

# The Influence of Teachers' Technology Use on Instructional Practices

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## Abstract

*This study investigated the relationship between technology use and skills and the use of constructivist instructional practices among teachers in rural schools. Teachers in this study responded to Moersch's instrument, the Levels of Technology Implementation (LoTi). The LoTi was administered to the fourth and eighth grade teachers in 11 school districts to determine if levels of classroom technology use and personal computer use predicted the use of constructivist instructional practices. Results indicate that there is a significant, positive relationship between both levels of classroom technology use and personal computer use and the use of constructivist instructional practices, with personal computer use being the strongest predictor. (Keywords: levels of technology implementation, constructivism.)*

## INTRODUCTION

Educators struggle with the problem of overcoming the inertia of instructional practices in the traditional classroom (Trimble, 2003). In these traditional classrooms, students are typically not provided with whole, dynamic learning experiences, but rather with limited, arbitrary activities. Schools frequently teach information from the various disciplines without providing adequate contextual support with opportunities for students to apply what they are taught. "The resulting inauthenticity of classroom activity makes it difficult for children to see how school learning applies to their lives" (Perchman, 1992, p. 33).

Brooks (2004) believes that there is a lack of focus on higher-order thinking skills because of an emphasis on standardized testing. She refers to such testing as single-event measures of accountability, which serve as a substitute for preparing students for the many different worlds beyond school classrooms. "Like agriculture, education has replaced natural processes with artificial ones. Over time, these artificial practices have become common" (p. 9).

This lack of attention to authentic experiences in education is particularly troubling when considering opportunities for children in poor, under-funded, often rural areas of the United States. Research indicates nationwide low performance in many subject areas (Bracey, 2002; Collins & Dewees, 2001; Riley, 2002). Riley's (2002) research further indicates that some geographic areas, particularly rural areas, are reporting low performance and that the achievement gap is persistent and intrinsically linked to the fact that millions of the nation's children still live in poverty.

Children in rural schools frequently do not have the same level of access to resources and experiences as children who live in suburban and urban areas. Beeson and Strange (2003) report that 43% of the nation's public schools are in rural communities or small towns of fewer than 25,000 people, and 31% of the nation's children attend these schools. Poverty is the largest persistent challenge rural schools face. Per capita income, salaries, computer use in the classrooms, school administrative costs, and transportation are among the top challenges for rural schools (Beeson & Strange, 2003).

Another serious problem plaguing rural schools is difficulty in hiring and retaining qualified teachers. Ingersoll (2004) examined data regarding staffing issues in high-poverty schools in both rural and urban areas. He concluded that factors tied to the characteristics and conditions of these schools are behind the teacher shortage in these schools. One of the main reasons for high turnover rates in these schools is the fact that teachers in high-poverty schools are frequently paid less than teachers in other types of schools. Other significant factors related to staffing problems in these schools are related to inadequate administrative support, excessive intrusions on teaching time, student discipline problems, and limited faculty input in decisions related to the schools.

## **CONSTRUCTIVISM AND LEARNING**

One way of increasing authenticity in the classroom is through the use of constructivist teaching methods (Voss & Post, 1988; Wenglinisky, 2004; White & Frederiksen, 1998). Constructivism is a learning theory that proposes learners create their own understanding as they combine what they already believe to be true based on a blend of past experiences with new experiences (Richardson, 1997). Constructivism as a philosophy of learning can be traced primarily to the work of John Dewey (1916) and Jean Piaget (1973). Vygotsky's work (1978) also contributed to the movement toward constructivism. Throughout most of the early to middle part of the 20<sup>th</sup> century, theories of learning shifted from a behaviorist orientation based on observable phenomenon to a cognitive orientation in the 1970s that emphasized internal cognitive processing. By the 1980s, a shift toward constructivism became evident. The perception that learning is an internal learner process continues to grow.

Dewey (1916) believed that learning was based on activity. Knowledge could only emerge from a context in which ideas were drawn out of circumstances that had meaning to the learner. He believed that the learning context must be a social context in which students work together to build knowledge. Piaget's view (1973) of learning was based on his view of child development. He believed that understanding is based on discovery and active involvement. Vygotsky (1978) believed that children should be encouraged to link concepts and derive their own ideas from those introduced to them. He developed a social learning perspective through which children learn through interaction with others.

Over the past several decades, both educators and policymakers have argued whether schools should emphasize facts or critical thinking skills. Much of this debate has not been based on empirical data. Wenglinisky (2004), using data from the National Assessment of Educational Progress (NAEP), concluded that

a clear pattern emerges from these data. Even though students must learn facts and basic skills, the data suggest that emphasis on advanced reasoning skills promotes higher student performance.

The use of constructivist pedagogical models promotes this meaningful type of learning process, a process in which learning helps students make sense of new information experienced in authentic problems by integrating the new information with previously constructed knowledge (von Glasersfeld, 1981). Authentic problems or actions are ill-structured complex problems analogous to those students face in everyday experience and will face in their future professions. In the learning process, these problems help learners organize their learning and facilitate growth in reasoning and problem solving skills (Voss & Post, 1988; White & Frederiksen, 1998).

The philosophy of constructivism is not new to education, but the ways in which it is applied to education are still evolving. One relatively new tool that can play a vital role in the use of constructivist teaching practices is technology-enhanced instruction.

## **TECHNOLOGY AND CONSTRUCTIVISM**

One of the first and most vocal proponents of the use of technology to promote this type of meaningful learning was Seymour Papert (1980, 1994) who believed that computers could provide powerful tools for learning. He also noted that schools frequently ignored the broad capacities computers have for instructional support, isolating them from the learning process rather than integrating them into all areas of the curriculum.

When constructivism is used effectively, teachers incorporate the ideas of students to prepare the lessons that they will teach in their classrooms. Teachers are beginning to use technology as a tool to promote students' ability to reason and solve authentic problems. "Teachers use existing technology to transform classrooms into dynamic centers of purposeful and experiential learning that intuitively move students from awareness to authentic action" (Moersch, 1998, p. 53). The appropriate use of technology can reinforce higher cognitive skill development and complex thinking skills such as problem solving, reasoning, decision making, and scientific inquiry (Moersch, 1999).

When teachers thoroughly integrate technology into the classroom, constructivist learning environments can evolve. A constructivist learning environment (Reeves, 1998) is a place in which learners work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities. Constructivist learning environments frequently encompass many different applications of media and technology (Becker & Ravitz, 1999; Middleton & Murray, 1999; Rakes, Flowers, Casey, & Santana, 1999). Such environments create active classrooms that combine the tools of constructivism with communication and visualization tools that enable communication and collaboration among learners in a socio-cultural context. Increased student achievement can result because of the synergy created through dynamic interactions (Dwyer, 1994; Sandholtz, Ringstaff, & Dwyer, 1997).

In a ten-year study of how the routine use of technology by teachers and students affected student learning, the Apple Classroom of Tomorrow (ACOT) project studied five classrooms throughout the United States (Dwyer, 1994; Sandholtz, Ringstaff, & Dwyer, 1997). Researchers provided each classroom with a wide variety of technology tools, training for teachers, and a coordinator at each school to provide technology assistance. The project's primary purpose was to investigate how routine use of computers and technology influence teaching and learning.

The analysis of data from the evaluation of the ACOT project was based on a database of more than 20,000 entries. Researchers saw technology “profoundly disturb the inertia of traditional classrooms” (Dwyer, p. 7). Researchers saw an increase in the use of constructivist teaching strategies with the use of technology in the classroom, observations also supported by research from Rakes et al. (1999) and Becker and Ravitz (1999). Teachers encouraged cooperative learning and collaborative efforts as they used more complex tasks and materials in their instruction along with more performance-based evaluation.

There is a need for further research on the link between teachers' technology use and classroom instructional practices. In spite of the apparent commitment to technology of some schools, it appears that many teachers use computers to support their current traditional teaching practices rather than as a tool to promote more innovative, constructivist practices (Cuban, 2001). Much of the current teacher technology training programs and other uses of technology-related funds may not be delivering the desired result: a positive effect on student learning.

For example, Doherty and Orlofsky (2001) studied 500 students in grades 7–12. As part of this research, investigators asked students how their teachers used computers for learning. The survey revealed that most students said their teachers do not use computers in sophisticated ways. If teachers are not provided the useful support needed to integrate computers into the overall framework of the classroom, it is unlikely that their students will use computers in ways that will improve learning (Fuller, 2000).

In order for technology to positively affect teaching methods—and therefore student learning—teachers must possess the technology-related skills needed to use technology and must actively use these tools in their classrooms (Iding, Crosby, & Speitel, 2002). In order to encourage these behaviors, teachers need appropriate, research-based training; opportunities to practice these skills; access to technology tools; and support, both in terms of encouragement from school administrators (Dawson & Rakes, 2003) and technical support (Fuller, 2000). Teachers and students cannot use computers that do not work.

Increasing technology use can create a vehicle through which educators can address teaching and learning opportunities for all students. The need for these opportunities is especially apparent in poor rural areas of the United States.

## RESEARCH QUESTIONS

The present study explores whether teacher use of technology, both in the classroom and for personal use, relates to the use of constructivist teaching practices and addresses four specific research questions.

**Research Question 1:** What are the predominate teacher levels on the Level of Technology Implementation, Personal Computer Use, and Current Instructional Practices scales?

**Research Question 2:** Is there a relationship between teachers' Current Instructional Practices scores and teachers' Level of Technology Implementation scores?

**Research Question 3:** Is there a relationship between teachers' Current Instructional Practices scores and teachers' Personal Computer Use scores?

**Research Question 4:** Is there a relationship between teachers' Current Instructional Practices scores and teachers' scores on both the Levels of Technology Implementation and Personal Computer Use scales?

## POPULATION

The purposive sample for this study was comprised of 186 fourth and eighth grade teachers from 36 elementary schools, 17 middle/junior high schools, and 13 high schools from 11 rural school districts in a southern state. The 11 districts were chosen from those designated by the Delta Rural Systemic Initiative. The purpose of this federal program was to bring about reform in delta communities in three southern states. These school districts also received a federally funded Technology Literacy Challenge grant that provided equipment and professional development for teachers in the use of technology. The total provided for equipment was \$10,931,503. Each district was provided about 300 hours of professional development for teachers. The equipment and training had been in place for a year prior to collection of the survey data.

Only school districts that served populations that consisted of 20% or more families whose incomes were below the poverty line were included in this study. The schools included in the sample included similar minority as well as free- and reduced-lunch populations. In the sample schools, the percent of free and reduced lunches ranged from 54% to 91%. From the total purposive sample of 186 teachers, 123 volunteered to participate. Seventy-one fourth grade teachers and 52 eighth grade teachers participated in the study; those grades were chosen because the state's "high stakes testing" is done at those two grade levels.

## METHODOLOGY

Teachers in the study responded to a fifty-item instrument, the Level of Technology Implementation (LoTi). The LoTi was administered to the fourth and eighth grade teachers to determine if their level of classroom technology use and personal computer use predicted their Current Instructional Practices. The instrument generated a profile for each participant in three domains: Level of Technology Implementation (LoTi), Personal Computer Use (PCU), and Current Instructional Practices (CIP).

### Instrumentation

The Levels of Technology Implementation (LoTi): A Guide for Measuring Classroom Technology Use was initially tested in August of 1997 and in June of 1998. Moersch (1995, 1998) determined reliability by using Cronbach's

Alpha, which showed a reliability measure of .74 for the LoTi, .81 for Personal Computer Use, and .73 for Current Instructional Practices. (People interested in using the instrument must register in order to see the entire instrument. Information concerning all details related to the instrument can be found at [http://www.loticonnection.com/.](http://www.loticonnection.com/))

**Levels of Technology Implementation.** The LoTi instrument measures the teacher’s level of classroom technology implementation ranging from 0 (non-use) to 6 (refinement) as described in Table 1 below.

**Table 1: Levels of Technology Implementation Summary**

Level	Description
0 Non-Use	There is no visible evidence of computer access or instructional use of computers in the classroom.
1 Awareness	Available classroom computer(s) are used primarily for teacher productivity (e.g., e-mail, word processing, grading programs).
2 Exploration	Student technology projects (e.g., designing Web pages, research via the Internet, creating multimedia presentations) focus on the content under investigation.
3 Infusion	Tool-based applications (e.g., graphing, concept-mapping) are primarily used by students for analyzing data, making inferences, and drawing conclusions.
4a Integration (Mechanical)	The use of outside resources and/or interventions aid the teacher in developing challenging learning experiences using available classroom computers.
4b Integration (Routine)	Teachers can readily design learning experiences with no outside assistance that empower students to identify and solve authentic problems using technology.
5 Expansion	Teachers actively use technology and information from outside entities to expand student experiences directed at problem solving, issues resolution, and student action.
6 Refinement	Computers provide a seamless and almost transparent medium for information queries, problem solving, and/or product development.

The Levels of Technology Implementation (LoTi) scale measures authentic classroom technology use in seven categories with responses to statements of 1–2 indicating “Not True of Me Now,” 3–5 “Somewhat True of Me,” and 6–7 “Very True of Me Now.”

**Current Instructional Practices.** The Current Instructional Practices (CIP) scale measures teachers’ classroom practices relating to a subject-matter versus a learner-based curriculum approach based on eight elements as described in Table 2.

**Table 2: Current Instructional Practices Summary**

Level of Intensity	Description
0	One or more questions were not applicable to the respondent.
1	Instructional practices are subject-matter based; strategies lean toward lectures and/or teacher-lead presentations; student evaluation is traditional.
2	The participant supports instructional practices consistent with a subject-matter based approach to teaching and learning, but not at the same level of intensity or commitment as Level 3. Teaching strategies tend to lean toward lectures and/or teacher-led presentations.
3	Teacher still uses a subject-matter approach, but also supports the use of student-directed projects that provide opportunities for students to determine the “look and feel” of a final product based on specific content standards.
4	Teacher may feel comfortable supporting or implementing either a subject-matter or learning-based approach. Learning activities are diversified and based mostly on student questions, the teacher serves more as a facilitator, student-projects are primarily student-directed, and alternative assessment strategies are used.
5	Instructional practices tend to lean more toward a learner-based approach. The essential content embedded in the standards emerges based on what students “need to know” as they attempt to research and solve issues of importance to them using critical thinking and problem-solving skills.
6	The teacher at this level of intensity supports instructional practices consistent with a learner-based approach, but not at the same level of intensity or commitment as Level 7.
7	Instructional practices align exclusively with a learner-based approach. The essential content embedded in the standards emerges based on students “need to know” as they attempt to research and solve issues of importance to them using critical thinking and problem-solving skills. Learning activities and teaching strategies are diversified and driven by student questions. Assessment includes performance-based, journals, peer reviews, self-reflections.

The Current Instructional Practices (CIP) scale measures teachers’ current classroom practices relating to a subject-matter versus a learner-based curriculum approach based on eight intensity levels with responses to statements consisting of 1–2 indicating “Not True of Me Now,” 3–5 “Somewhat True of Me,” and 6–7 “Very True of Me Now.”

**Personal Computer Use.** The Personal Computer Use (PCU) scale measures the skill and comfort level of teachers when using technology for personal use based on eight intensity levels as described in Table 3 below.

**Table 3: Personal Computer Use Summary**

Level of Intensity	Description
0	The participant does not feel comfortable or have the skill level to use computers for personal use. Participants rely more on the use of overhead projectors, chalkboards, and/or paper/pencil activities than using computers for conveying information or classroom management tasks.
1	The participant demonstrates little skill level. Participants may have a general awareness of various technology-related tools such as word processors, spreadsheets, or the Internet, but generally are not using them.
2	The participant demonstrates little to moderate skill level. Participants may occasionally browse the Internet, use e-mail, or use a word processor program, yet may not have the confidence or feel comfortable troubleshooting simple “technology” problems or glitches as they arise. At school, their use of computers may be limited to a grade book or attendance program.
3	The participant demonstrates moderate skill. Participants may begin to become “regular” users of selected applications such as the Internet, e-mail, or a word processor program. They may also feel comfortable troubleshooting simple “technology” problems, but rely on mostly technology support staff or others to assist them with any troubleshooting issues.
4	The participant demonstrates moderate to high skill. Participants commonly use a broader range of software applications including multimedia (e.g., PowerPoint, Hyperstudio), spreadsheets, and simple database applications. They typically are able to troubleshoot simple hardware and/or peripheral problems without assistance from technology support staff.
5	The participant demonstrates high skill level. Participants are commonly able to use the computer to create their own Web pages, produce sophisticated multimedia products, and/or effortlessly use common productivity applications (e.g., FileMaker Pro, Excel), desktop publishing software, and Web-based tools. They are also able to troubleshoot most hardware and/or peripheral problems without assistance from technology support staff.
6	The participant demonstrates high to extremely high skill level. Participants are sophisticated in the use of most multimedia, Web-based, desktop publishing, and Web-based applications. They typically serve as “troubleshooters” for others in need of assistance and sometimes seek certification for achieving selected technology-related skills.
7	The participant is an expert computer user, troubleshooter, and/or technology mentor. They typically are involved in training others on any technology-related task and are usually involved in selected support groups from around the world that allow them access to answers for all technology-based inquiries they may have.



The Personal Computer Use (PCU) scale measures the teacher's comfort and skill level with computers based on eight intensity levels with responses to statements of 1–2 indicating “Not True of Me Now,” 3–5 “Somewhat True of Me,” and 6–7 “Very True of Me Now.”

### Limitations

Results of this study should be interpreted in view of the following limitations.

1. The questionnaire did not consider the complexity of software applications used at the school sites or the frequency of their use.
2. The sample is restricted to fourth and eighth grade teachers in 11 poor, rural school districts in a southern state.
3. The study explored relationships among variables; therefore, the analysis cannot establish cause and effect relationships.
4. There may exist unexamined factors affecting the relationship between technology use by teachers and their instructional practices that are not accounted for in the methodology.
5. All information in the survey is self-reported data. The information provided was based exclusively on the perceptions of the participants.

## RESULTS AND DISCUSSION

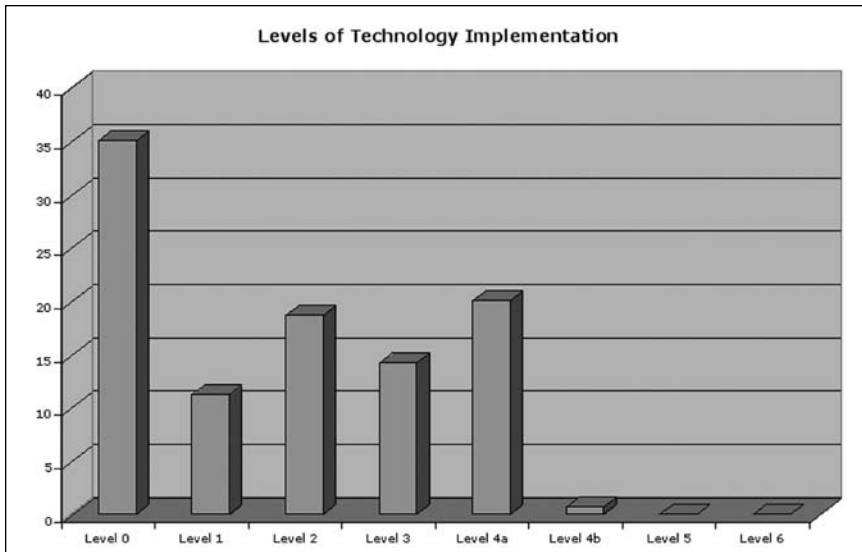
**Research Question 1:** What are the predominate teacher levels on the Level of Technology Implementation, Personal Computer Use, and Current Instructional Practice scales?

**Levels of Technology Implementation Results Summary.** For this sample, the predominate level is 0 (Non-Use). A Level 0 implies technology-based tools (e.g., computers) are either (1) completely unavailable in the classroom, (2) not easily accessible by the classroom teacher, or (3) there is a lack of time to pursue electronic technology implementation. Existing technology is predominately text-based (e.g., ditto sheets, chalkboard, overhead projector).

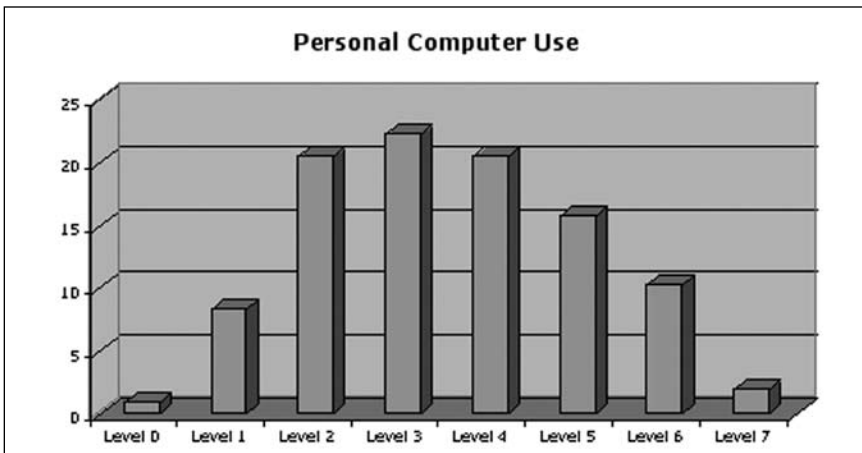
Figure 1 (page 420) displays the LoTi profile and approximates the degree to which each respondent is either supporting or implementing the instructional uses of technology in a classroom setting. Based on their responses, 35.1% of the respondents' highest level corresponded with Level 0 (Non-Use). This indicates participants perceive a lack of access to or time to use technology. The percent of the population for the remaining levels include Level 1 at 11.2%, Level 2 at 18.7%, Level 3 at 13.2%, Level 4a at 20.1%, and Level 4b at .7%. None of the teachers in the sample scored at the highest levels of Expansion (Level 5), or Refinement (Level 6).

This represents an alarmingly high number of teachers who express a lack of technology use given the amount of technology training and equipment provided for these poor, rural school districts. Despite substantial grant-funded infusions of money for training and equipment, teachers in this sample still perceived their ability to use technology as extremely limited, whether because of lack of access to equipment or lack of time to use technology.

**Personal Computer Use Results Summary.** The predominate intensity level for this sample is 3, indicating moderate skill levels. Figure 2 (page 420) dis-

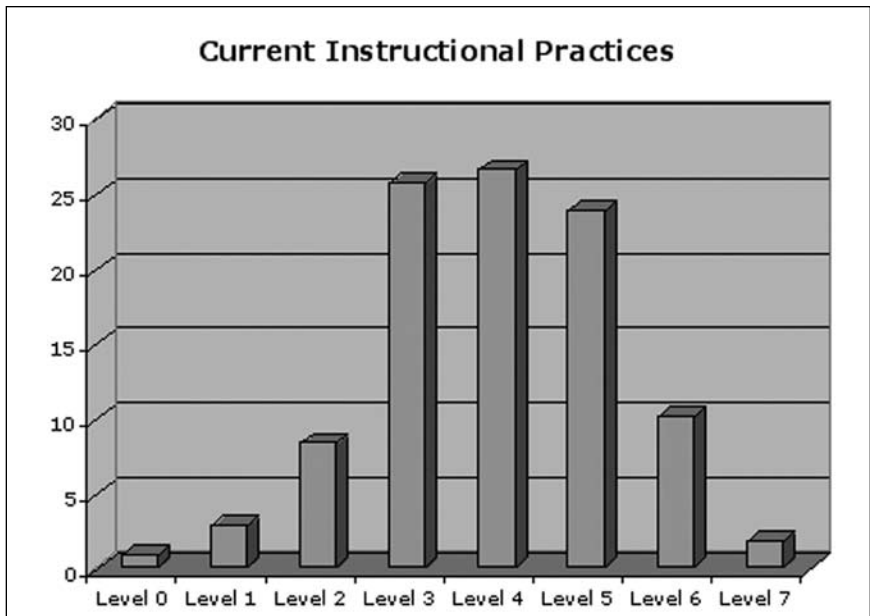


*Figure 1. Levels of Technology Implementation.*



*Figure 2. Personal Computer Use.*

plays the Personal Computer Use (PCU) results that address each respondent's comfort and proficiency level with computer use (troubleshooting simple hardware problems, using multimedia applications) at home or in the workplace). Level 0 (0.9%) indicates that the respondents do not feel comfortable or have the skill level to use computers for personal use. Level 1 (8.3%) indicates little skill levels. Level 2 (20.4%) indicates little to moderate skill levels. Level 3 (22.2%) indicates moderate skill levels. Level 4 (20.4%) indicates moderate to high skill levels. Level 5 (15.7%) indicates high skill levels. Level 6 (10.2%) indicates high to extremely high skill levels. Level 7 (1.9%) indicates the respondents are expert computer users and/or technology mentors.



**Figure 3. Current Instructional Practices.**

Only slightly more than one-fourth (27.8%) of the respondents scored in the highest three skill levels (5, 6, and 7). Again, these results are disappointing coming from a population that was targeted for technology training and equipment. The levels of teacher skill and comfort levels with computers were lower than expected.

**Current Instructional Practices Results Summary.** The predominate intensity level for the CIP for this sample is 4. Figure 3 displays the Current Instructional Practices (CIP), which addresses the respondents' support for or implementation of instructional practices consistent with a constructivist, learner-based curriculum design (i.e., learning materials determined by the problem areas under investigation, multiple assessment strategies integrated authentically throughout the curriculum, teacher as co-learner/facilitator, focus on learner-based questions).

For the CIP scale, responses at Level 0 (0.9%) indicate that one or more questions were not applicable to the participants. Level 1 (2.8%) responses indicate that instructional practices are subject based. Level 2 (8.3%) responses indicate a level similar to Level 1, but with more intensity. Level 3 (25.7%) responses indicate that the participants use a subject-matter approach, but also support the use of student-directed projects. Level 4 (26.6%) responses indicate that the respondents may feel comfortable supporting or implementing either a subject-matter or learning-based approach. Level 5 (23.9%) responses indicate that the participants' instructional practices tend to lean more toward a learner-based approach. Level 6 (10.1%) responses indicate that the participants are similar to those at Level 7, but with less intensity. Level 7 (1.8%) responses indicate that the participants' instructional practices align exclusively with a learner-based

approach. These results were more encouraging than expected, with more than half of the respondents describing the use constructivist teaching practices to at least a moderate degree.

**Research Question 2:** Is there a relationship between teachers' Current Instructional Practices scores and teachers' Level of Technology Implementation scores?

In order to examine the relationship between the score on the Current Instructional Practices scale and the scores on the Level of Technology scale, the data were analyzed using multiple regression with Current Instructional Practices scores entered as the dependent variable and the Level of Technology Integration scores entered as the independent or predictor variable.

Results of standard multiple regression, in which all variables were entered into the predictive equation, revealed an  $R^2$  of .16,  $F = 23.07$ ,  $p < .001$ , and indicates there was a significant linear relationship between the criterion variable (CIP) and the predictor variable (LoTi). About 16% of the variance in the Current Instructional Practices scores can be accounted for by the LoTi score. Results indicate that  $R^2$  is very poor (.16) and the predictive value of the Level of Technology Integration score is likely to be unacceptable.

The bivariate correlation (2-tailed) between CIP and LOTI is .40 ( $p < .01$ ). The positive, moderate correlation between CIP and LOTI indicates that teachers who scored higher on the LOTI scored higher on the Current Instructional Practices scale.

Based on results of research by Becker and Ravitz (1999) and Middleton and Murray (1999), it was expected that the positive relationship between the Levels of Technology Implementation and Current Instructional Practices would be stronger. Becker and Ravitz found that teachers who used various computer technologies in the classroom, particularly student-centered, Internet-based teaching activities, are more likely than other teachers to demonstrate changes associated with constructivist reforms. In this particular population, the positive relationship exists, but does not provide sufficient predictive power. This may be an additional indication that the technology-related training provided to these teachers did not provide a strong enough link between technology tools and their curriculum as indicated in the LoTi results for these teachers.

**Research Question 3:** Is there a relationship between teachers' Current Instructional Practices scores and teachers' Personal Computer Use scores?

In order to examine the relationship between the scores on the Current Instructional Practices scale and the scores on the Personal Computer Use scale, the data were analyzed using multiple regression with Current Instructional Practices scores entered as the dependent variable and the Personal Computer Use scores entered as the independent or predictor variable.

Results of standard multiple regression, in which all variables were entered into the predictive equation, revealed an  $R^2$  of .25,  $F = 22.83$ ,  $p < .001$  indicate there was a significant linear relationship between the criterion variable (CIP) and the predictor variable (LoTi). About 25% of the variance in the Current Instructional Practices scores can be accounted for by the Personal Computer Use score. Results indicate that the Current Instructional Practices score can be predicted by the Personal Computer Use score. In this case,  $R^2$  is weak, but interpretable.

The bivariate correlation (2-tailed) between CIP and PCU is .51 ( $p < .01$ ). The positive, moderate correlation between CIP and PCU indicates that teachers who scored higher on the PCU have higher scores on the Current Instructional Practices scale.

These results are similar to findings by Rakes et al. (1999). Teachers' strong, basic technology skill levels appear to provide teachers with a comfort level with computers needed to support constructivist teaching practices. In this regard, the basic technology skills training provided these teachers appears to have been somewhat successful with a segment of the population.

**Research Question 4:** Is there a relationship between teachers' Current Instructional Practices and teachers' scores on both the Levels of Technology Implementation and Personal Computer Use scales?

In order to examine the relationship between the score on the Current Instructional Practices and the scores on the both Level of Technology Implementation scale and Personal Computer Use scales, the data were analyzed using multiple regression with Current Instructional Practices scores entered as the dependent variable and the Level of Technology Implementation and Personal Computer Use scores entered as the independent or predictor variables.

Results of standard multiple regression, in which all variables were entered into the predictive equation, revealed an  $R^2$  of .28,  $F = 23.84$ ,  $p < .001$ , and indicate there was a significant linear relationship between the criterion variable (CIP) and the set of predictor variables. Results indicate that the Current Instructional Practices score can be predicted by both the Level of Technology Implementation score and the Personal Computer Use scores. About 28% of the variance in the Current Instructional Practices scores can be accounted for by both the LoTi and the PCU scores. In this case,  $R^2$  is weak, but interpretable.

The sample multiple correlation coefficient was .53. The positive, moderate correlations between both LoTi and PCU and CIP indicate that teachers who scored higher on both the LoTi and PCU have higher levels of Current Instructional Practices. Both predictors, Levels of Technology Implementation and Personal Computer Use, contributed to a slightly better prediction of Current Instructional Practices scores. This result confirms Moersch's (1999) assertion that appropriate use of technology can reinforce higher cognitive skill development and complex thinking skills as promoted through the use of constructivist teaching practices.

## FUTURE RESEARCH

One challenge for future research is to discover more specific ways computer-based technologies influence the classroom practices of teachers. What other factors may act in conjunction with technology use that encourage constructivist practices? How do preexisting teacher attitudes toward technology affect their use of technology in the classroom? How do preexisting teacher attitudes toward constructivism affect their use of these teaching? How do various types of training affect constructivist teaching practices? How does the availability of technology resources contribute to constructivist teaching practices? What types of technology training best facilitates the change from traditional to constructivist teaching methods?

McKenzie (2001) laments the fact that many school districts have put the proverbial cart before the horse in planning for the use of technology with a less than desirable return on the investment. There continues to be much emphasis on the purchase and installation of equipment without sufficient funding for staff development.

This challenge should be about using new tools to help students master the key concepts and skills embedded in the science, social studies, art and other curriculum standards. It is not so much about PowerPointing, spreadsheeting or word processing. The focus should be on teaching and learning strategies that make a difference in daily practice—on activities translating into stronger student performance. (§ 10)

The results of the current study confirm that teachers who have solid basic skills and comfort levels with technology and those who use computer technologies in their classrooms are more likely to use constructivist teaching practices. Given the current emphasis on producing students with high levels of thinking skills, any tools that can encourage the use of constructivist classroom practices and encourage the development of thinking skills in students should be considered important for all teachers and students. Promoting higher achievement in efficient ways of using computer technologies, particularly in under-funded schools, is worthy of further investigation.

The ultimate goal of research on the use of technology as a tool for constructivist teaching practices is to verify a link between classroom technology use, constructivist instructional practices, and improved student achievement. Future research should specifically explore the effect of technology use in constructivist classrooms on student performance.

As demonstrated in this study's teacher population, the availability of computers and training do not necessarily result in the widespread use of technology. Perhaps one key to understanding this lack of action on the part of many teachers lies in the future analysis of teacher beliefs regarding the effectiveness of technology as an instructional tool. Pajares (1992) suggested that "Beliefs are far more influential than knowledge in determining how individuals organize and define tasks and problems and are stronger predictors of behavior" (p. 311). Teacher beliefs concerning their personal ability to effectively use technology and their beliefs regarding the potential effect on student achievement is quite possibly a significant factor in determining what actually happens in the classroom.

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