CA: Academic Press.

Schoenfeld, A.H. (1987). Cognitive science and mathematics education. Hillsdale, NJ: Lawrence Erlbaum Associates.

Schubert, W.H. (1986). Curriculum: Perspective, paradigm, and possibility. New York: Macmillan Publishing Company.

Shulman, L.S. (1989). Teaching alone, learning together: Needed agendas for the new reforms. In T. Sergiovanni & J. Moore (Eds.), Schooling for tomorrow: directing reforms to issues that count. Boston: Allyn and Bacon.

Spadano, J.W. (1996). Examining a homework model as a means of advancing ownership of understanding and responsibility in secondary mathematics education. (Doctoral dissertation, Dissertation Abstracts International, University of Massachusetts Lowell, 1996).

Stanulonis, J. (1992). Tips for beginners. Mathematics Teacher, 85 (3), 196.

Stephenson, H.W. (1983). Making the grade: school achievement in Japan, Taiwan, and the United States. (Annual Report). Stanford, CA: Stanford University, Center for Advanced Study in the Behavioral Sciences.

Thorndike, E.L. (1903). Educational psychology. New York: The Science Press.

Tyler, R.W. (1950). Basic principles of curriculum and instruction. Chicago: University of Chicago Press.

Vygotsky, L.S. (1978). Mind in society. Cambridge, MA: Harvard University Press.

Zaltman, G., Florio, D.H. and Sikorski, L.A. (1977). Why research is not readily used in educational settings. Dynamic Educational Change. New York: The Free Press.

SE060435

ERIC®

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: ADVANCING OWNERSHIP OF UNDERSTANDING AND RESPONSIBILITY THROUGH HOMEWORK IN MATHEMATICS EDUCATION

Author(s): SPADANO, ZEIDLER, CHAPPELL

Corporate Source: UNIV. OF SOUTH FLORIDA

Publication Date:

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic/optical media, and sold through the ERIC Document Reproduction Service (EDRS) or other ERIC vendors. Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following two options and sign at the bottom of the page.

☑ Check here **For Level 1 Release:** Permitting reproduction in microfiche (4" x 6" film) or other ERIC archival media (e.g., electronic or optical) *and* paper copy.

The sample sticker shown below will be affixed to all Level 1 documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Level 1

The sample sticker shown below will be affixed to all Level 2 documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Level 2

☐ Check here **For Level 2 Release:** Permitting reproduction in microfiche (4" x 6" film) or other ERIC archival media (e.g., electronic or optical), but *not* in paper copy.

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but neither box is checked, documents will be processed at Level 1.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic/optical media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries."

Sign here→ please

Signature: Dana L. Zeidler

Printed Name/Position/Title: DANA L. ZEIDLER, Ph.D. PROFESSOR, SCI. EDU.

Organization/Address: UNIV. OF SOUTH FLORIDA 4202 E. FOWLER AVE TAMPA, FL 33620-3533

Telephone: 813 974 7305

FAX: 813 974 3837

E-Mail Address: zeidler@tempest.coedu.usf.edu

Date: 10/1/97

ERIC

(over)

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, *or*, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

ERIC/CSMEE
1929 Kenny Road
Columbus, OH 43210-1080

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

ERIC Processing and Reference Facility
1100 West Street, 2d Floor
Laurel, Maryland 20707-3598

Telephone: 301-497-4080
Toll Free: 800-799-3742
FAX: 301-953-0263
e-mail: ericfac@inet.ed.gov
WWW: http://ericfac.piccard.csc.com