Journal of Elementary Science Education, Vol. 20, No. 4 (Fall 2008), pp. 49-60.

Lasting Impact of a Professional Development Program on Constructivist Science Teaching

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Abstract

This study was conducted to examine the effectiveness of the GK-12: Lowcountry Partners for Inquiry program that included an emphasis on constructivist teaching methods for science teachers and science graduate students. The goal was to monitor middle school teachers' use of constructivist practices in their classrooms two years after their last program experience. Classroom observations, Constructivist Learning Environment Surveys (CLES), and interviews were conducted to assess their use of constructivist practices. Data suggest that teachers' use of constructivist practices increased following completion of the GK-12 program. Scores in each of the five CLES categories were significantly higher two years post program involvement than at the end of the program ($p < 0.05$). Teachers reported that they not only continued but also increased their use of constructivist practices because of the increased achievement and improved critical thinking skills of their students.

Introduction

Social scientists have recognized the value of a constructivist learning approach for a number of years (Moussiaux & Norman, 1997). Bolliger (2004) reported that this approach fosters active learning and the development of critical thinking skills. Investigation of pedagogy and constructivist teaching and the impact of its use on achievement are ongoing. Although there are many aspects to constructivist teaching methods in the classroom, the practice is broadly defined below:

> *Constructivism* is a view of learning that sees learners as active participants who construct their own understandings of the world around them. Using past experiences and knowledge, learners make sense of the new information that they are receiving. (Brown & Adams, 2001, p. 7)

Nix, Fraser, and Ledbetter (2003) note that constructivist teaching models include (1) personal relevance, (2) scientific uncertainty, (3) critical voice, (4) shared control, and (5) student negotiation. *Personal relevance* emphasizes the individual while the curricula focuses on personal growth, autonomy, and the concept that material to be learned has a unique meaning. In a constructivist classroom, students create meaning through activities that use manipulatives, questions, and relevant experiences. Students who understand scientific uncertainty are encouraged to

question what they are learning and ask questions that will help them gain a better understanding (Van Sickle, Tempel, Gaskill, & Tempel, 2005). In a constructivist classroom where *scientific uncertainty* is emphasized, students see knowledge that arises from theory-dependent studies. That knowledge is acquired in a social context that is evolving with the human experience (Johnson & McClure, 2000).

Freire (1985), Simon (1987), Giroux and McLaren (1989), and Lensmire (1995) describe *critical voice* by emphasizing students' involvement in the dialogue to the extent that their "voices would sound and be heard" (Lensmire, 1995, p. 1). Critical voice is developed by the teacher to foster a social climate in which the students feel it is appropriate and legitimate to question the teacher's approach and methods (Van Sickle et al., 2005). The teacher's role in a constructivist classroom also changes from bestowing information to orchestrating discussion and mediating activities through which students gain an understanding of concepts through action. Classrooms that provide *shared control* engage in constructivist teaching practices that tend to be more student-centered with an emphasis on student input and action. In such an environment, shared control is fostered as the teacher invites student input to jointly determine the learning environment (Johnson & McClure, 2000). Student negotiation occurs as teachers provide students with the opportunity to describe and justify their new ideas about content (Taylor, Fraser, & Fisher, 1995; Van Sickle et al., 2005). In the constructivist classroom, students are viewed as collaborators who work together in the learning process. Moreover, *student negotiation* and input is critical in the discussion of concepts so that students are able to create an understanding based on their current knowledge.

Constructivism is a theory of learning rather than one of teaching, and some skepticism has been raised over its implementation (Richardson, 2003). Many people believe that the essential elements of effective constructivist teaching are unknown. Arguments have been made that in order for teachers to be effective constructivist teachers, they must have strong depth of content knowledge. Subject knowledge may be adequate in secondary schools, but it is not as common at the elementary level where educators teach many different subjects at a time. There is also a disregard for a constructivist approach among some teachers, especially veterans, who believe that the approach creates a chaotic and disruptive classroom environment (Richardson, 2003). Many teachers lack a strong belief in the effectiveness of constructivist teaching methods in the classroom and are thus unlikely to use these practices. In a study completed by the Washington School Research Center, a total of 669 classrooms were observed in 34 schools. Strong constructivist teaching was observed in only 17% of the classroom lessons (Abbott & Fouts, 2003).

On the other hand, many teachers have a strong belief in constructivist practices and do their best to implement them, but they often lack administrative support (Dempsey, 2002; Haney & McArther, 2002). Many principals do not want to take the time or resources to reform programs to include constructivism. Teachers also complain that principals do not understand the need for financial support for hands-on manipulatives in lieu of textbooks. Principals may also give teachers poor evaluations for using their textbooks as a reference rather than as a primary source (Dempsey, 2002) and may perceive the constructivist classroom environment as chaotic and lacking teacher control. Finally, some teachers argue that few professional development programs are given about constructivist teaching practices (Dempsey, 2002). Loucks-Horsley, Love, Stiles, Mundry, and Hewson (2003) found that "Historically, professional development has focused on only adding new skills and knowledge without helping teachers to rethink and discard or transform thinking and beliefs" (p. 46). This type of professional development leaves teachers feeling

besieged, rendering the practice ineffective. The lack of constructivist teaching initiatives is surprising given data that suggests that its use has a positive impact on achievement (Abbott & Fouts, 2003). The full implementation of these practices in the classroom appears to take more than 90 hours of professional development, with an understanding of the definitions of these practices developing in the same time frame (Van Sickle, Tempel, & Tempel, 2007).

In 1994, teacher education and professional development were added to the original six National Education Goals. Professional growth is at the heart of school renewal and, ultimately, the quality of education. A constructivist perspective enables teachers to link theory and practice in ways that promote growth and change. When professionals create their own questions and means for answering them, they can construct their own understandings and their own classroom improvements. Unfortunately, a constructivist approach has not been characteristic of teacher education reforms mandated by most national reformers (Schwarz, 2001). Professional development must include consideration of constructivist practice, addressing the beliefs held by educators and the methods they use to incorporate these beliefs into their teaching.

Several factors are involved if change is to occur as a result of constructivist professional development: (1) teachers need adequate time for the phases of the change process to occur: initiation, implementation, and institutionalization (Loucks-Horsley et al., 2003); (2) teachers and staff need to learn and apply collaborative skills to make shared decisions, solve problems, and work collegially; and (3) teachers must address diversity by providing awareness and training related to the knowledge, skills, and behaviors needed to ensure an equitable and quality education for all students (Gonzales, Pickett, & Hupert, 2002).

Tienken and Achilles (2005-2006) report that professional development in any form is generally ineffective, failing to produce real changes in teacher behavior or in student outcomes. Further, they note that those who receive professional development should demonstrate positive changes in skills, knowledge, attitudes, and behavior resulting in improved student performance. Unfortunately, data too often suggests that professional development is ineffective, resulting in little change in teacher behavior or student achievement.

The study reported here examined constructivist teaching practices used by teachers who had 225 hours of professional development in constructivist teaching methods two years previously. It was hypothesized that professional development for teachers that included theory and practice in constructivism, such as in the GK-12: Lowcountry Partners for Inquiry program, would result in its continuing use. The specific aims were to measure the level of current constructivist practice and compare it to program end data, and to identify and describe reasons why teachers decided to continue employing constructivist teaching practices in their classrooms. Both self-report and external evaluator reports continued to be used to examine the effects of the professional development.

Method

Participants

Four teachers who completed 225 hours of professional development in constructivist teaching methods in a three-year program at the College of Charleston (CofC) were studied two years after completion of the program. The program focused on the five parameters of constructivist learning and teaching

through courses taught in collaboration with the Medical University of South Carolina (MUSC). Graduate fellows from CofC and MUSC paired with teachers in the Charleston County School District (CCSD) to create lessons that modeled the constructivist methods they were taught in the program. Teachers were able to enter the graduate fellows' laboratories to gain hands-on experience and a real-world perspective of the science they teach. The roles were also reversed as the fellows entered the teachers' classrooms and used the methods to convey the types of practices and information the fellows use in the field. The fellow/teacher pair videotaped lessons they taught and then watched and discussed their teaching in the course in which close attention was paid to the constructivist methods they had learned earlier. The teachers who were selected for the program teach in the CCSD that is a large, primarily urban school district. The partnership between the colleges of graduate studies at the CofC and MUSC was supported, in part, by an NSF GK-12 grant (0139313). To learn more about the GK-12: Lowcountry Partners for Inquiry program visit www.musc.edu/grad/NSF/nsfhome.htm.

Instrument

The Constructivist Learning Environment Survey (CLES) (Taylor, Fraser, & White, 1994) was used to rate the teachers' use of constructivist practices in the classroom. The CLES evaluates the five parameters of constructivist teaching described earlier. The CLES consists of 35 questions, seven of which are allocated for each of the five parameters. The score range is five to 35 per parameter. The average score per subscale is 18, and it represents that the person "sometimes" felt they were using this tactic when teaching. A scale which offers five choices from one being "not at all" to five being "always" generates the scores. The CLES survey has been recognized throughout the education community as an excellent measure of constructivism in the classroom. The Cronbach alpha values for each parameter are as follows: personal relevance = 0.81, scientific uncertainty = 0.54, critical voice = 0.79, shared control = 0.85, and student negotiation = 0.68 (Taylor et al., 1994). Alpha values indicate the consistency of responses made to items within a parameter. The greater the consistency, the higher the alpha values, with 1.0 being the maximum. Detailed field notes were also collected based on what was observed in each classroom. Finally, an interview was conducted with each teacher to gain deeper insight about each teacher's use of constructivist teaching practices in their classroom.

Design and Procedures

Each of the four participants' classrooms was observed for a total of eight hours to help ensure that the scores were reflective of practice. The observer was trained in the observation of use of constructivist techniques (CLES) in the classroom by the principal investigators. The observer took extensive field notes of each classroom encounter. After eight hours in each classroom, the observer completed a CLES of the teacher based on the observations. The observer's CLES scores were a control to ensure the accuracy of the self-report. Each teacher also filled out a CLES examining their own use of constructivist teaching practices throughout the school year. Allowing teacher self-assessment was introduced to eliminate potential observer bias. The teachers themselves likely have a better perspective of their routine use of constructivist teaching methods. One problem with self-reporting is the potential for inflation of scores. After the CLES post program was

completed for each teacher, their scores were compared to their scores on the CLES at the immediate conclusion of the program.

An interview was conducted with each teacher after completion of the classroom observations and CLES questions were asked pertaining to the following: (1) the use of constructivist teaching practices, (2) student achievement each teacher perceived as related to the use of constructivist teaching practices, and (3) the amount of professional development each teacher had received in constructivist teaching methods since the GK-12 program. After the initial data were analyzed, a second interview of the teachers was conducted to clarify the results.

Data are presented as mean +/- Standard Error of the Mean (SEM). The Wilcoxon Rank-Sum test, appropriate for the small sample size, was used to compare current mean CLES scores with the mean scores at the immediate conclusion of the program. This test is powerful, less sensitive to outliers than the two-sample *t*-test, and does not assume a normal distribution (Lam & Longnecker, 1983).

Results and Discussion

Summaries of the CLES data for each of the four teachers on each of the parameters are shown in Figures 1 through 5. The data in Figures 1 through 5 include end of program, two years post program, and outside observer values. Figure 6 shows the average CLES score for the four teachers from the end of the program and two years post program.

Teachers' use of constructivist teaching methods increased following the conclusion of the GK-12 program. CLES scores for all four teachers were higher after two years than at the immediate conclusion of the program ($p < 0.05$). Personal relevance, scientific uncertainty, critical voice, shared control, and student negotiation all showed a significant increase ($p < 0.05$). Mean teacher scores determined by outside observation as well as self-assessment improved after the conclusion of the program.

Figure 1. Personal Relevance

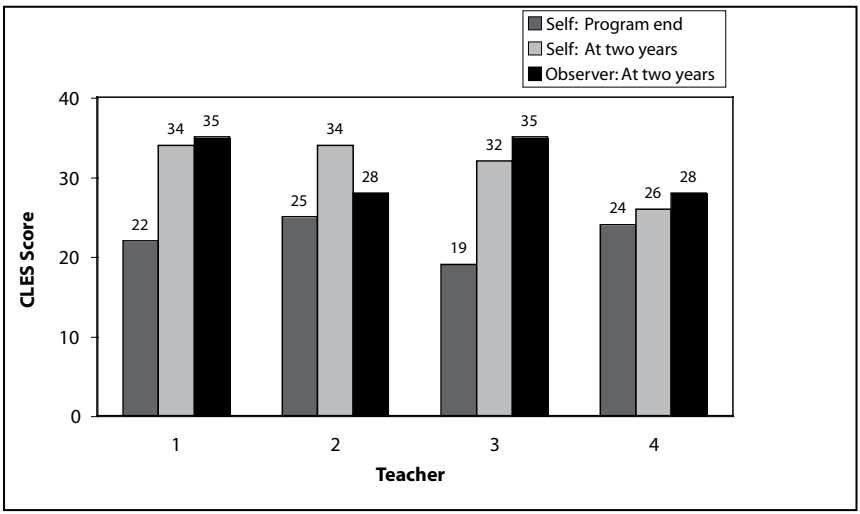


Figure 2. Scientific Uncertainty

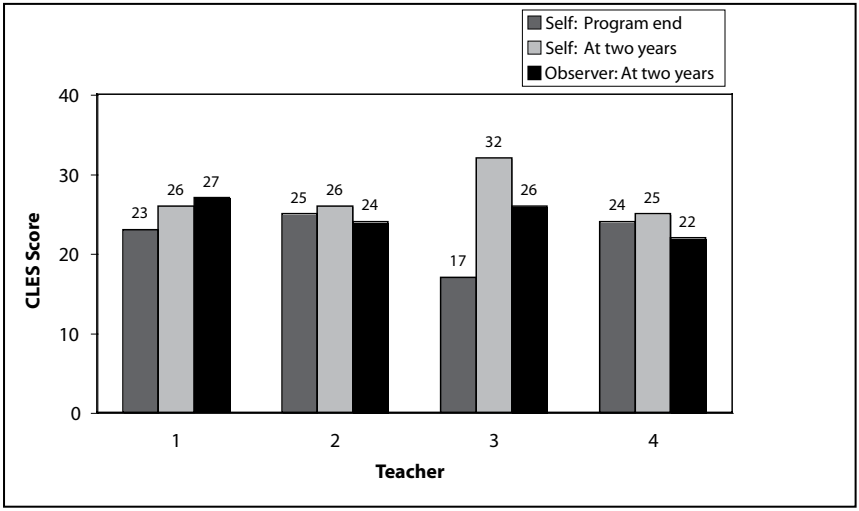


Figure 3. Critical Voice

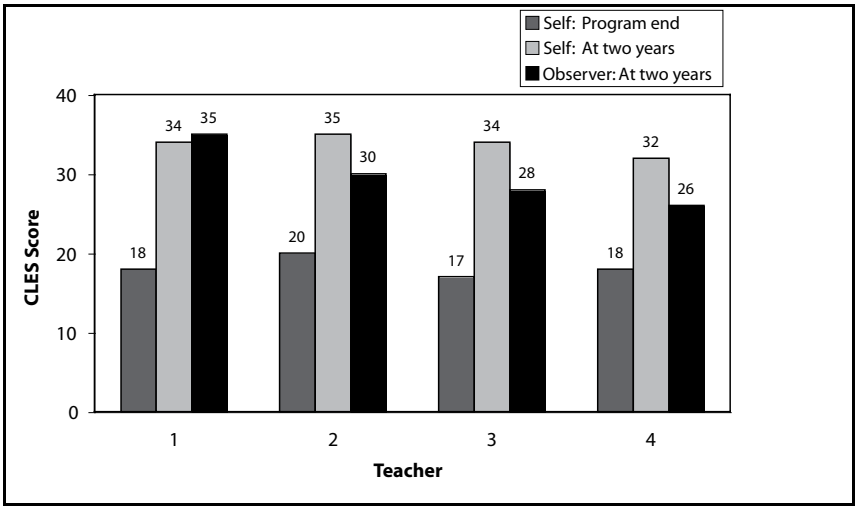


Figure 4. Shared Control

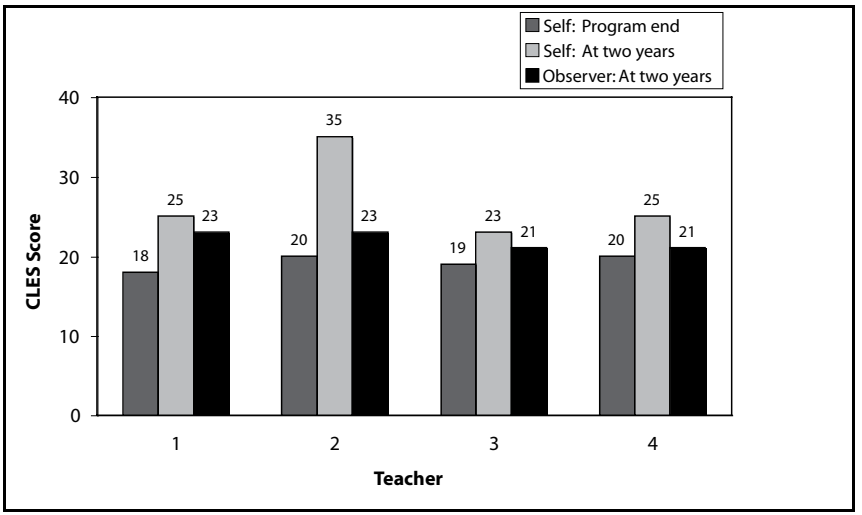
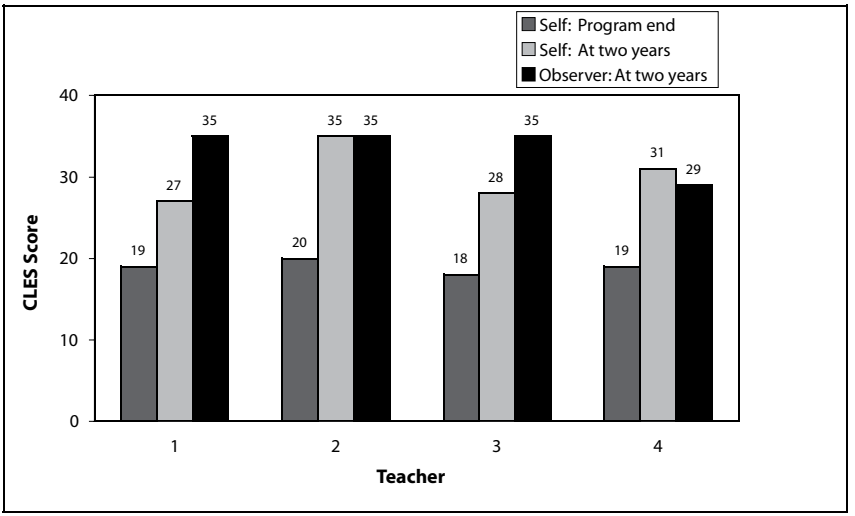


Figure 5. Student Negotiation

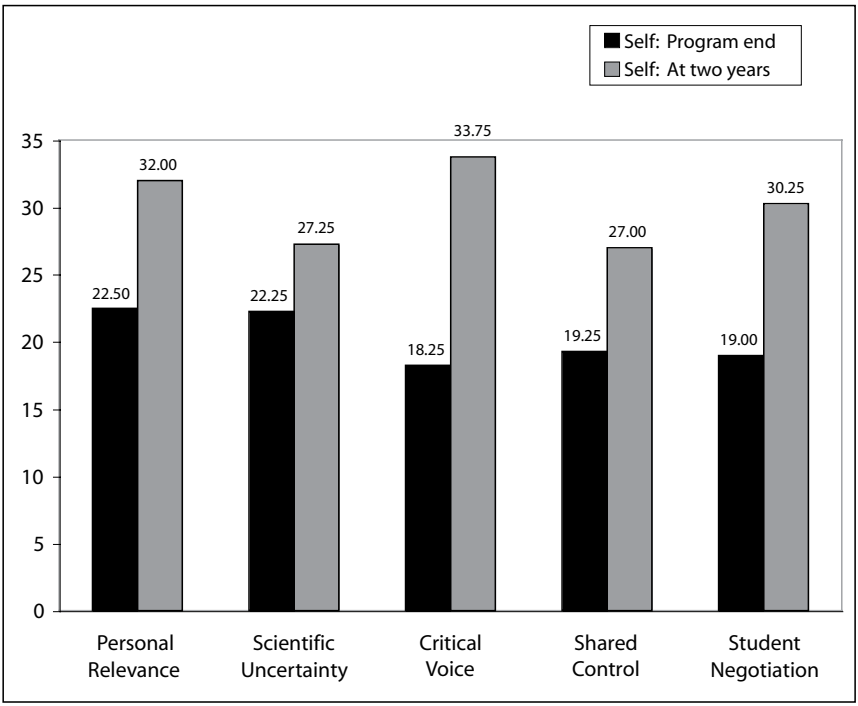


Figures 1 through 5 show differences between the self-reported CLES scores of the teachers and those of the observer. For each parameter, both the teachers' and the outside observers' score were significantly higher ($p < 0.05$). The limited classroom observation time available could explain the difference between the observer and teacher scores. A second equally plausible explanation is that a teacher may over-estimate their use of constructivist methods. In general, the observers' scores were higher or nearly the same as the teachers' scores. The observers' CLES scores

resulted from eight hours of classroom experience for each teacher; the teachers' self-reported CLES scores arose from the generalizable mindset of the teachers' day-to-day use of constructivist teaching methods over an entire year.

Figure 6 shows the mean scores of the four teachers at the end of the program and two years after the program. The mean scores were significantly higher ($p < 0.05$) two years after the program.

Figure 6. Average CLES Scores



Teacher Interviews

When teachers were asked why they chose to increase constructivist teaching methods, all four responded by saying that it works and is an effective teaching strategy. Teacher 2 answered, "It works, it's interesting, it makes sense, and I get to be creative and actively challenged." When inquiring about the benefits the teachers have discovered through implementing constructivist teaching methods into their classroom, all four acknowledged improvement in student achievement, better student relationships, improved critical thinking skills, and a more engaged classroom. Teacher 1 replied, "It [constructivist teaching methods] certainly boosts critical thinking skills. I think constructivist teaching lends itself to intrinsically motivating students. There is ownership of the lessons and, thus, higher achievement." Teacher 2 responded, "Students are more energetic in a positive way; they are more engaged. Their faces look alive rather than the 'glazed over' look." The teachers used a plethora of activities in their classrooms that fostered a constructivist approach. Activities promoting constructivist teaching that were

both observed and mentioned by teachers include open-ended labs, discovery labs, reflection, journal writing, and kinesthetic/hands-on lessons.

When the teachers were asked what type of professional development was available within the schools that supported constructivist teaching, all of the four stated that nothing was available; however, all four shared that they had completed graduate programs at the CofC where they learned and experienced the constructivist teaching model. Teacher 1 commented, "Each one of the professors had valuable techniques to share and assist with constructing meaningful lessons using open-ended lessons." Teacher 4 was so enthusiastic about the program that she wanted to become a trainer for future teachers and fellows.

During the second interview, teachers were asked exactly why they believed their CLES scores had increased. Teacher 2 stated that the program changed her belief structure about her methods of instruction, and, as she practiced constructivist teaching, she became more skilled. All the teachers declared that student achievement and increased critical thinking skills were the primary motivators for the continued use of constructivist teaching and that with practice, their use of constructivist teaching methods improved. Teacher 4 stated, "Student achievement is directly related to students' active involvement. Students have to learn to become critical thinkers."

All four teachers further confirmed that the support, duration, and relevance of the GK-12 program were major influences in their persistent use of constructivist teaching methods. Teacher 1 commented, "The GK-12 program has been a dynamic experience for me. It has helped me become a better facilitator for learning. I would hope that the methods and experience from the GK-12 [program] would change the way all classes are formatted in the future." The aforementioned suggests that the use of constructivism related largely to the teachers' exposure to classes that resulted in this change of classroom practice and that they had little or no support from the building administration.

Conclusion

This study was conducted to examine the use of constructivist teaching methods two years after participating in the GK-12: Lowcountry Partners for Inquiry program. Four teachers who participated in the program were studied. Each of the four teachers' classrooms were observed for eight hours, extensive field notes of the classroom observations were taken by a trained observer, the CLES was completed by the observer, and each teacher was interviewed to examine self-assessment of continuing use of constructivist teaching methods. The teachers also completed a CLES based on their own use of constructivist teaching methods. The CLES scores of the teachers and the observers were compared to the CLES scores for each teacher at the immediate conclusion of the program. For each of the four teachers, CLES scores had increased in all five categories from the end of the program ($p < 0.05$). It is of interest that not all participants had improved scores to the same extent. Future studies will examine possible factors ranging from teachers' belief structures to administrative support. Teacher interview data suggested that a change in belief structure and practice were reasons for increased CLES scores. Teachers commented that student achievement and improved critical thinking skills were primary motivators for continuing use of the constructivist model. Teachers also stated that the duration, support, and relevance of the GK-12: Lowcountry Partners for Inquiry program reinforced their interest in practicing the constructivist model in their classrooms.

Recommendations

Most of the professional development offered to teachers leaves them confused and overwhelmed, rendering the professional development ineffective (Loucks-Horsley et al., 2003). The GK-12: Lowcountry Partners for Inquiry program promoted the continuing use of constructivist teaching methods for its participants. Constructivist teaching methods have been recognized as a powerful instructional strategy for many years (Moussiaux & Norman, 1997). Teachers who participated in the program experienced increased student achievement and improved critical thinking skills for the students.

The constructivist teaching model keeps students motivated and engaged while relating learning to life outside of the classroom. The constructivist approach increases student achievement as well as their enthusiasm for learning. It is recommended that the constructivist teaching model be used in all classrooms to ensure effective teaching and learning.

The duration, support, and relevance of the GK-12 program motivated teachers to achieve mastery of the use of the constructivist teaching method in their classrooms. Professional development, such as the GK-12: Lowcountry Partners for Inquiry program, should be available for teachers in every learning community. Professional development programs in constructivist teaching practices should be available with extensive support and relevance to the participants. With this type of professional development, teachers can facilitate student acquisition of critical thinking skills as students take ownership of their learning.

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Manuscript accepted November 16, 2007.