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ABSTRACT

The findings of this study support the positive effect of constructivist learning practices, specifically on emphasis on problem solving strategies and their effect on student mathematics achievement. The results also suggest that setting, certification, teaching experience, gender, and minority status are factors related to the use of constructivist teaching, learning, and supervision practices. These findings imply that smaller rural schools may provide environments that are more suitable for constructivist teaching practices to occur and that younger staffs, females, minorities, and mathematics teachers are more likely to use constructivist practices. (Contains 23 references and 6 tables.) (ASK)

RELATIONSHIPS OF TEACHING, LEARNING, AND SUPERVISION: THEIR INFLUENCE ON STUDENT ACHIEVEMENT IN MATHEMATICS

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Relationships of Teaching, Learning, and Supervision: Their Influence on Student Achievement in Mathematics

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The findings of this study support the positive effect of constructivist learning practices, specifically an emphasis on problem solving strategies and their effect on student mathematics achievement. The results also suggest that setting, certification, teaching experience, gender, and minority status are factors related to the use of constructivist teaching, learning, and supervisory practices. These findings imply that smaller rural schools may provide environments that are more suitable for constructivist teaching practices to occur and that younger staffs, females, minorities, and mathematics teachers are more likely to use constructivist practices.

INTRODUCTION

Student achievement in mathematics remains a major topic in education. International comparisons of math achievement show that students in the United States lag behind their counterparts in other industrialized countries (NCES, 1995b, Stevenson & Stigler, 1992, NCEE, 1983). Therefore, education policy makers have devoted considerable attention to the problem of how to improve United States students' achievement in mathematics. A theory of learning that promises to deliver higher levels of achievement is the use of constructivism within educational settings. Its influence on instructional practices and the effect it may have on student achievement cannot be underestimated.

Teachers' collective opinions of teaching, learning, and supervision are often referred to as important components of improving student achievement. However, much of the research about constructivism has been limited to its effects on students (Au, 1993; Dunlap and Grabinger, 1996; Jonassen, Myers, and McKillop, 1996). Little research has been documented that uses constructivism and supervision in the same sentence. Although studies generated by the effective schools literature (Zigarella, 1996) have identified variables that have been used to describe effective classrooms, a limited amount of empirical information exists that characterizes constructivist theories of learning. The findings from this study contribute to the literature by offering evidence of the linkages among teacher perceptions of constructivist teaching, learning, and supervisory practices by identifying their characteristics, factors, and interrelationships and the effects on student math achievement.

To date, much of the research investigating constructivism as a form of school renewal has centered upon the perceptions of how students learn rather than how teachers learn. In many cases, research methodology features isolated case studies or small-scale ethnographies that examine teaching, learning, and supervision apart from one another. Although studies generated by the effective schools literature have identified variables that have been used to describe effective classrooms, a limited amount of quantitative studies exist that characterizes constructivist theories of learning.

This study examines teachers' views of constructivist teaching, learning, and supervisory practices, by researching the characteristics, factors, and interrelationship of perceptions and environmental conditions that ultimately influence student math achievement. The focus of this study examines relationships between the perceptions of constructivist practices contained in the National Education Longitudinal Study of 1988. The advantages of using a large-scale national database to study constructivist teaching, learning, and supervisory practices provide unique opportunities for in-depth examinations of educational practices. Previous studies of this nature do not offer a quantitative research design containing the level of sophistication that characterizes the NELS sample. Specifically, the study examined four areas of interest: a) teachers' perceptions of constructivist teaching, learning, and supervision; b) factors influencing teachers' perceptions of constructivist teaching, learning, and supervision; c) the relationships of teachers' perceptions of constructivist teaching, learning, and supervisory practices; and d) the influence of constructivist practices on student math achievement.

A Constructivist Framework

This study is grounded in the theory of constructivism (Dewey, 1916; Piaget, 1973; Vygotsky, 1978). Since the theoretical foundation of constructivism was formulated, several authors have added to the literature (Brooks & Brooks, 1993; Fosnot, 1989; Papert, 1993). Consequently, modern constructivism has broadened to incorporate ideas about cultural and social learning. Inquiring about one's prior knowledge, allowing student responses to guide lessons, and assessing what students have learned rather than what has been taught requires attitudes of openness and vulnerability that some teachers are unwilling or unable to adopt (Brooks & Brooks, 1993). It is important that teachers and supervisors share a collective responsibility for student learning and display an attitude of cooperation and willingness to learn new ways to teach and enhance learning.

According to Brooks and Brooks (1993), constructivism draws upon the synthesis of cognitive psychology, philosophy, and anthropology to create a comprehensive theory of knowledge and learning. Constructivist theory defines knowledge as temporary, developmental, socially and culturally mediated, and non-objective. From this perspective, learning is understood as a self-regulated process of resolving inner cognitive conflicts that may become apparent through collaborative discourse, reflection, and concrete experience. Constructivist pedagogy consists of: a) structuring learning around relevant and meaningful concepts; b) placing value on the individual's need to actively create knowledge; c) adapting programs to provide a blend of individual and social interaction; and d) integrating authentic experiences within the context of instructional activities.

It is clear that research has shown that much can be gained by infusing constructivism into instructional frameworks (Au, 1993; Brooks & Brooks, 1993; Fosnot, 1989; Papert, 1993; Wilson, 1996). It offers promise in the development of successful learning experiences that allow students, teachers, and school administrators to think, apply knowledge, and solve problems. For example, we know that individuals are more likely to retain knowledge that they create or learn through active problem solving (Papert, 1993; Piaget, 1973) and that learning is often a social process, enriched by the insights of others (Au, 1993; von Glasersfield, 1995; Vygotsky, 1978). We also know that learning involves making connections and those connections depend upon what the individual brings to learning – prior knowledge and past experiences (Brooks & Brooks, 1993; Piaget, 1973).

METHODS

Data Source

Data was drawn from the National Educational Longitudinal Study of 1988 (NELS), which was designed and conducted by the U.S. Department of Education's National Center for Education Statistics (NCES, 1992) under the U.S. Department of Education. NELS was part of a long term project to study the educational, vocational, and personal development of students at various grade levels and the personal, family, social, institutional, and cultural factors that may affect that development (Ingels, Dowd, Baldridge, Stipe, Bartot, Frankel, 1993). As a large-scale study, NELS is particularly well suited for research purposes. First, NELS was developed to investigate the institutional, social, and family background factors that influence student' educational development from eighth grade, through high school, and into post-secondary education. Second, NELS uses a survey design with a two-stage, stratified sample that provides the opportunity to examine data from two clusters: teacher responses and student achievement. Third, NELS provides variables from the base year (1988) and first follow-up questionnaires (1990). For the purpose of this study, (a) students who had mathematics achievement scores in both the base year and the first follow-up study, and (b) teachers who completed questionnaires from the first follow-up study were included in the sample to examine relationships between the perceptions of constructivist practices. In addition to items representing the constructs of constructivism, NELS also contains important school and teacher background variables, the impact of which was also examined in the study. NELS includes data from 14,915 teachers and 1,035 schools. This rich database offers excellent opportunities to create reliable and valid measures of constructivist teaching, learning, and supervisory practices.

Indicators of Constructivism

Indicators of constructivism (constructivist teaching, learning, and supervisory practices) were created by identifying variables through exploratory factor analysis that captured the constructs of constructivism. Constructivist teaching practices were represented by three composite variables: teacher empowerment, teacher collaboration, and professional support. Constructivist learning practices were represented by three composite variables: problem solving, professional development, and teacher commitment. Constructivist supervisory practices were represented by three composite variables: administrative support, building leadership, and staff morale. Descriptions of these constructivist practices are presented in Table I. Reliability of these variables was examined using Crombach's alpha method. Results showed that coefficients ranged from .52 to .83. Variables indicating school and teacher characteristics (e. g. school size, setting, gender, certification, experience, race), which have commonly been used in correlation studies on school achievement, were also included in this study.

Table I
Variables of Constructivist Practices

Variables	Descriptions
CONSTRUCTIVIST TEACHING PRACTICES	
Teacher Empowerment F1T2_17B Teacher control over content F1T2_17A Teacher control over texts/materials F1T2_17C Teacher control over teaching F1T4_9D Teacher influence establishing curriculum	A factor-weighted, standardized composite score. The factor has an eigenvalue of .832 and explains 18.1% of the variance. Alpha = .67
Teacher Collaboration F1T4_1A Coord. content with department teachers F1T4_1P Familiar w/content taught by dept. tchrs. F1T4_1N Coord. content with teachers outside dept. F1T4_2E Great deal of cooperative effort in school	A factor-weighted, standardized composite score. The factor has an eigenvalue of .756 and explains 16.2% of the variance. Alpha = .52
Professional Support F1T4_8D Dept. colleagues improved teaching F1T4_8B Dept. chair improved teaching F1T4_8E Teachers outside dept. improved teaching	A factor-weighted, standardized composite score. The factor has an eigenvalue of .836 and explains 15.4% of the variance. Alpha = .63
CONSTRUCTIVIST LEARNING PRACTICES	
Teacher Commitment F1T323HH Hours communicating with parents F1T323IH Hours tutoring individual students F1T323JH Hours in academic counseling with students F1T323KH Hours in personal counseling with students	A factor-weighted, standardized composite score. The factor has an eigenvalue of .694 and explains 14.1% of the variance. Alpha = .55

Emphasis on Problem Solving F1T2M19J Emphasis on problem solution F1T2M19G Emphasis on math concepts F1T2M19F Emphasis on importance of mathematics	A factor-weighted, standardized composite score. The factor has an eigenvalue .761 of and explains 16.4% of the variance. Alpha = .64
Professional Development F1T3_20F Enrolled in university extension courses F1T3_20G Enrolled in college courses in education during school year F1T3_20H Enrolled in other college courses during school year	A factor-weighted, standardized composite score. The factor has an eigenvalue of .726 and explains 15% of the variance. Alpha = .57
CONSTRUCTIVIST SUPERVISORY PRACTICES	
Administrative Support F1T4_2M Principal consults staff before making decisions F1T4_2K Principal interested in innovation F1T4_2Q Union and administration work together F1T4_1P Administration knows problems faced by staff F1T4_1Q Teachers encouraged to experiment with teaching	A factor-weighted, standardized composite score. The factor has an eigenvalue of .819 and explains 23.2% of the variance. Alpha = .80
Building Leadership F1T4_1G Principal deals with outside pressures F1T4_1H Principal makes plans and carries them out F1T4_1J Goals/priorities for school year are clear F1T4_1O Principal knows what kind of school he wants	A factor-weighted, standardized composite score. The factor has an eigenvalue of .873 and explains 22.5% of the variance. Alpha = .83
Staff Morale F1T3_15 Teacher would become a teacher again F1T4_2G Teacher usually looks forward to each day F1T3_16 Teacher feels satisfied with job	A factor-weighted, standardized composite score. The factor has an eigenvalue of .819 and explains 16.5% of the variance. Alpha = .75

NOTE: NELS:88 variable names are capitalized. The prefix F1 refers to the first follow-up year of the NELS:88 Longitudinal Study.

Data Analysis

Data analysis began by first using descriptive statistics to summarize all variables associated with the study. Descriptive information was used to conduct an analysis of the dependent and independent variables to make sure they measured distinct concepts. Second, correlational statistics was used to identify how changes in the perceptions of teaching, learning, and supervisory practices effect one another. Third, factor analysis was employed as an exploratory tool to build composite measures of the constructs of interest. Once this were accomplished, hierarchical multiple linear regression analysis was used to determine the relationships between the independent and dependent variables while controlling for other pertinent school and teacher characteristics. Prior examination of the correlation matrix indicated that the variables chosen were suitable for regression analysis. In hierarchical regression, unlike simple regression methods where variable selection is made merely by statistical criteria, the researcher determined which variables were included in the model based on logic, theory, and the results of prior research (Sheskin, 1997).

A hierarchical linear model was used to predict the dependent variable from a series of independent variables that reflected not just the level on which the dependent variable was measured, but also those of higher, more aggregated, levels of analysis. Using the parameters (regression coefficients) that were estimated at the first level of analysis (school demographics in this study) as dependent variables and the variables from higher levels of analysis (teacher background data) as independent variables, this second stage of analysis shows how the teacher variables affect the way in which school variables influence the outcome variable.

The standard statistical analysis program (e.g., SPSS) assumes that data are collected from a simple random sampling design. The cluster sampling design of NELS: 88 violated this assumption, resulting in an inflated significance level. To compensate for this bias, every weight used in this study was divided by the mean of the weight and was then divided by an estimated design effect (Ingles et al., 1992). The new relative weight was used in all data analysis.

RESULTS

Descriptive Analysis

NELS: 88 include data from 14,915 teachers and 1,035 schools that was used to produce a sample of 13,108 teachers from 949 public schools. The gender of the teachers in this sample was almost evenly divided with 6,816 (52%) males, 6,292 (48%) females, and 390 non-respondents to this item. Approximately, one-fourth of the teachers sampled had less than ten years of experience with twenty-four percent of all teachers sampled having earned certification in mathematics. The data set was predominately of white, non-Hispanic backgrounds (91%) although there was an identifiable element of ethnic diversity with Black and Hispanic populations accounting for eight percent of the sample.

The majority of the teachers in this sample (59%) taught in schools ranging in size between 800 and 1999 students while twenty-six percent were employed in schools with less than 800 students. Most teachers were from suburban areas, with twenty-eight percent from urban areas and thirty-one percent from rural areas. The south was the most heavily represented region with thirty-nine percent and the west and northeast the least with each showing only twenty-one and seventeen percent respectively.

Relationships of Composite Variables

What are the relationships of public school teachers' perceptions of constructivist teaching, learning, and supervisory practices? Correlation analysis was used to examine the extent to which measures of constructivist practices relate to one other. The results of this analysis show that all nine composite variables representing constructivist teaching, learning, and supervisory practices are represented in several cross relationships. Results show that several variables of constructivist practices were positively related. The strength of the relationships varied. For example, teacher collaboration, a constructivist teaching practice, had the strongest relationship (r =.32) with the support teachers receive from administrators, a constructivist supervisory practice, and (r =.29) with the emphasis teachers place on problem solving, a constructivist learning practice. Teacher empowerment, a constructivist teaching practice, was also related (r =.23) to administrative support, a constructivist supervision practice, and (r =.09) to the emphasis teachers place on problem solving, a constructivist learning practice. Slight correlations (r =.14) exist between professional support, a constructivist teaching practice, and staff morale, a constructivist supervisory practice, and between administrative support, a constructivist supervisory practice, and problem solving, a constructivist supervisory practice. Relationships do exist and there appears to be a conceptual relationship between the perceptions of constructivist teaching, learning, and supervisory practices.

These results confirm previous findings that show that teachers who collaborate with other teachers are more likely to place emphasis on problem solving within their classrooms and receive support from administrators. Likewise, teachers who perceive themselves as empowered are more likely to receive support from administrators and place greater emphasis on problem solving within their classrooms.

Influence of School Demographics and Teacher Characteristics

To adjust for the influence of school demographics and teacher characteristics on measures for constructivist teaching, learning, and supervisory practices a series of OLS regressions were performed. Tables II to VII display the results of hierarchical linear model analyses. Four variables were identified that were related to constructivist teaching practices: rural settings (β = .106), teachers certified in mathematics (β = .067), teachers with ten years or less at the secondary level (β = .079), and female teachers (β = .163).

The first column of numbers displays standardized regression coefficients (β's) that can be used to compare the relative strength of each independent variable. The second column of numbers shows the standard error for each regression coefficient. At the bottom of each model is the regression constant and R square. The purpose of the R squared statistic is to show the percent of variation in the dependent variable that is explained by the independent variables.

Table II
Results of Multiple Regression of School Demographics and Teacher Background on Teacher Empowerment

Independent Variable	Model 1 Dependent Variable Teacher Empowerment		Model 2 Dependent Variable Teacher Empowerment	
Demographic Variables	B	SE†	B	SE†
School size < 1200	.031	.006	.021	.006
Public schools	-.202***	.043	-.187***	.050
Urban settings	-.126***	.032	-.120***	.034
Rural settings	.100***	.027	.106***	.028
Teacher Background Variables				
Gender if female			-.071***	.025
Ethnicity if minority			-.079***	.018
Master educational level			.050***	.025
Doctoral educational level			.027	.108
Mathematics certification			-.106***	.025
Secondary teaching experience < 10			.003	.012
Teacher under 35 Years of age			.023	.005
Years teacher is in the same building < 10			-.071***	.012
(Constant)		.591	.772	
R^2		.053	.088	

* p < .05. ** p < .01. *** p < .001
† Regression coefficient and standard error: Significance levels are adjusted for design effects (DEFF's).

When examining teacher empowerment (See Table II) measured by the control teachers have within their classrooms, schools in rural settings ($\beta = .10$) produced positive effects on teacher empowerment. The effect increased slightly ($\beta = .11$) when teacher background variables were added to the base model. Because standardized variables were used, for a coefficient of .11, one standard deviation difference in the independent variable would be associated with .11 (or eleven percent) of a standard deviation difference in the dependent variable. This means that one standard deviation difference among rural schools is associated with 11% of a standard deviation in teacher empowerment.

The data indicates that rural schools may be places where constructivist teaching practices are likely to be found. The reasons for this may include smaller numbers of students within the school, the need for heterogeneously grouped classrooms, and/or use of cooperative learning strategies when generating meaningful lessons that meet a range of ability levels. Indeed, in 1994 Kearney suggested that teachers in small rural schools have stronger student-teacher relations, greater communication among staff members, and higher levels of morale than other teachers.

Table III
Results of Multiple Regression of School Demographics and Teacher Background on Professional Support

Independent Variable	Model 1 Dependent Variable Professional Support		Model 2 Dependent Variable Professional Support	
Demographic Variables	B	SE†	B	SE†
School size < 1200	.023	.047	-.023	.007
Public schools	.020	.033	.016	.053
Urban settings	.017	.029	.015	.035
Rural settings	.033	.004	.008	.029
Teacher Background Variables				
Gender if female			-.031	.026
Ethnicity if minority			-.009	.019
Masters educational level			.001	.026
Doctoral educational level			-.061***	.113
Mathematics certification			-.021	.027
Secondary teaching experience < 10			.079***	.012
Teacher under 35 Years of age			.014	.005
Years teacher in the same building < 10			.031	.013
(Constant)		-.120	-.103	
R^2		.002	.013	

* p < .05. ** p < .01. *** p < .001
† Regression coefficient and standard error: Significance levels are adjusted for design effects (DEFF's).

When looking at age as a factor in studying teachers, both Anderson and Iwanicki (1984) and Sarros & Sarros (1992) discovered that younger teachers reported higher levels of burnout than those with more experience. The results of this study did not substantiate these claims. Teachers who had taught less than ten years at the secondary level showed a positive relationship ($\beta = .079$) in Table III with constructivist teaching practices. Other research supports the view of constructivist practices as a relatively new educational practice and suggests that younger teachers may be more willing to use constructivist practices than older teachers who are not familiar with the theoretical concepts of constructivism (Brooks & Brooks, 1993). Professional staff development that address the teaching-learning process may provide the support necessary to keep all teachers updated and aware of important educational reforms applicable to their classrooms.

Table IV
Results of Multiple Regression of School Demographics and Teacher Background on Emphasis on Problem Solving

Independent Variable	Model 1 Dependent Variable Problem Solving		Model 2 Dependent Variable Problem Solving	
Demographic Variables	B	SE†	B	SE†
School size < 1200	.022	.012	.036	.013
Public schools	.063	.078	.017	.089
Urban settings	.094	.058	.028	.065

Rural settings	.007	.051	-.017	.053
Teacher Background Variables				
Gender if female			.163***	.046
Ethnicity if minority			.089	.032
Master educational level			-.029	.047
Doctoral educational level			.030	.351
Mathematics certification			.079	.186
Secondary teaching experience < 10			-.019	.022
Teacher under 35 years of age			.009	.009
Years teacher is in the same building < 10			-.044	.023
(Constant)	-.268		-.817	
R^2	.007		.048	

* p < .05. ** p < .01. *** p < .001
† Regression coefficient and standard error: Significance levels are adjusted for design effects (DEFF's).

Gender showed a relationship to both constructivist teaching (β = .098) and learning practices (β = .163) indicating that female teachers are more likely to emphasize problems solving in their classrooms, enroll in professional coursework, and spend time beyond the school day with students or parents than their male counterparts. Reasons for this may be that female teachers are inherently more verbal, less involved in extra-curricular responsibilities, and often remain available after the school day to tutor or offer academic counsel for individual students. Table IV demonstrates that an emphasis on problem solving as measured by the emphasis place on solving problems, learning mathematical concepts, and understanding the importance of mathematics is strongly predicted by female teachers.

Table V
Results of Multiple Regression of School Demographics and Teacher Background on Teacher Collaboration

Independent Variable	Model 1 Dependent Variable Teacher Collaboration		Model 2 Dependent Variable Teacher Collaboration	
Demographic Variables	B	SE†	B	SE†
School size < 1200	.012	.006	-.008	.006
Public schools	-.019	.044	-.098***	.049
Urban settings	-.079***	.033	-.074***	.033
Rural settings	.028	.028	.042	.027
Teacher Background Variables				
Gender if female			.098***	.024
Ethnicity if minority			.048	.018
Master educational level			.028	.024
Doctoral educational level			.007	.105
Mathematics certification			.067***	.025
Secondary teaching experience < 10			.010	.011
Teacher under 35 Years of age			.006	.005
Years teacher is in the same building < 10			-.069***	.012
(Constant)	.006		.243	
R^2	.008		.030	

* p < .05. ** p < .01. *** p < .001
† Regression coefficient and standard error: Significance levels are adjusted for design effects (DEFF's).

The data shown in Table V indicates that teachers certified in mathematics and females are well suited to employ constructivist teaching practices in their classrooms, especially when the desired outcome includes greater student mathematics achievement.

Table VI
Results of Multiple Regression of School Demographics, Teacher Background, and Constructivist Teaching, Learning, and Supervisory Practices on Student Math Achievement

Independent Variable	Model 1 Dependent Variable Math Achievement		Model 2 Dependent Variable Math Achievement		Model 3 Dependent Variable Math Achievement	
Demographic Variables	B	SE†	B	SE†	B	SE†
School size < 1200	-.006	.054	.004	.083	-.029	.19
Public schools	-.166***	.357	-.129***	.655	-.152***	1.53
Urban settings	-.123***	.257	-.075***	.435	-.075	1.06
Rural settings	-.087***	.237	-.084***	.361	-.056	.80
Teacher Background Variables						
Gender if female			.008	.318	-.069	.726
Ethnicity if minority			-.120***	.226	-.123***	.540
Master educational level			.066***	.324	.088	.721
Doctoral educational level			-.018	1.413	-.036	7.105
Mathematics certification			.017	.328	.058	3.080
Secondary teaching experience < 10			.028	.153	.009	.344
Teacher under 35 years of age			.043	.064	-.019	.145
Years teacher is in the same building < 10			-.050***	.158	-.003	.356
Constructivist Teaching, Learning, & Supervisory Practices						
Professional support					-.013	.340
Teacher collaboration					-.034	.456
Teacher empowerment					.037	.374
Teacher commitment					.008	.332
Emphasis on problem solving					.143***	.383
Professional development					.010	.337
Administrative support					.030	.408
Building leadership					.013	.359
Staff Morale					-.021	.363
(Constant)	51.820		50.203		46.914	
R^2	.034		.053		.076	

* p < .05. ** p < .01. *** p < .001
† Regression coefficients and standard errors: Significance levels are adjusted for design effects (DEFF's).

Ultimately, the study found (See Table VI) that an indicator of constructivist learning practices, specifically problem solving, had a positive effect ($\beta = .143$) on student math achievement. Problem solving was measured by the degree of emphasis on problem solution, mathematical concepts, and the importance of mathematics. The analysis supports the conclusion that, for teachers, problem-solving strategies within the classroom have a significant effect on student achievement in mathematics. When teachers emphasize problem solving within their classrooms the likelihood of achieving positive relationships with student achievement in mathematics increase.

DISCUSSION

The results of this study illuminate the use of constructivist practices in educational settings and challenge behaviorist views of instruction through simple stimulus–response methodology. For example, this study found that constructivist learning practices had the greatest effect on student math achievement. The analysis supports the conclusion that problem-solving activities within the classroom have a strong and significant effect on student math achievement. Problem solving activities involve questioning, reasoning, and communicating with less of an emphasis on answers to computational problems and more stress on the process of problem solving and answering open-ended questions.

Other educational research has found similar results. In a study of middle school children, higher level achievement (problem solving) was positively related to mathematical activities in which the teacher gave no help (Peterson & Fennema, 1985). Conversely, imitating rules or memorizing manipulations tended to diminish the importance of understanding what mathematics is and how problems are solved (Cobb, 1986).

Wheatley used the construct of problem solving to support a model of constructivist teaching in 1991. Wheatley proposed that the teacher's role is to provide stimulating and motivational experiences through negotiation and act as a guide in the building of a personal schema. Wheatley suggests that teachers should select tasks that cause students to find a problem. After students have had sufficient time to collaborate through group activities, the class is convened as a whole for sharing. By engaging in problem solving activities teachers find themselves coaching, leading discussions, and exploring alternative solutions more often than when using the traditional lecture method of instruction.

When interviewing high school juniors and seniors, Goos (1996) found that 98% agreed (or strongly agreed) that the "best way to learn mathematics was to make sure you understood why things work". Peterson (1988), in two independent studies, asked elementary students to recall a previously taught mathematics lesson and to explain what they understood about the topic. She found that regardless of the student's ability, mathematics grades were significantly related to the student's ability to explain the lesson. These outcomes confirmed that understanding concepts involved when solving problems was significantly related to the student achievement in mathematics.

Constructivism represents a promising educational philosophy that is grounded in learner-centered practices. Constructivist teaching offers a bold departure from traditional behaviorist classroom strategies. The goal is for teachers to design opportunities for the learners to play an active role in assimilating knowledge into their mental frame of prior experiences. The ability of students to apply their school-learned knowledge to the real world is valued over memorizing bits and pieces of knowledge that may seem unrelated. The constructivist approach requires teachers to relinquish their role as sole information dispenser and instead to continually analyze their curriculum planning and instructional methodologies. Perhaps, the best quality for a constructivist teacher to have is the "instantaneous and intuitive vision of the pupil's mind as it gropes and fumble to grasp a new idea" (Brooks & Brooks, 1993, p. 20). Clearly, the constructivist approach opens new avenues for learners as well as new challenges for the teacher.

Supervisors, in turn can encourage teacher-centered practices by providing opportunities for teachers to take risks and explore new approaches to learning. They can promote teacher reflection by encouraging teachers to challenge, and perhaps change, their assumptions. They can develop collegial relationships with teachers and encourage frequent collaboration. Moreover, they can facilitate a comprehensive examination of classroom performance that honors the learning process as a fluid means of achieving deep understanding and active use of knowledge.

Limitations of the Study

As in most research, the current study has limitations. First, the study examined the relationships of school demographics, teacher background, and constructivist teaching, learning, and supervisory practices to student achievement in a single circular domain – mathematics. Mathematics is the school subject in which learning is most influenced by schooling and the least affected by family factors (Murnane, 1975). It is possible, therefore, that the effects of these variables on student achievement observed in mathematics might be diminished (or even absent) in studies of student achievement in other curricular domains. Consequently, there is a need for researchers to apply and test the model used in the current study to further research constructivist practices in other academic subjects.

A second limitation of the study results from the sampling design of the NELS: 88 study. The NELS: 88 data does not provide researchers with a representative sample of students taught by a particular teacher. Teacher data was treated as properties of students. In a strict sense, this approach is less than ideal. Statistically speaking, the study of teacher effects on student achievement should examine effects occurring at the three levels of analysis –student, teacher, and school. Instead, in the base year (1988), only two levels, students and schools, were chosen to be representative of all United States eighth grade students, while teachers were selected because one or more of the students in their classes were included in the NELS: 88 study.

Finally, the NELS: 88 study forced the investigator to rely on a non-experimental research design. Although this study used longitudinal data to assist in the process of making causal inferences, it is nevertheless a correlational study. In any correlational study, cause-effect inferences are subject to alternative explanations. Only experimental evidence can establish the causal ordering among variables.

To overcome the potential limitations discussed, NELS: 88 data include weighting factors that statistically adjust the data to compensate for unequal probability of selection of the sample and to reduce bias caused by non-response.

Recommendations for Further Study

This investigation raises a number of questions that suggest a need for further research. The literature review indicated that teachers, who had worked in non-constructivist environments for many years, might lack the professional knowledge needed for successful involvement in constructivist environments (Brooks & Brooks, 1993). The literature raised concern about the level of commitment required of educators using a constructivist process. With limited time and resources available in most schools, it is suggested that the number of activities and the time needed to implement constructivist practices could exhaust even the most active of teachers. Research literature indicates that teachers should feel higher levels of empowerment and create multiple opportunities for their students to reach higher levels of academic achievement if constructivist practices are evident within their classrooms (Brooks & Brooks, 1993). More quantitative studies paired with existing qualitative studies are needed to help understand the dynamics and implications of these situations.

The leadership role was introduced in this study as a method to help distinguish effects of teacher empowerment from administrative leadership. This study showed that they clearly are two distinct issues. The leadership role in empowered schools is an important element that bears additional study from a constructivist perspective. These issues may include the various leadership styles that could exist within constructivist environments, the teachers' perceptions of their principals, and the actual levels of decision making abilities given to teachers within constructivist environments. Even though there has been much discussion about teachers becoming involved in the decision making process, the questions used in this study were somewhat limited in scope and may not have ascertained exactly what types of decisions were actually being made. Further research could investigate those decisions and the satisfaction levels associated with the various levels of involvement.

The final implication for future research is methodical. The research design used in this study suffered from a number of shortcomings that may have influenced the study's likelihood of finding teacher effects on student achievement. One problem was the limited amount of time the students in the NELS data spent in class with the teachers in the study. This biased the study against finding teacher effects. In the future, studies should consider assessing measures of achievement that could be attributed to a single teacher. This suggests that the results of this analysis of a large-scale data set needs to be replicated in smaller, more intensive field studies.

CONCLUSION

These findings have important implications for educators and instructional supervisors. Constructivist teaching, learning, and supervisory practices may provide the means to invigorate teachers by allowing them to control their professional lives. Teachers need to know that their jobs are important. They need frequent comments regarding their performance within the classroom, opportunities to grow professionally, and indicators of their increased value to the organization. Simple collegial relationships are not enough. The collaborative atmosphere should be one where teachers share a belief that positive interactions can create strong connections among the entire school community. The results will be teachers who believe that they are capable of having a positive effect on student performance, who will choose challenging activities for their students, and who will be motivated to confront obstacles.

These findings suggest that schools that encourage teacher participation in decision making and take steps to develop a sense of professional community with a strong commitment toward improved instructional practice are more likely to produce enthusiastic teachers who are willing to invest their energy for the improvement of the organization. Enthusiastic teachers with high levels of motivation and confidence in their ability to educate their students appear to be the major keys in increased student achievement and school effectiveness. Effective educators armed with the knowledge of constructivist teaching, learning, and supervisory practices can direct their efforts toward common goals and priorities.

It is a formidable task to create constructivist environments in which students, teachers, and supervisors are encouraged to think and explore. However, the key to meeting this challenge may rest in research that illuminates relationships among constructivist teaching, learning, and supervisory practices.

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