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ABSTRACT

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Increasing Science Achievement and Student Development as Related to Practicing Teachers' Self - Efficacy

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Paper presented at the annual conference of the Eastern Educational Research Association

Hilton Head, South Carolina, 2001

Abstract

The purpose of this research was to describe how self-efficacy affects the development and science achievement of practicing teachers after their participation in a half day long hands-on science lesson provided by the Science on Wheels project. The 42 practicing K-8 teachers were from eight different counties located in a rural mid-eastern state. A novel survey was created to determine the science achievement and self-efficacy level of the teachers (Bandura, 1995). The survey had 30 questions and the questions were modified from existing surveys in the area of science achievement and self-efficacy. The survey was administered at the beginning of the hands-on science lesson and at the end of the half day long lesson. The hands-on science lesson the inservice teachers participated in was designed for middle school students and dealt with the topics of "Matter" and "Light." The middle school students and the inservice teachers participated in the hands-on science lessons which were part of the "Science On Wheels" program. The data from the surveys were analyzed using a paired t - test to determine differences in the pretest and posttest data.

The pretest and posttest data had numerous significant findings. The inservice teachers reported that after they participated in the hands-on science lessons, they felt significantly more confident that they could plan a constructivistic/inquiry science lesson [$t(41) = 4.47 < .01$]. The teachers also felt they could serve as a resource person [$t(41) = 4.50 < .01$] and perform science demonstrations in front of large groups [$t(40) = 4.32 < .01$] of people. The last significant finding dealt with a person's ability to tutor another person. The inservice teachers felt more confident that they could tutor a fellow teacher in science [$t(40) = 3.90 < .01$].

Literature Review

When examining the subject areas of student development, science achievement, and self-efficacy the topic that connects all of these areas together is human development. The developmental period for practicing teachers typically covers young adulthood to middle adulthood. Two prominent theorists in the area of development were Erik Erikson and William Perry. Perry's (1970) theory dealt with forms of intellectual and cognitive development. Perry (1970) believed that development occurred along a continuum of nine positions. Positions seven through nine relate to adulthood and are labelled as "Commitments In Relativism Developed." In position seven, the person makes an initial commitment in some type of area. During position eight the person experiences the implications of commitment and explores the subjective and stylistic issues of responsibility. Ultimately during position nine, the person experiences affirmation of identity among multiple responsibilities and realizes commitment as an ongoing, unfolding activity through which he/she expresses his/her life style (Perry, 1970).

Understanding positions seven through nine, "Commitment in Relativism Developed," as a whole unit; a person develops an identity consistent with his or her own personal beliefs. A person begins to make a commitment in such areas as marriage, career, and in a specific set of values. The person establishes a sense of certainty through making numerous commitments in life. Diverse views are now balanced against a person's individually defined set of values.

Erikson (1959, 1968, and 1980) postulated that adults can be in the stage of "Intimacy versus Isolation" or "Generativity versus Stagnation" during the adult period. During the period of intimacy a person understands who he or she is and makes a commitment to another person relative to their own identity. Isolation is just the opposite in that a person does not form close relationships. A person who is generative has the ability to care for other people as well as society and is productive both socially, emotionally, and intellectually as well as respected at work. A person in a period of stagnation fails to have any meaningful accomplishments.

Along with the area of human development is the topic of self-efficacy. Bandura (1995) believed that "self-efficacy is concerned with people's beliefs in their capabilities to produce given attainments" (p.1). Albert Bandura (1959) was the first to examine and create a social learning theory related to aggression and, in his latter works, coined the term "self-efficacy." In an examination of Bandura's (1977) and Sears' (1951) theory, Grusec (1992) found that "beliefs about self-efficacy arise from the individual's history of achievement, . . . from observations of what others are able to accomplish, . . . attempts of others to mold feelings of self-efficacy through persuasion, and from consideration of one's own physiological state" (p.785).

If a person has low self-efficacy in the area of science and does not feel competent in science, this may affect their development and ultimately their career path. Even before a person forecloses on a career, males and females still tend to gravitate toward traditional career options. Betz and Hackette (1981) found gender differences in self-efficacy with regard to traditional versus non traditional occupations. Taking into account traditional and nontraditional occupations, males reported an equivalent self-efficacy in each occupational area. As one would traditionally expect, "females reported significantly higher levels of self-efficacy with regard to traditional occupations and significantly lower levels of self-efficacy with regard to nontraditional occupations" (Betz and Hackette, 1981, p. 399).

Weiss (1978) found that science teachers felt competent in the area of science in relation to the amount of time they spent teaching science. Stake and Easley (1978) found that teachers do not spend a significant share of the curriculum related to teaching science. Basically, teachers do not enjoy teaching science nor do they feel competent teaching science. This view has not greatly changed in the last twenty years. "Teachers know little about either the content of science or the way scientific knowledge is acquired" (Rigden, 1999, p. 59).

According to Yager (2000) elementary school teachers are not content specialists and are generally responsible for all subject areas in grades K-8. Given this finding, funding has been implemented since 1983 to target science and mathematics teachers both in-service and preservice. The goal of this funding, and subsequent increase in funding, has been to make sure that teachers are prepared to teach science to the students in grades K-12. The National Science Education Standards released four goals of science education in grades K-12. These are (1) to make sure students understand and experience the excitement of the natural world, (2) to use scientific processes to make decisions, (3) to be able to speak intellectually on scientific and technological topics, and (4) to increase their contribution to society by knowing, understanding, and being able to perform scientific skills (Yager, 2000).

Teachers have a great stake in all of these changes and the achievement of these goals. Yager (2000) says, "Teachers have an opportunity to cultivate and nourish their students' innate curiosity about the world" (p. 2). Teachers must find ways to teach students in the classroom that actively involve and challenge the students. The goals listed above also help in diminishing a teacher's own misconceptions and help the teacher to assist students in applying scientific knowledge and skills. In this type of environment, a teacher must be given opportunities to learn because so much information is changing and being acquired by the scientific community (Yager, 2000).

Yager (2000) discusses the Iowa Chautaugua Model (ICM) that was developed to affect teacher training and, ultimately, student learning. In the ICM there were several factors garnered from the study which includes increased effectiveness of teaching and increased student learning for those involved with the implementation of this model. They are (1) to help teachers find their role in the shift to more effective teaching, (2) to help teachers to develop confidence in their role, (3) to provide positive and corrective feedback in a nonthreatening manner, (4) to directly involve the participants in the planning, distribution, and assessment of the new practices, and (5) to synthesize theory, practice, and role-modeling to assist teachers in making connections (Yager, 2000). To summarize the importance of teacher confidence in teaching science effectively, Yager (2000) mentions one of the premises of Science For All Americans, "teachers are central" (p. 8).

In order to fully understand the relationship between self-efficacy and achievement, it is necessary to study three main implications for science teachers as described by Jinks, Lorsbach, and Morey (2000). These are (1) that the science curriculum will be impacted, (2) that the mode of instruction will be impacted, and (3) that the forms of assessment will be impacted (Jinks, et al. 2000). According to Jinks, et al. (2000) the teacher needs to make sure there are small, separate positive learning experiences for the students that gradually increase in difficulty. This is opposed to the more traditional approach of presenting a larger concept and then breaking apart the ideas from the top. Jinks, et al. (2000) believes that self-efficacy will be enhanced if learning experiences ascend in difficulty and sequence.

This theory has many implications for the classroom teacher. The students must strive for autonomy. In doing so, Jinks, et al. (2000) has listed some suggestions on how teachers can increase self-efficacy and, ultimately, student autonomy. They are (1) provide opportunities to reflect on and assess how the students perform in science and identify criteria that students may believe affects their learning, (2) develop more problem-solving lessons, (3) ask the students to contribute to what they want in the science curriculum, (4) make sure lessons contribute to lifelong learning instead of being busywork, (5) provide opportunities for the students to collaborate, and (6) encourage more small group activities and individualized instruction (Jinks, et al. 2000).

Jinks, et al. (2000) also stipulates that self-efficacy hinges on accurate assessment. The teachers may want to evaluate their students' self-efficacy beliefs by soliciting the following information: (1) ask how well do the students expect to perform in science, (2) ask if the students feel confident in their understanding and fully know what they have learned, and (3) ask if they think they are able to learn science (Jinks, et al. 2000). Jinks, et al. (2000) cautions that students should always be able to give reasons and rationalizations for why they have such specific beliefs. Jinks, et al. (2000) cites Bandura (1986) as having said that people will often change how they feel after they have reflected on their behavior and thinking. Jinks, et al. (2000) states that if low self-efficacy students are not allowed to revise their thoughts on science achievement then their self-efficacy will not change.

Gallagher (2000) discusses the idea of teaching for application of science knowledge. He writes that teachers generally have little knowledge related to the application of science knowledge. Because of this, teachers do not include applications of scientific thought in their lessons. They are not able to assist students in making connections to the world around them (Gallagher, 2000). Gallagher (2000) suggests that teachers be made aware of common misconceptions in science such as the appearance of water droplets on the outside of a drinking glass. Gallagher (2000) recommends exposing teachers to research on these misconceptions so that more dialogue can occur in the classroom dispelling these ideas.

Gallagher (2000) mentions his work at Michigan State University on the Mercedes Model of teaching for application and understanding. He says there are three main factors in this model: (1) acquiring a knowledge base, (2) promoting understanding of information and making connections among facts, and (3) searching for applications of the knowledge (Gallagher, 2000). He says that this does not imply that direct instruction is wrong; it merely did not take the students to a higher level of thinking (Gallagher, 2000). He summarizes by saying that his model, like any other model, requires "considerable effort and much reflection and intellectual struggle" (Gallagher, 2000, p. 5).

This present study will describe the connection between practicing teachers' self-efficacy, science achievement, and developmental theories. The goal of this research was to understand how science achievement impacts self-efficacy and overall development. Such an impact was viewed through the self-report of the practicing teachers.

Research Methods

The purpose of this research was to describe how self-efficacy affects the development and science achievement of practicing teachers after their participation in a half day long hands-on science lesson. The 42 practicing K-8 teachers were from eight different counties located in a rural mid-eastern state. A novel survey was created to determine the science achievement and self-efficacy level of the teachers (Bandura, 1995). The survey had 30 questions and the questions were modified from existing surveys in the area of science achievement and self-efficacy. The survey was administered at the beginning of the hands-on science lesson and at the end of the half day long lesson. The hands-on science lesson the inservice teachers participated in was designed for middle school students and dealt with the topics of "Matter" and "Light." The middle school students and the inservice teachers participated in the hands-on science lessons which were part of the "Science On Wheels" program. The data from the surveys were analyzed using a paired t - test to determine differences in the pretest and posttest data.

Description of "Science on Wheels"

Science on Wheels is a three-year grant from the Toyota Foundation USA to the University. This grant awarded the University $385,000.00 to develop and implement a service to the schools in an eight county region in a rural mid-eastern state. The primary objectives of the grant were threefold. The first objective dealt with the enhancement of scientific literacy in geographically isolated schools with the greatest need according to socioeconomic status, statewide test scores, and access to outside resources. The second objective was to serve as professional development for teachers by introducing methodology, strategies, and techniques designed around the constructivist theory of learning. Hands-on/Inquiry type lessons are delivered to the students and teachers. They are shown how and why such an approach is effective. The third objective was to create a practicum experience for preservice, undergraduate students. The students were taught how to prepare lesson plans, assist in the delivery of the lessons, and gain first-hand knowledge about working with students in rural Appalachia with its diverse needs and, thereby, experience a re-dedication to teaching and working with children.

Results

The pretest and posttest data had numerous significant findings. The inservice teachers reported that after they participated in the hands-on science lessons, they felt significantly more confident that they could plan a constructivistic/inquiry science lesson [$t(41) = 4.47 < .01$]. The teachers also felt they could serve as a resource person [$t(41) = 4.50 < .01$] and perform science demonstrations in front of large groups [$t(40) = 4.32 < .01$] of people. The last significant finding dealt with a person's ability to tutor another person. The inservice teachers felt more confident that they could tutor a fellow teacher in science [$t(40) = 3.90 < .01$].

It is also worth noting the questions that did not produce a significant change due to the intervention (hands-on science lesson). Overall, the science teachers felt unprepared to do hands-on science activities that are developmentally appropriate, they are not significantly enthusiastic about demonstrating science activities, and they are not significantly confident that they can be successful in a science course. As a final note of importance, the majority of teachers do not feel confident that they can answer questions about a science experiment.

Discussion

The purpose of this study was to examine self-efficacy and science achievement among practicing teachers. As stated earlier, the Science on Wheels Project takes a hands-on science lesson to the schools for students in grades four through eight. A primary objective of this project was to demonstrate to the teachers the use of constructivism as a learning theory and to demonstrate the application of the state's Instructional Goals and Objectives (IGOs) to science education. The state mandates that fifty-percent of science instructional time be spent in hands-on teaching. The Science on Wheels Project takes hands-on teaching to the schools and enhances the pedagogy of the teacher.

Since it is a common thought in the educational community that teachers teach as they were taught, the new training and experiences should help to engender science achievement among the students and help the teachers to become more comfortable with teaching science. One of the significant results of the study showed that teachers felt more capable to help tutor a colleague with science. In teacher education, science methods for elementary teachers is not a priority and teachers usually feel at a slight disadvantage in teaching science. To have shown an increase on this item is a major achievement for this project. The teachers also felt that they could plan science lessons using a constructivist theory and make developmentally appropriate lessons which incorporated the state's Instructional Goals and Objectives.

Some limitations to this study should be noted. The teachers are in rural and economically deprived areas. Museums and cultural events are severely limited. Access to colleges and universities require hours of travel each way and are difficult for teachers with families to reach. Therefore, the results of this study may not be generalizable to a broader and more urban area. Also, not all areas are fortunate enough to have a Science on Wheels project which will bring the teaching methods and demonstrations to the actual classroom. The project uses inexpensive materials readily available to teachers and leaves lesson plans and ideas for follow-up teaching. The website contains many thematic units that may be downloaded and used in elementary classrooms.

The teachers involved in the surveys reported that they felt confident in presenting science in front of large groups. This is a significant fact since so many teachers become anxious when they have to present before groups of their peers in college and at conferences. The teachers also reported that they now felt that they could serve as resource persons for science. These reports indicate a positive sense of self-efficacy. The teachers appear to perceive that they are more confident and can complete certain tasks with a higher degree of success after the hands-on and constructivist science lessons were presented to them and their students. It would be difficult to inspire confidence in a student if a teacher also lacked such confidence.

Since science is purported to be the basis for the majority of careers in the coming decades as America ages, the need for medical care will also rise. All teachers need to gain a sense of confidence in their own science achievements and nurture that confidence in their students. Teachers can do a great deal to influence career choices and the literature indicates that a positive self-efficacy generated by successful achievement in a subject area does have an influence on career choices. Professional development courses, college courses, and inservice programs should be offered to teachers to augment and enhance their self-efficacy. Developing the perception of a positive self efficacy is one of the best ways of ensuring the success of our society.

Teachers in the area of science need to feel more competent in their subject area as well as have an understanding of the instructional approaches related to hands-on science. The effect of modeling new scientific hands-on experiments provide in-service teachers with new methods and techniques which enable them to teach science more effectively. By providing teachers with hands-on instructional approaches, such techniques have increased their competence related to planning science lessons as well as their self-efficacy related to science. Many of the teachers were anxious to teach the topic of science and when asked to do so they greatly limited their discussion in this area. When the teachers were motivated to teach the topic of science, the students also enjoyed learning about science.

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