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AUTHOR	Carter, William; Sottile, James M., Jr.; Carter, Jennifer
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ABSTRACT

The purpose of this research was to document the relationship among student development, science achievement, and self-efficacy among middle school students. A novel survey was created to determine the self-efficacy levels of the middle school students. The middle school students were also administered two novel content quizzes in the area of "Matter" and "Light" designed for their educational level in a pretest and posttest manner. The surveys and quizzes were administered across an eight county region of a mid-eastern rural state to students in grades four through eight. The hands-on science lesson was part of the "Science on Wheels" program. When analyzing the data by a paired "t" test significant findings were found as related to knowledge among middle school students and their self-efficacy level also significantly changed because the students wanted to have a career in science and felt more confident in science after hands-on science lessons. (Contains 22 references.) (Author/MM)

Science Achievement and Self-Efficacy Among Middle School Age Children as Related to Student Development

William Carter

James M. Sottile Jr.

Jennifer Carter

Marshall University

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Abstract

The purpose of this research was to document the relationship among student development, science achievement, and self-efficacy among middle school students. A novel survey was created to determine the self-efficacy levels of the middle school students. The middle school students were also administered two novel content quizzes in the area of "Matter" and "Light" designed for their educational level in a pretest and posttest manner. The surveys and quizzes were administered across an eight county region of a mid-eastern rural state to students in grades four through eight. The hands-on science lesson was part of the "Science on Wheels" program.

When analyzing the data by a paired "t" test significant findings were found as related to the self-efficacy surveys and content quizzes. The hands-on science lessons increased content knowledge among the middle school students and their self-efficacy level also significantly changed because the students wanted to have a career in science and felt more confident in science after the hands-on science lessons.

Literature Review

Self-efficacy can be simply defined as the perception of competence regarding the performance of specific tasks (Bandura, 1984). Understanding student perceptions about his or her own self-efficacy, a component of self-concept, and how it might affect academic achievements, can provide significant implications in classroom instruction and instructional behaviors (Jinks and Morgan, 1999). Pajares (1995) maintains that how a student develops the facts that comprise and affect self-efficacy is important in analyzing the impact these elements have on students and subsequent performance in educational settings.

Bandura, Barbaranelli, Capara, and Pastorelli (1996) in cooperation with the University of Rome, studied self-efficacy beliefs and academic achievements of 11-14 year olds against a network of psychosocial influences and parental perceptions. The types of self-efficacy analyzed included perceived academic self-efficacy. Mothers and teachers were included in the study. The findings indicated that vicarious life experiences such as socioeconomic status of a family, parental academic efficacy and parental aspirations influence student achievement and self-efficacy.

Bong (1998) examined the role of personal factors such as gender, ethnicity, and expertise in determining the generality of academic self-efficacy judgments. This study revealed that girls and boys differed in self-efficacy perceptions in domain specific tasks such as mathematics and English. In the area of expertise, the students placed in the higher ability groups showed self-efficacy generalizations that were more accurate compared to the other groups. Cooper and Robinson (1991) also noticed that perceptions of support from parents and teachers had a significant, but fragile, relationship with mathematical and career self-efficacy. A longitudinal study reported by Felson (1984) purports the theory that if a student has a lower degree of self-efficacy, he/she may be less likely to work hard because they may already be programmed to expect failure.

Bandura (1993) reported that self-belief, a branch of self-efficacy, affected behavior in four ways: choice of behavior, how much effort a person will apply to a particular task, a person's emotions and thought patterns, and how a person views behaviors. Bandura (1993) stated that

"self-efficacy is a more powerful determiner of the choices that individuals make than either anticipated outcomes or the actual skills and knowledge relevant to the behavior in question" (p.131).

Pajares (2000) discusses how people with low self-efficacy tend to think that things are much more difficult than reality would dictate. A person with low self-efficacy may tend to be more anxious over how to solve problems than individuals with high-efficacy, who tend to attack the problem, and feel confident about the effectiveness of his/her approach. Self-efficacy affects how a person thinks, feels, and acts. "High-efficacy people attributed failure in difficult tasks to insufficient effort...whereas those with low-efficacy beliefs attributed it to deficient ability" (Pajares, 2000, p.3).

Through personal success and failure (enactive or mastery experience) a person learns high or low self-efficacy, depending on the outcome of the experience. Vicarious experience is the way a person learns self-efficacy by watching the actions of others. When people compare their own situations and abilities with the potentials of those around them, they learn vicariously through social comparisons. People, especially children, set their goals and ambitions according to what is important to those around them (Pajares, 2000).

Self-efficacy not only affects the way a person approaches problems, but it has an indirect impact on a person's psychological and physical health. Self-efficacy has been linked to depression and obesity in both children and adults (Faith, Fontaine, Cheskin, & Allison, 2000). Depression and obesity, if not treated may contribute to further health problems with age. Low self-efficacy and depression may initiate a cycle of chronic health problems.

A person's self-esteem and self-efficacy can be influenced by society in many ways. A person who is obese may experience social discrimination. Because of the intentional or unintentional discrimination, obese individuals are less likely to get assistance for college tuition, do not have equal job opportunities, or even a chance at finding a life partner. If someone is told from childhood they are not good enough, smart enough, or pretty enough, they must fill that void with something. In some cases food is the substitute. After a study on obesity, it has been suggested if

you encourage people and help them raise their self-efficacy, academically and socially, as well as boost their self-esteem, they are more likely to loose the weight and keep it off (Faith, Fontaine, Cheskin, & Allison, 2000).

For people with low self-efficacy, Pajares (2000) believes that "failure is just another reminder that they are incapable" (p.11). On the other hand a person with high self-efficacy decides that they should have just worked harder. Pajares (2000) writes "it is usually easier to waken confidence through negative messages than to strengthen it through positive encouragement" (p. 9).

In a recent publication by the North Central Regional Educational Laboratory (NCREL) it was described that our education system should emphasize efficacy (Barrell, 1995). As educators we should "teach and engage students in specific strategies that offer them opportunities to make decisions and solve problems on their own without being told what to do at all times" (Barrell, 1995 p. 1). It is important that children learn self-regulation. It is important that a child learns more than the process of memorization, but also has enough confidence to question the material being taught. The more questions they ask the more that they will learn to be interested in outside sources.

There are five strategies that can be taught to help a person problem solve. These strategies are: " (1) talking ourselves through problems; (2) asking what we know and need to find out; (3) posing questions; (4) visualizing relationships; [and] (5) drawing our own conclusions" (Barrell, 1995 p.2). If children learn how to solve problems on their own, they can solve problems independently. By doing so, they raise their self-confidence and self-efficacy. Bandura (1993) suggested that self regulatory skills are meaningless if students cannot apply them in a persistent manner in the face of difficulties, distraction, and stress. Bandura (1993) believes that "self-directed learning requires motivation as well as cognitive and metacognitive strategies" (p. 136).

A study completed by Ford and Thomas (1997) noted that self-perception (efficacy) does, in fact, affect an individual's personal performance. It is also noted that self-fulfilling prophecies also have a major role in the achievement of children. In the study, gifted children who came from

low socioeconomic backgrounds were discovered to have parents who were "watchful of their children, hyperaware of their children's accomplishments, and actively involved in developing their abilities" (Ford and Thomas, 1997, p.2). It was found that parents who had high expectations and active participation in their child's education had more intelligent children. Berry (1987) found that self-efficacy enhances student's memory performance by enhancing persistence. Chang (1989) also found that gifted students expressed more enjoyment in learning than average students.

In fact, it is possible to predict the outcome of a person's achievement based on their intelligence and self-efficacy. Pajares (1996) believed that precise judgments of capabilities paired to specific outcomes afford the greatest prediction of performance outcomes. These are typically the sorts of judgments that individuals use when confronted with behavioral activities.

In relation to academics, hands-on inquiry learning has been shown to improve student performance in a number of studies (Frederick & Shaw, 1998; Mathis & Nokiyama, 1988; and Tyler-Wood, Cass, and Potter, 1997). A study by Hicks (1998) found that inquiry based learning at a rural middle school for academically challenged students increased the number of those passing science classes by approximately thirty percent. Another study completed by Butta (1998) found that rural high school students participating in cooperative, hands-on instruction had a three percent higher grade point average than those participating in traditional science instruction.

While many studies focus on whether inquiry-based instruction improves science performance few studies examine how it affects student attitudes related to science, particularly over the long-term. One longitudinal study that did examine the interest of students in science over several years, examined both the achievement levels and attitude toward science by middle school students participating in a hands-on summer program with those that did not. The program showed promising results. Gibson (1998) examined middle school students attending a two-week, hands-on science workshop with students having similar science aptitude and interest in the subject. She found that students participating in the program had a more positive attitude toward science in general and continued to have a more positive outlook even while they were in high school. While

both the control and experimental groups showed a decrease in interest over time the experimental group demonstrated less of a loss.

Given the material cited in the literature review, understanding the self-efficacy level of middle school students is an important topic. The role that achievement plays as related to self-efficacy is also an important topic of discussion. Understanding the connection between self-efficacy, hands-on science, achievement, and student development will be the main goal of this research.

Research Method

The purpose of this research was to document the relationship among student development, science achievement, and self-efficacy among middle school students. A novel survey was created to determine the self-efficacy levels of the middle school students. Variables included demographics relating to past experiences, family composition, age, gender, and confidence levels.

The middle school students were also administered two novel content quizzes in the areas of "Matter" and "Light" designed for their educational level. The surveys and quizzes were administered across an eight county region of a mid-eastern rural state to students in grades four through eight. University staff and graduate assistants administered the pretest and posttest surveys and quizzes after a one-half day, hands-on science lesson. The hands-on science lesson was part of the "Science on Wheels" program.

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 Southwestern West Virginia. 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. This innovative project has produced hundreds of pages of lesson plans, inflamed the desires of hundreds of preserve teachers to work in rural schools, and brought about a heightened awareness of the need for science as a subject and possible career for the students.

Results

The middle school data dealing with the topic of "light" revealed significant findings. Taking into account the 51 pretest and posttest content quizzes related to light, the question dealing with "how light travels" [$t(50) = 4.261 < .05$] showed a significant difference between the pretest and posttest scores when using a paired t-test to analyze the data. Figure 1 shows the prominent differences per each question as related to the percent correct on the pretest and posttest surveys.

Figure 1

		Pretest	Posttest
Question	1.	25.5	56.9
	2.	5.9	54.9
	3.	19.6	70.6
	4.	29.4	66.7
	5.	39.2	62.7
	6.	37.3	7.8

The middle school data related to the topic of "matter" also had prominent results when comparing the percent correct for the pretest and posttest scores (Refer to Figure 2). The percent correct for each question increased after the science lesson. The content question related to a

"molecule chain" showed a significant difference between the pretest and posttest scores [t(96)=9.03 < .05] and the content question related to "polymers" had a significant change [t(96)=-4.32<.05]

Figure 2

		Pretest	Posttest
Question	1.	13.1	57.9
	2.	25.2	84.1
	3.	71.0	83.2
	4.	33.6	82.2

The self-efficacy scale administered in a pretest and posttest manner to 64 middle school students revealed significant findings. After the science lesson the students wanted to pursue a science career [t (62) = 4.956 < .05] and they felt more confident that they could have a career in science. The students also had a stronger sense of their science abilities [t (62)=3.82<.01] when they completed the posttest content quiz and self-efficacy survey. At the end of the science lesson the students wanted to pursue a career in science, they increased their content knowledge in science (light and matter), and they felt more confident about their science abilities.

Discussion

The purpose of this research was to bring to the attention of the educational community the \connection between self-efficacy and hands-on science instruction. The results reported herein demonstrate positive relationships in three major areas of science education. These results demonstrate a positive link between academic self-efficacy, achievement, and career potential. Although achievement and career potential do not guarantee scientific literacy, their power cannot be ignored. Most educators agree intuitively, that a sense of success in one domain may lead to a more global sense of efficacy.

The literature suggests that self-efficacy is learned and is not a deep psychological construct. This same literature suggests many variables that impact the development of an

individual's self-efficacy. One of the major variables concern the home environment of the student. It is agreed in the literature that a home where the parents are supportive and discuss specific ways of thinking and learning (problem solving) with their child will produce a positive self-efficacy within that child. Another major factor in developing positive self-efficacy beliefs is the learning theory in place at the school. Brown (1998) identifies constructivism as the effective approach of instruction because it promotes modeling, group discussion, hands on experiences, and a sense of self-worth for the individuals.

In group work, the students talk, share ideas, and explore their beliefs with one another. All ideas are valid and students can learn from modeling their behavior after another student. Discussion and self-talk were a major part of this constructivistic approach. The hands-on, performance outcome activities are not judged as being "right" or "wrong." The students learn by participation and were able to construct meaning and reach concept attainment. During the guided discovery, embedded assessment, and discussion; concept development took place and learning occurred. This is evident when one reviews Figures 1 and 2 which clearly indicate that learning occurred. Achievement levels showed significant positive change.

The old saying that "success breeds success" was quite evident in the results of this study. Not only did achievement show a significant positive change, there were significant changes in the participants' perceived ability in science. Although this was domain specific and cannot be generalized globally, there is sufficient encouragement to complete further research on other domains.

A significant change was also found in the area of career choice. The post survey revealed a positive significance in the number of participants who thought they may want to pursue a career in science or a science related field. It seems reasonable that from the results of this study and a review of the literature that implications for curricular changes, teaching strategies, and more partnerships to bring science into the isolated rural schools of Appalachia, could produce lasting benefits for students. It is well documented in this research that hands-on science, small group

work, and discussion have a significant impact on the middle school students. Their achievement levels rose significantly.

Science reform has been an on-going topic since 1957 with the launching of Sputnik. Self-esteem and self-concept have contributed many hundreds of articles to the literature. Only recently has social cognitive theory come to the forefront as a possible reform tool. The results are domain specific and yet most researchers see a value in building a positive sense of self-efficacy. It must be remembered that correlation and causality are not the same. More research needs to be completed. More variables that affect self-efficacy need to be determined. Intervention strategies need to be developed.

This research with its implications to instruction and instructional behaviors should become an important part of the preparation of teachers. The instructional design of the classroom should include training in and the development of thinking strategies that bolster self-efficacy. Vicarious experiences outside the classroom should be considered carefully and addressed in parenting classes as well as teacher preparation programs. Hands-on and inquiry based instruction are known to enhance self-esteem and should become a part of the lesson whenever possible. Eliminating apathy toward school and the dislike of certain subjects in school should greatly improve with training related to increasing self-efficacy. With these changes there is a decrease in disruptive behaviors and a possible abatement of violence. In the decades of school reform, building a positive sense of self-efficacy in children can lead to success for the student.

Conclusion

This research has been conducted to bring to the attention of the science educational community and the educational researchers that self-efficacy beliefs may contribute to science achievement. Science achievement and science self-efficacy also impacts career choices in science and the perception of one's ability to learn and do science with success. Current research in this field seems to indicate that such beliefs have potential and that further research is needed.

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