Applying Technology to Restructuring and Learning

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ABSTRACT

How can classroom teachers be assisted in developing constructivist learning environments supported by technology in schools with large populations of traditionally underserved students? What role does available technology and professional development and support play in allowing or promoting changes in teaching methods? Results of the Southwest Educational Development Lab project, *Applying Technology to Restructuring and Learning (ATRL),* indicate that teachers changed their classrooms practices and professional development coupled with access to technology was instrumental in that change. Teacher knowledge of how computer technology can be used to enhance learning and how to plan effective learning activities were shown to be more important than strong personal computer skills.

Keywords

Constructivist Learning Environments, Computer Supported Collaborative Learning, Professional Development.

INTRODUCTION

Classroom teachers are practitioners that need to be trained in developing constructivist learning environments supported by technology. Building bridges between research on learning and teaching and classroom teachers can provide the practitioner community and students with the benefits of the research efforts.

The *Applying Technology to Restructuring and Learning (ATRL)* project was aimed at developing an understanding of what is required to help and support classroom teachers in the process of learning to implement constructivist strategies and use new tools. The study examined school context issues, teacher qualities and the role of professional development. *Constructivism* was defined as a learning theory that "proposes that knowledge or meaning is not fixed. . . but rather is constructed by individuals through their experience. . . in a particular context" (Honebein, Duffy, & Fishman, 1991). *Constructivist learning environment* (CLE) was defined as a classroom in which "instruction is more a matter of nurturing the ongoing processes whereby learners ordinarily and naturally come to understand the world in which they live" (Knuth & Cunningham, 1991, p. 164). *Technology* was defined as computers, whether alone or in combination with other hardware, software, or networks.

The purpose of the intervention was to assist and support participating teachers in creating technology-assisted constructivist learning environments. ATRL project staff provided assistance in a variety of roles – technology consultant, researcher, designer, developer, and professional development facilitator. Project staff worked in three areas vital to the creation of these learning environments: planning, professional development, and follow-up assistance and support.

The research component of this project involved an *intervention study* with a two-tiered research design. *Tier One* was a collective case study of the approximately 150 classrooms, located across six school sites, whose teachers participated in 72 hours of ATRL professional development. *Tier Two* consisted of six detailed case studies of individual teachers whose experiences represented the process and the practices they employed in creating a constructivist learning environment within their classrooms. Both quantitative and qualitative data were collected and analyzed.

An analysis of several technology training curricula for classroom teachers revealed that technology skills training is frequently the primary focus with little or no emphasis on managing technology use (Sun, Heath, Byrom, Phlegar, & Dimock, 2000). However, ATRL teachers participated in professional development that modeled technology management in the classroom, as well as instructional strategies that teachers could immediately apply in their classrooms.

Establishing a theoretical framework

"Constructivism is not a theory about teaching, but is a theory about knowledge and learning," (Brooks and Brooks, 1993, p.vii) thus the ATRL project team developed a framework for understanding and exploring the implications of this theory for teaching. Through a review of the literature (e.g. Brown, Collins & Duguid, 1989; Duffy & Jonassen, 1992; Brooks & Brooks, 1993; Duffy & Cunningham, 1996; Jonassen, 1996; Maddux et al, 1997) the team arrived at a common understanding of constructivist learning theory which they distilled into the following six working principles of constructivism. These principles became the foundation for the ATRL project and were used for developing and carrying out each of the professional development sessions.

B. Learners bring unique prior knowledge, experience, and beliefs to a learning situation.

C. Knowledge is constructed uniquely and individually, in multiple ways, through a variety of authentic tools, resources, experiences, and contexts.

D. Learning is both an active and reflective process.

E. Learning is a developmental process of accommodation, assimilation, or rejection to construct new conceptual structures, meaningful representations, or new mental models.

F. Social interaction introduces multiple perspectives through reflection, collaboration, negotiation, and shared meaning.

G. Learning is internally controlled and mediated by the learner.

By developing and sharing these common ideas of how learning occurs, the ATRL team was able to create relevant and engaging learning experiences in professional development sessions that promoted collaboration and learner-centered activities.

Because the project team's goal was to effectively model authentic learning environments in its professional development sessions, they created activities that used limited numbers of computers rather than having a computer available for every participant, since teachers reported that comfort in managing limited resources was more important than expertise in any one application.

Models for managing technology in the classroom

Several models for managing technology in the classroom were also used throughout the professional development sessions. These models employed particular grouping strategies and were designed so that teachers could replicate them in their classrooms. These models are described below.

The Active Learning Environments learning stations model was designed with a thematic focus of "Your Community." The facilitator presented the activity and then functioned as a "consultant" for the remainder of the activity. With the goal of the project explained, teams of four to five rotated through three different "learning stations" to gather data and information about their community. One station used a digital camera to gather images, another station used a simple electronic spreadsheet to analyze data, and a third station used printed materials about the community. Each of the stations had roles for each of the team members as well as instructions for completing the tasks at that station.

The Navigator Model was another group approach designed by the ATRL team. This model was more technology intensive than the Active Learning Environments model, and it was designed so participants could learn to use a software application while learning about some content. In this model, several teams of four were given a different part of a concept to explore within their team. To do this, they were asked to create a "concept map" using concept-mapping software. While the team carried out its initial discussion, one person from each team attended "Navigator" training. Teachers selected for that role, spent approximately twenty minutes with the Navigators teaching them the basics of concept-mapping software. Once trained, the Navigators returned to their teams, and instructed the rest of the team the software. The Navigator could only give instruction and could not touch the keyboard. The rest of the team rotated using the keyboard so that everyone had a chance to use the software.

The Facilitator or Expert Model was designed to accommodate different skill levels of the participants. The facilitator/expert was a person who had some experience with the software and showed novice users ("students") how to use the software application. The facilitator/expert could not touch the mouse or keyboard. Each group had its own facilitator/expert and the role did not rotate within the group. This model was useful for carrying out more complex projects that required different skill sets and levels of expertise. When ATRL staff carried out this staff development session, it pre-assigned teams and distributed the technology skilled teachers across all of the teams with the designation that they would be the technology facilitator/expert for that team.

In *The* C*ollaborative Grouping Model* all team members were responsible for creating a part of some final product. Other models included individual work, working in pairs, and working in groups of three or more.

In all cases, participants discussed the advantages and disadvantages of the different management models and also the appropriate uses of each model in their classrooms. Many opportunities were provided for teacher reflection about learning, classroom management of technology resources, and instructional strategies throughout the professional development sessions provided by the ATRL project.

Over the two years of the project, sixteen modules, seven videotapes, and multiple print resources for teachers were developed and incorporated into a professional development portfolio, *Active Learning with Technology*. Each of the sixteen staff development modules shared the following characteristics: They took into account teachers' understanding and beliefs about how students learn; They were supported by constructivist learning theory, both in terms of instructional approaches and the type of activity in which the learner engages; Utilized inquiry, problem-based teaching and learning; Used commonly available software found in classroom settings; Included two or more instructional strategies for managing a constructivist learning environment supported by limited amounts of technology; and they provided opportunities for teacher reflection on how different instructional strategies could be applied to their classrooms.

Follow-up assistance and support

Two major categories of follow-up assistance were also provided to participant teachers and school administrators. First, over the course of two years, project staff made regular follow-up visits to each participating site school in addition to the visits for professional development sessions. During these additional visits, staff observed participating teachers' classrooms, consulted with teachers individually and in small groups, and provided feedback, resources, technical support, and information based on teachers' concerns and needs. The ATRL staff also provided ongoing interactive assistance via the project's web site, a list server, e-mail interaction, and telephone conversations. Second, the ATRL staff developed a variety of materials designed to aid teachers in creating constructivist learning environments supported by technology.

Sites

Selected school sites included a school in Arkansas, Louisiana, Oklahoma, New Mexico and two Texas sites (SEDL's region) from each state in SEDL's region, with an additional site in Texas. The six site schools represented a variety of demographic and contextual characteristics in order to create a variable sample for the research study. Because of the selection criteria used for selecting the six site schools to participate in this research study, it is important to reiterate that this is a purposive sample, rather than a random sampling. This approach is consistent with the qualitative inquiry process (Borg & Gall, 1989).

DATA ANALYSIS AND RESULTS

Different data sources for analysis, both qualitative and quantitative, contributed to answering the research question. Quantitative data sources included: a project-developed observation protocol, and the *Teaching, Learning & Computing Teacher* survey (Becker & Anderson, 1998). Qualitative data sources included field notes, informal observations, unstructured interviews, case study interviews, lesson plans, staff development evaluations, and videotaped interviews and classroom episodes.

How can teachers be assisted in developing constructivist learning environments supported by technology? To inform answers to this research question, analyses of observation data included comparisons across the categories on the observation protocol to document which practices modeled during professional development were transferred into classroom practice. Comparisons of these categories, and of observation data, and of the computer skills self-assessment with field notes were also conducted.

The baseline computer skills checklist was compared with subsequent administrations of the checklist to look for relationships between teachers' technology skills and constructivist approaches. The computer skills checklist was also examined to gauge whether professional development session offerings to identify computer skills increase as a result of professional development sessions.

Analysis of videotaped teacher interviews and the in-depth case study interviews helped reveal the personal process of change that individual teachers must deal with when participating in an innovation. Interviews allowed teachers to discuss their fears and frustrations as well as successes and milestones in transforming their practice into constructivist classrooms supported by technology. Collaboration among teachers within instructional groups or among ATRL participants seemed to encourage teachers interested in creating CLEs. Simply talking about ideas with others helped teachers as one teacher explained, "I feel better now as I talk to other teachers, asking questions and sharing experiences. It makes me feel more open-minded, and willing to try new things."

The Teaching, Learning, and Computing Teacher survey asked teachers what they believed about teaching and learning and what support they needed to help them become the teachers they wanted to be. These data were compared to observation data to augment each teacher profile. As the participating teachers had received professional development designed to assist them in creating CLEs, it was hypothesized that rankings on constructivist practice and use of technology on the *Teaching, Learning, and Computing Teacher Survey* would be higher for participating teachers than in the national sample. The statistical method for this comparison was an Eta correlation ratio that measured the strength of relationships between the ATRL teachers and the national sample.

Part Two of the classroom observation protocol contained descriptors of observable characteristics of a constructivist learning environment supported by technology, regardless of content area or grade level. The descriptors in this protocol were formulated around the six principles of constructivism (mentioned previously). The descriptors for each of these six principles were coded on a scale from one to five by SEDL staff for each classroom observation. Each descriptor was then analyzed to determine the level of constructivist practice for each project teacher. Changes in mean scores from baseline to year one and year two were noted and regarded as an indication of change in practice. The five levels of constructivist practice observed for each descriptor were: (1) *Not evident*, (2) *Minimal*, (3) *Sometimes*, (4) *Frequen*t, (5) *Regular practice*.

Results from the observation protocol were entered into an SPSS database and analyzed. Types of analyses included:

H. Cluster analysis, in order to sort cases by common characteristics into groups or clusters. This classification scheme allowed tracking of movement among teachers in terms of constructivist approaches.

I. Means tests, in order to determine teachers' "scores" in each of the descriptors in the observation protocol. These means were used to determine low, medium-low, medium-high, and high constructivist practices for each project teacher. Change in mean scores from baseline to the end of year one and year two were noted and regarded as an indication of change in practice if they achieved a significance level of .05 percent.

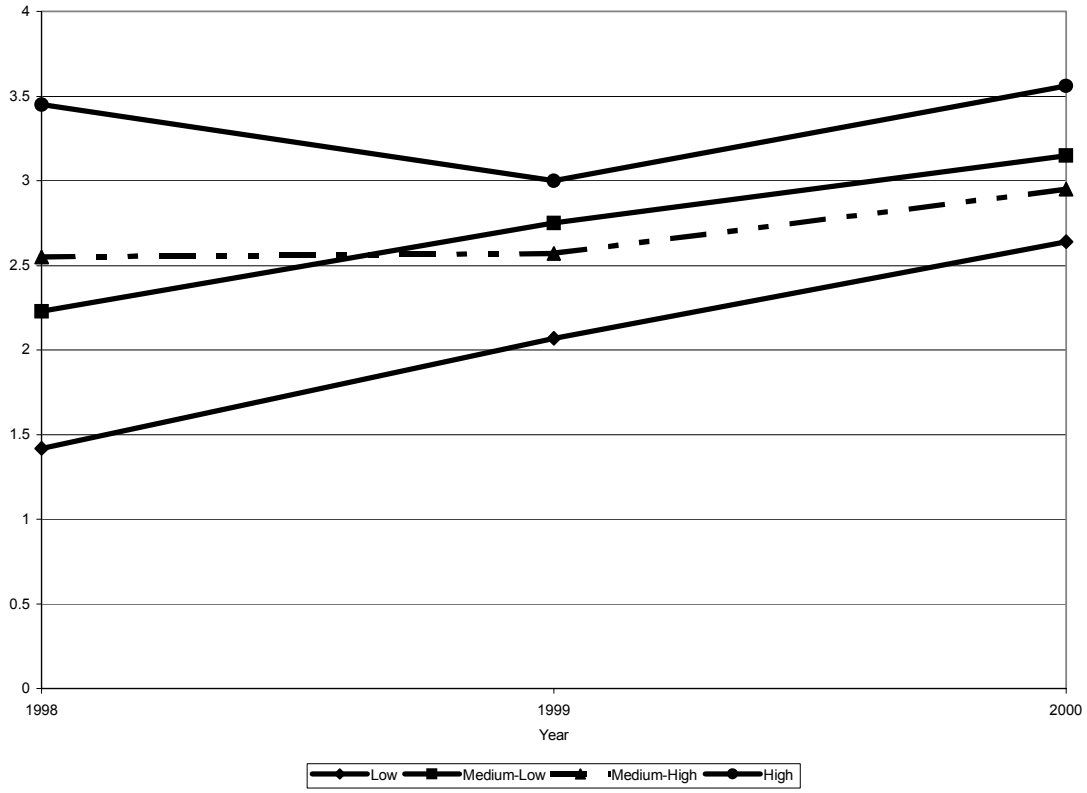
J. Cross tabulations of teachers' use of technology and level of use of constructivist approaches as recorded on the observation protocol during formal classroom observations.

Classroom Clusters

There was no one model or prototype of a constructivist learning environment. Rather, analysis of quantitative and qualitative data reveals that classrooms fell along various points on the continuum of constructivist practices. For the purposes of classification, classrooms were placed in clusters along a continuum of constructivist approaches: low, low-medium, high-medium and high. The classifications are comparative, not absolute, and indicate that these classrooms are low, medium, or high in relationship to one another. The purpose of placing classrooms in clusters was to categorize classrooms according to a set of common characteristics and to track the movement of these clusters over two years: Where did classrooms start out and where did they move? Did classrooms remain in their particular category over time and if so, why? Each category will be discussed below in greater detail.

As can be seen from Figure I those clusters that had the lowest baseline constructivist "scores" showed the greatest change in classroom practice; Those with the highest baseline constructivist "scores" showed the least change.

Figure 1: Changes in Cluster Mean Scores



Low constructivism

Fifteen percent of classrooms observed at the end of year two of the ATRL project were identified as "low constructivism." This type of classroom fell on the lowest end of the constructivist spectrum with few or no constructivist practices. Low constructivist environments were teacher-centered: the teacher did most of the talking and the major class dynamic was whole group instruction. Typically, the teacher stood or sat in front of the class with students seated in rows. Such classrooms were characterized by a high degree of centralization and conformity. All students worked on the same activity at the same time. The teachers in this category worked with the whole class as a group, or rotated around the room to assist individual students.

Discourse was quite limited, consisting mainly of students responding to teacher-directed questions, usually providing short or rote answers. Student contributions or attempts to contribute were often not acknowledged and students were offered

little opportunity to express their viewpoints or share their knowledge about a particular domain. There was usually little or no teacher-supported interaction between students. Though there may have been some use of small groups, there was often little student autonomy and students worked individually on teacher-assigned tasks.

Technology use: In terms of materials, traditional resources such as the overhead projector, textbooks, worksheets, paper and pencil, and the chalkboard were used. Though these classrooms may have had classroom computers, students infrequently or never used technology. When used, these classrooms tended to employ tools that mirrored traditional practices, such as students taking *Accelerated Reader* tests individually or the use of computers for teacher productivity.

Medium-low constructivism

By the end of year two, 24 percent of the formally observed classrooms were identified as medium-low constructivism. Medium-low constructivism classrooms differed from low constructivism classrooms primarily by the way they were organized for learning and by their use of technology—though the most obvious distinction between the two may be one of form as opposed to substance. Within these medium-low classrooms, students typically tended to sit together in groups working on a particular activity. Quite often these groupings were in the form of learning centers in which students were engaged in a number of discrete activities that were formerly conducted as a whole group activity. The worksheet was still prevalent in the low-medium constructivist classroom. Of the activities occurring at each station, approximately half may have been "open ended," that is requiring greater student creativity, problem solving, or greater student autonomy. Though students may have exchanged ideas on assignments, and were allowed to experiment and explore new ideas, students tended to be working together more individually than collaboratively.

The degree of collaboration varied across classrooms within this category. In some classrooms, students were arranged in loosely cohered groups, interacting with materials and to a much lesser extent, with one another, in solving problems. In others, the entire class was involved in the same activity at the same time. Though working in collaborative settings, students communicated very little or not at all, and the main communication pattern was still teacher to student(s).

Technology use: There was no pattern of technology use in a low-medium constructivist learning environment. For example, students in a low-medium constructivist classroom may have been engaged in an open-ended activity such as the creation of a product of their choosing, or in a more close-ended assignment, for example an *Accelerated Reader* test or word processing a report. Oftentimes, however, the computer activity was the most open ended, eliciting student creativity, problem solving or critical thinking skills.

While the teacher demonstrated activities, students engaged in some hands-on activities and more skilled students assisted less skilled students. The teacher solicited students' knowledge about a particular topic and generally offered more in-depth questioning of students' prior knowledge, understanding and opinion. However, patterns of communication were still predominantly teacher-student, versus student-student.

Medium-high constructivism

Approximately 32 percent of classrooms formally observed were identified as medium-high constructivism. Medium-high constructivist classrooms differed from medium-low classrooms in terms of substance rather than style. They were more learner-centered with the teacher in the role of facilitator or working with small groups of students. In such classrooms the teacher employed a variety of instructional methods, including class discussion, student writing, and responding to questions.

Students also worked in collaborative groups or pairs and typically interacted with a variety of materials: books, reports, worksheets, individualized instruction from the teacher, and the World Wide Web, to gain information. In some classrooms students were responsible for their own work, as opposed to a collaborative product. Some of the classrooms were characterized by teacher-led activities, but in such cases the teacher asked open-ended questions and solicited students' prior understanding. While the primary pattern of communication in medium-low constructivist classrooms was either teacher-student or a weak student-student pattern of communication, in medium-high constructivist learning environments the communication pattern was student-student and student-teacher.

While medium-high constructivist classrooms, like their medium-low counterparts, often employed learning stations, the activities in each tended to be more thematic and open-ended and the activities distributed. In other words, while students, at their various centers, may have been working on the same thematic unit, the activities at each station varied and students were not all doing the same thing at the same time. While students might not be organized into centers, they were in fact working either individually or collaboratively on multiple activities.

Technology use: A number of technology management models were evident in this medium-high constructivist environment. First, learning centers were employed in which students were provided with greater opportunity for communication, peer tutoring and collaboration, though the degree and kind of collaboration tended to vary across classrooms. None of the centers observed was thematically integrated, and some were based upon traditional content such as cursive handwriting and alphabetizing spelling words. In all of the centers the students interacted with each other by

talking and discussing the task at hand, although in most of the centers students were responsible for their own written assignment or product for assessment.

A second model involved "concurrent groupings" where part of the class worked on a task at the computer while the rest of the class focused on another activity. Sometimes the activities were related to each other, for example in two classrooms, four pairs of students gathered information from the Internet to complete an assignment about a particular author. At the same time the remainder of the students who were not on the Internet wrote a personal response to the author about the story they listened to. In a third classroom, the majority of the class worked on a reading assignment for a class novel and a creative writing assignment, while two students worked with a student teacher on a *Hyper Studio* stack.

A third model involved all students having access to all computers. This model occurred in very specific settings—a library and computer lab—where access to multiple technologies was more prevalent than in the classroom. In the computer lab most students had their own computer, and in the library, groups of three to five students created a group presentation. Some of these students were practicing the oral part of their presentation, while other small groups worked at the computer. In all of the three models described above, as students were engaged in activities, the teacher either worked with another small group of students, or rotated among students, and offered assistance as needed. Though medium-high classrooms exhibited certain models of technology management there was no discernible pattern of technology use. Since activities in general tended to be more open ended, technology use also conformed to this pattern. Unlike the medium-low constructivist classroom, where the computer station activity may have been the most open ended and creative of the stations, there was no indication that this was so in a medium-high constructivist environment.

High constructivism

Twenty-nine percent of all classrooms formally observed were identified as high constructivism. The high constructivist learning environments differed from the medium-high constructivist learning environments in terms of the frequency and depth of student-centered approaches. These classrooms were characterized by students working together, autonomously, cooperatively and collaboratively, at their own pace and on a real world topic of their own choosing, with different groups conducting different activities simultaneously. Students appeared highly engaged and motivated by the curriculum and were allowed to come up with their own expressions of a problem they had solved or a product they had created.

In such high constructivist classrooms, the teacher was truly a facilitator or guide, typically circulating among students and observing student work. Most noticeable was that teacher talk, in relation to that of the students, was minimal. In most high constructivism classrooms, the teacher rarely talked to the class as a whole and answered questions or offered guidance only when it became obvious that students had exhausted all other forms of assistance. Further, within a high constructivist learning environment, the teacher appeared to be a co-learner with students, spending less time conveying information, and more time guiding students to sources of information. Field notes and formal observations noted that teachers in high constructivist classrooms often learned from and with students. Most often the learning took the form of some sort of new technology use but also included new concepts or facts within the subject area being studied. The research of Roehrig-Knapp & Glenn (1996) supports this "co-learning" role of the teacher in a constructivist learning environment.

Technology use: Students used several computer applications—on-line encyclopedias, the World Wide Web, presentation software, content-specific CDs, graphics software and word processing—for the purposes of research and expression. In all instances of high constructivist learning environments observed, students were independently using computers to solve problems, create intellectual products, produce written work, and other classroom activities. These classrooms had an atmosphere of inquiry and communication that encouraged student contribution and direction. Students in such a high CLE appeared to be highly engaged in the learning process and enjoyed a good relationship with their teachers. In such an environment the teacher was the model of a guide, facilitator, coach and mediator.

Typically, project teachers indicated that the constructivist approaches modeled in professional development sessions, were meaningful to their experiences. Teachers then seemed to utilize such approaches with or without technology with students. Further, as teachers became more comfortable with technology, they were more likely to let students use it. Once teachers allowed students to use technology and saw that many students had a certain amount of expertise, they were more likely to cede control of technology to students. Once this control was loosened and teachers saw that students worked well with technology and that their work improved as a result, they began to cede control in other areas, granting students' greater autonomy in their work.

Professional Development, Student Culture, and Constructivist Approaches

Findings indicate that many factors appeared to have influenced teachers as they changed their practice to accommodate constructivist practices supported by technology. Professional development opportunities appeared to have made a major impact on teachers' practice. Professional development that allowed teachers to construct professional knowledge about pedagogy, content, and technology, as well as strategies for managing the changing classroom environments seems to have brought about the creation of constructivist learning environments supported by technology. Peer support was instrumental

for teachers as they changed their practice and also seemed to play an important part in the process of creating constructivist learning environments. This support came from colleagues or others such as an expert or leader.

As knowledge is a product of the activity, context, and culture in which it is situated, it is important for teachers to understand their community of practice. There was not much evidence that teachers drew upon students' diverse background in their classes. Further, teachers appeared not to harness the benefits of the culture, knowledge and language that minority families have to offer. According to Trueba (1999), teachers need to provide culturally different children with an environment that capitalizes on students' existing linguistic and cultural knowledge. If teachers acknowledge the richness of students' first language and the value of their life experiences and culture, the stage is set for student empowerment. It is crucial to create " ... a positive learning environment in which children become engineers of their own intellectual destiny and co-construct their future" (Trueba, 1999, pp 147).

The majority of the ATRL teachers seemed to know little about their students' background as reflected in their answers to a *Funds of Knowledge* (Moll, et al., 1992) questionnaire developed by the ATRL project. Ninety-one percent of the teachers who completed this questionnaire did not know if their students spoke languages other than English at home. In addition, 58% of the teachers did not share the ethnicity or the socioeconomic status of their students. In informal interviews, some teachers claimed that their students' background hampers their behavior and their willingness and ability to learn. It is possible that teachers did not ask students about their prior knowledge because they thought students knew little or nothing about the subject at hand.

For a student to open up and share what he/she knows, the student must trust the teacher and feel safe. It may be that this atmosphere was lacking in some classes and that when teachers did question students about cultural experiences, knowledge of a topic, etc., students were less inclined to respond. When students and teachers shared the same ethnicity/race more constructivist approaches, such as the use of prior knowledge were evident, even though such use appeared minimal and involved very visible or superficial aspects of culture, such as foods, celebrations, or heroes. Higher level approaches where students are permitted to view concepts and issues through the prism of their own culture were not reported. Although 54% of project teachers, had been exposed to diversity training, more research and training is needed in how to help teachers achieve classrooms where students feel safe and valued and where supportive relations with teachers and peers give children the opportunity to fully develop their talents and capacity.

RECOMMENDATIONS, CONCLUSIONS AND POINT OF VIEW

The study found four clusters of constructivist learning environments based upon variations in the intensity and frequency of constructivist approaches. The clusters were Low, Medium Low, Medium High and High. Within the clusters, classrooms shared many common characteristics. Teachers' change in practice was significant across the two years of the study.

We can assist teachers by providing them with collaborative groups where they can build peer support networks, and where they can share knowledge and gain assistance in the process of implementing new ways of teaching within their schools. Administrative support is critical to initiate and maintain change.

We need to know how to help teachers develop safe and empowering classroom environments for minority students and present models to them on how to use and be sensitive to students' funds of knowledge and cultural capital.

While the presence of technology may make teachers cognizant of the need to change instructional practice, it did not result in changing practice *per se*. Not only must we make technology available, we must increase teachers' understanding of how to employ technology in meaningful ways. For the teachers in this study, change appeared to occur with teachers' increased confidence/comfort using technology, supported by a collaborative group of other teachers in the school. As teachers participated in the ATRL professional development sessions, they learned to use technology, but, more importantly, became conscious of themselves as learners and more cognizant of best instructional practices. The teacher became less a repository of knowledge and more a general manager of learning in the classroom. The student role, in turn, was transformed from spectator to the protagonist in the learning process.

In the beginning stages of the adoption process of new constructivist teaching and learning strategies, it is important to count on close peer support and expert help in the development of lesson plans. In addition, the availability of opportunities for teachers to build confidence and comfort with the use of technology in a safe environment makes a difference in achieving the actual integration of technology tools in a constructivist learning environment in the classroom.

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