Effects of a Summer Teacher Tour Program on Agriculture and Science Teachers' Knowledge of Applying Science, Technology and Math in Research and Industry

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Abstract

In order to make teachers more aware of the demands of the economy, industry, and research, two groups of agriculture and science teachers were taken on tours of research and industry facilities across the state of Georgia. During each of the four-day tours, teachers were transported across the state by bus and visited The University of Georgia, Georgia Technical Institute, six Centers of Innovation, and a cross section of the industries that the universities and Centers of Innovation serve. The objectives of this project were to engage high school teachers of science and agriculture in a program that would (a) increase science content knowledge, (b) develop teachers' comfort levels with inquiry based teaching strategies, (c) expose them to new teaching technologies, and (d) influence them to share ideas with fellow teachers. When comparing retrospective means with post-experience means, on a 5-point Likert scale, teachers reported close to a three point change in their knowledge level of how the Georgia Centers of Innovation fit into the overall economic growth plan for the state of Georgia. Additionally, responses to open-ended questions indicated that teachers found the tour extremely beneficial and believed that it would help them in utilizing inquiry based instruction to teach science content knowledge in their classrooms.

Introduction

Students in the United States of America are falling behind their international counterparts in the two academic areas most commonly linked to country success, math and science. Governmental initiatives, such as No Child Left Behind, are intended to provide the impetus for schools to improve their students' academic performances by federally mandating assessment and accountability standards (U.S. Department of Education, 2004). Private initiatives, such as the American Association for the Advancement of Science's Project 2061, have also been developed to improve student performance in mathematics, science, and technology by improving curriculum, instruction, and assessment (American Association for the Advancement of Science, 2007). Even the corporate sector is getting involved in the effort to improve the academic performance of youth. In 2004, Bayer was a sponsor of the U.S. Summit on Science and continues to promote improved scientific literacy at the elementary education level through its Making Science Make Sense initiative (Allan, 2004). While these efforts have certainly helped to increase awareness of the need for greater math and science literacy, there is still a demand for additional, practical solutions that teachers can implement in their own classrooms. Simply mandating higher academic standards is not enough. Attainable tools and solutions must be provided in order to meet those standards.

According to the Third International Mathematics and Science Study (TIMSS) conducted by the International Association for the Evaluation of Educational Achievement in 1995, American eighth

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grade students ranked 28th in the world in math proficiency and 17th in science proficiency (U.S. Department of Education, 1999). More recently, U.S. students (15 years of age) performed below average in both math and science when compared to students of the same age in other industrialized countries (Lemke et al., 2004). Even within the United States, many students are failing to achieve proficiency levels. Seventy percent of eighth grade students in the U.S. were not proficient in math (Perie et al., 2005). The results are similarly grim in science, where only 29% of eighth grade students were at or above the proficient level (Planty et al., 2007)

Research shows student achievement is linked to teacher content knowledge (Hill et al., 2005). Students perform better when teachers have a strong background in the subject matter being taught. Miller and Gliem (1996) discovered that preservice agriculture teachers were not capable of applying basic mathematics skills to agriculture related problems. This finding is a harsh realization as the movement continues toward agriculture classes counting for graduation credit in science and math (Dormody, 1993). With that in mind, the researchers sought to engage teachers with industry that relies heavily on the application of scientific and mathematical principles. If teacher knowledge increases, there is greater potential for students to have increased knowledge and interest in science and math related careers. To facilitate this increased content knowledge, Thompson (1998) recommended in-service professional development opportunities emphasizing real life science applications, especially physical science. The findings of Warnick et al. (2004) suggest that collaborative in-service workshops be developed that bring science and agriculture teachers together to improve content integration and hone technical skills while working in collaborative teams.

This research examines the effects of taking agriculture and science teachers on a one week tour of current applications of science, math, and technology in industry and research across the state of Georgia. More specifically, this article describes teachers' self-perceptions of their knowledge and experience as related to science, technology, and mathematics in industry and research, after completing a summer tour.

Theoretical and Conceptual Framework

A constructivist framework was used to develop this study. In its most simple form, constructivism asserts that people build their own beliefs, knowledge, and understanding based on the experiences they have had in past and present contexts (Doolittle and Camp, 1999). In the classroom, constructivism is evidenced by a greater dedication to the process of facilitating the formation of knowledge, rather than simply relaying factual information to the learners (Confrey, 1990). A constructivist classroom is characterized by student-teacher dialogue, open-ended questions, and hands-on experiences (Powell, 1995). These techniques allow students to assemble knowledge gradually, at a comfortable pace for each individual.

Constructivism is particularly appropriate in more complex subjects. Science and math education can be improved by incorporating a constructivist approach into the classroom (Gil-Perez et al., 2002; Spinner and Fraser, 2005). O'Sullivan et al. (2000) reported eighth grade science students who were taught by teachers with a science degree averaged higher test scores than students of teachers without science degrees. There exists a need to supplement the experience (or lack of) of science teachers in order to best develop scientific literacy in youth.

Materials and Methods

The objectives of the summer teacher tour program were to:

1. Increase Science Content Knowledge - Increase the technological and scientific literacy of the group by exposing them to research on college campuses. Teachers may not have a deep understanding of what they are shown, but they will appreciate the ever-changing landscape of research and how research begins adding to their scientific and technological literacy. Ideal professional development leads to teachers who, in partnership with outside resources, provide productive learning environments for students. Teachers who experience research first-hand not only better understand the scientific content and processes but also develop a renewed interest in and commitment to their field (Loucks-Horsley et al., 1998).

2. Develop Inquiry Based Teaching Strategies - Make teachers aware of the science, mathematics, and technological skills students need for high impact 21st century jobs. Jobs of the 21st century will go to students who are innovative and have strong knowledge foundations in science, technology, and mathematics. Teacher exposure to the opportunities available and the skills needed to be successful will empower them to not only educate youth on the importance of science and math skills, but to educate youth using strategies that require practicing such skills. By introducing teachers to the research process, they can then utilize that process in their classrooms by using inquiry learning.

3. Expose Teachers to New Teaching Technologies - Expose teachers to critical workforce needs. Most teachers do not realize that the U.S. is facing a critical shortage of students trained and interested in pursuing STEM (science, technology, engineering, and mathematics) degrees. Through interactions with industry leaders, teachers learn about current and future job demands as well as the technology proficiencies that the future workforce will need. They also gain insight into new technologies and resources available for their classrooms.

4. Share Ideas with Fellow Teachers - Share ideas among teachers and build relationships for ongoing partnerships between K-12 and post-secondary institutions. The sharing of materials, course offerings, and assessment requirements by teachers who are from the same school, department, or grade is a key component of successful professional development activities (Garet et al., 2001). Incorporating shared readings and discussion fosters cooperation among teachers and highlights potential future partnerships.

This is a descriptive study designed to measure change in individuals' awareness due to participation in the Teacher Quality Education Program's Centers of Innovation Tour. The tour was a four-day event held in the summer; twenty teachers participated in the event each year which involved tours of university laboratory facilities at three different college campuses, the Georgia Centers of Innovation, and various business and industries related to the work being conducted at the universities and businesses. The tour stops included: Agriculture Innovation Center (AIC), Aerospace Center of Innovation, Life Sciences Innovation Center (LSIC), Center for Applied Genetics Technology, Manufacturing Excellence Innovation Center (MEIC), and the Enterprise Innovation Institute (Price, 2007).

Population

Participation in the program was open to agriculture and science educators in the state of Georgia. Space was limited to the first twenty participants to register. A census of participants was conducted at the last session of the tours in both 2007 and 2008.

Instrumentation

A researcher-developed questionnaire with a retrospective post-test format was used. The questionnaire consisted of ten awareness statements. Participants were asked to select their level of awareness of a topic before the tour and after the tour, using a five point Likert scale where 1 = very low; 5 = very high (Table 3). Four Likert-type questions were included to assess the likelihood that teachers would use the information in their classrooms, how beneficial the reading materials were, and the overall benefit of the tour (Table 2). In addition to the standard evaluation required by the Teacher Quality Higher Education Program Grants, a retrospective posttest was conducted using a five point scale (1 = none; 5 = complete) in order to measure changes in participant knowledge level with regards to 13 key indicators (Table 1). The instruments were delivered to participants at the end of the tour and all instruments were completed and collected for a true census of participants.

Results and Discussion

Mean changes were measured for 13 key indicators of teacher learning (Table 1). Participants reported the least amount of change (mean = 1.8) in "knowledge of the role high school education plays in Georgia's Key Industries." Teachers perceived they already possessed a moderate level of knowledge prior to the tour regarding the role that high school education plays in Georgia's Key Industries. This moderate level of knowledge prior to the tour limited the amount of possible improvement that was available for the participants. The teachers had a relatively low increase in knowledge because they already had a moderate understanding of the role high school education plays in Georgia's Key Industries.

The greatest change (M = 2.9) in knowledge level for the teachers was related to their knowledge of how the Georgia Centers of Innovation fit into the overall economic growth plan for the state of Georgia. The specific reason for this level of change in knowledge

Table 1. Participant's Change in Knowledge Level from Pre Test to Post Test

Question	Change
1. Knowledge of activities taking place at the Agriculture Innovation Center.	2.6
2. Knowledge of activities taking place at the Aerospace Innovation Center.	2.4
3. Knowledge of activities taking place at the Center for Applied Genetic Technologies.	2.5
4. Knowledge of activities taking place at the Life Sciences Innovation Center.	2.8
5. Knowledge of activities taking place at the Manufacturing Excellence Innovation Center.	2.8
6. Knowledge of activities taking place at the Enterprise Innovation Institute.	2.7
7. Knowledge of the role high school education plays Georgia's Key Industries.	1.8
8. Knowledge of the 21st century career opportunities for Georgians.	1.9
9. Knowledge of the role science education plays Georgia's Key Industries.	1.8
10. Knowledge of how to utilize Georgia Centers of Innovation in your classroom activities.	2.8
11. Knowledge of how Center of Innovation activities can be aligned with GPS's.	2.5
12. Knowledge of how the Georgia Centers of Innovation fit into the overall economic growth plan of the state of Georgia	2.9
13. Knowledge of the role that globalization plays in influencing Georgia economic development.	1.9
Total Average Change	2.4

Note. Pre-and Post-test Scale: 1 = Very Low; 2 = Low 3 = Moderate; 4 = High; and 5 = Very High.

was not investigated by the researchers, but is believed to be due to the relatively recent creation of the Centers of Innovation only four years prior to the first tour.

Table 2. Participants' Perceptions of Information, Materials, and the Overall Benefit of the Tour

Question	M
1. 14. What is the likelihood that you will use information gained on this tour in your classroom?	4.7
15. How beneficial were the reading materials The World is Flat?	3.9
16. How beneficial were the reading materials Tough Choices or Tough Times?	4.2
17. How would you rate the overall benefit of this tour?	4.9

Note. Scale: 1 = Very Poor; 2 = Poor; 3 = Moderate; 4 = Good; and 5 = Excellent.

Table 3. Change in Participants Knowledge and Comfort Levels

Tour Target Objectives	Pretest Mean	Posttest Mean	Change	Percent Change
Science Content Knowledge	3. 6	4.3	0.8	20%
Knowledge of Inquiry Based Teaching Strategies	3.6	4.6	1.0	25%
Knowledge New Teaching Technologies	3.3	4.1	0.8	20%
Comfort Level with Sharing Ideas With Fellow Teachers	4.3	4.7	0.4	10%

Note. Scale: 1 = Very Low; 2 = Low 3 = Moderate; 4 = High; and 5 = Very High.

The mean response of all participants with regards to their perceptions of information, materials, and the overall benefit of the tour was measured on a five point scale (Table 2). Teachers indicated there was an excellent likelihood they would use information gained on this tour in their classrooms. To encourage the use of tour information in the participants' classrooms, time was provided for lesson plan development, sharing best practices, and developing partnerships with the universities, Centers of Innovation, and industries.

In addition to the tours and lesson planning, participants engaged in discussion of assigned readings. When asked about the level of benefit from these readings, teachers responded positively. Teachers responded with means of 3.9 and 4.2 (Likert Scale 1-5) respectively to the two reading assignments that accompanied the tour; "The World is Flat" by Thomas L. Friedman (2006) and "Tough Choices or Tough Times" by the National Center on Education and the Economy (2006). Anecdotal data indicated teachers believed the books were interesting but there was not enough time on the tour to adequately read the assigned chapters each night. The pace of the tour and the late evenings left teachers exhausted in the evenings and just under half were able to read the assigned chapters for the next day. Even so, participants rated the overall benefit of the tour as excellent (M = 4.9).

As for the four main objectives of this tour, teachers experienced a 20% increase in their science content knowledge; a 25% increase in their ability to develop inquiry based teaching strategies; a 20% increase in exposure to new teaching technologies; and a 10% increase in willingness to share ideas with fellow teachers, when pre and post-test means were compared (Table 3). The overall level of change for all objectives was 2.4. This change in learning on all four objectives suggest that these subjects responded well to the constructivist classroom and responded well to student-teacher dialogue, open-ended questions, and hands-on experiences thus offering support for Powell, 1995; Gil-Perez et al., 2002; and Spinner and Fraser, 2005.

Summary

This tour can be a point of beginning for The University of Georgia and Georgia Tech to solidify some of their K-12 outreach efforts. K-12 teachers are a viable conduit for reaching pre-collegiate students and we are counting on their ideas for future efforts. These tours were successful in raising teacher awareness and increasing the teachers' ability to make meaningful connections between what is being taught in high school classrooms and what is happening across the state in industry. Marc Tucker, president of the New Commission on Skills of the American Workforce, said, "There is growing mismatch between the demands of the economy and what our schools are supplying" (Herszenhorn, 2006 p. B5). These tours and others like it help to correct that mismatch by increasing teacher content knowledge and with using inquiry learning and new technologies in their classrooms.

Literature Cited

Allan, B. 2004. Bayer to sponsor U.S. summit on science. http://www.bayerus.com/MSMS/MSMS_News/MSMS_NewsDetail.aspx?ID=5F6BE504-B77A-CAE9-49023246C125F878. Bayer Corporation. September, 29,2011.

American Association for the Advancement of Science. 2007. About project 2061. http://www.project2061.org/about/default.htm. September 29, 2011.

Confrey, J. 1990. What constructivism implies for teaching. Jour. for Research in Mathematics Education 4:107-122, 195-210.

Doolittle, P.E. and W.G. Camp. 1999. Constructivism: The career and technical education perspective. http://scholar.lib.vt.edu/ejournals/JVTE/v16n1/doolittle.html. Jour. of Vocational and Technical Education 16(1). September 29, 2011.

Dormody, T.J. 1993. Science credentialing and science credit in secondary agr. education. Jour. Of Agr. Education 34(2):63-70.

Friedman, T.L. 2006 The world is flat: A brief history of the twenty-first century–updated and expanded. New York, NY: Farrar, Strauss, and Giroux.

Garet M., A. Porter, L. Desimone, B. Birman and K. Yoon. 2001. What makes professional development effective? Results from a national sample of teachers. American Educational Research Jour. 38(4):914-945.

Gil-Pérez, D., J. Guisasola, A. Moreno, A. Cachapuz, P. Pessoa De Carvalho, J. Martínez Torregrosa, et al. 2002. Defending constructivism in science education. Science and Education 11(6):557-571.

Herszenhorn, D.M. 2006. Expert panel proposes far-reaching redesign of the American education system. The New York Times, December 15, 2006, p B5.

Hill, H.C., B. Rowan and D.L. Ball. 2005. Effects of teachers' mathematical knowledge for teaching on student achievement. American Educational Research Jour. 42(2):371-406.

Lemke, M., A. Sen, E. Pahlke, L. Partelow, D. Miller, T. Williams, et al. 2004. International outcomes of learning in mathematics literacy and problem solving: PISA 2003 results from the U.S. perspective (NCES 2005-003). Washington, DC: U.S. Dept. of Education, National Center for Education Statistics.

Loucks-Horsley, S. P. Hewson, N. Love and K. Stiles. 1998. Designing professional development for teachers of science and mathematics. Thousand Oaks, CA. Corwin Press, Inc.

Miller, G. and J.A. Gliem. 1996. Preservice agr. educators' ability to solve agriculturally related mathematics problems. Jour. of Agr. Education 37(1):15-21.

National Center on Education and the Economy. 2006. Tough choices or tough times: The report of the new commission on the skills of the American workforce. San Francisco, CA. Jossey-Bass.

O'Sullivan, C.Y., M.A. Lauko, W.S. Grigg, J. Qian and J. Zhang. 2002. The nation's report card, science 2000 (NCES 2003-453). Washington, DC: National Center for Education Statistics.

Perie, M., W.S. Grigg and G.S. Dion. 2005. The nation's report card: Mathematics 2005 (NCES 2006-453). Washington, DC: National Center for Education Statistics.

Planty, M., S. Provasnik, W. Hussar, T. Snyder, G. Kena, G. Hampden-Thompson, et al. 2007. The condition of education 2007 (NCES 2007-064). Washington, DC: National Center for Education Statistics.

Powell, R.R. 1995. Epistomological antecedents to culturally relevant and constructivist classroom curricula: A longitudinal study of teachers' contrasting world views. Teaching and Teacher Education 12(4):365-384.

Price, D. 2007. Centers of innovation. http://www.georgia.org/WhyGeorgia/Innovation/Pages/CentersOfInnovation.aspx . Georgia Dept. of Economic Development. September 29, 2011.

Spinner, H.and B.J. Fraser. 2005. Evaluation of an innovative mathematics program in terms of classroom environment, student attitudes, and conceptual development. International Jour. of Science and Mathematics Education 3(2):267-293.

Thompson, G. 1998. Implications of integrating science in secondary agr. education programs. Jour. of Agr. Education 39(4):76-85.

U.S. Dept. of Education. 2004. Four pillars of NCLB. http://www.ed.gov/nclb/overview/intro/4pillars.html. September 29, 2011.

U.S. Dept. of Education. 1999. Highlights from TIMSS: The third international mathematics and science study (NCES 1999-081). Washington, DC: National Center for Education Statistics.

Warnick, B. K., G. W. Thompson and E. S. Gummer. 2004. Perceptions of science teachers regarding the integration of science into the agr. education curriculum. Jour. of Agr. Education 45(1):62-73.