Teaching Science And Engineering-Related Topics Using Experiential Methods: An Action-Research Study

Chandra Aleong, (Email: caleong@desu.edu), Delaware State University
John Aleong, University of Vermont

ABSTRACT

This article describes a portion of a long-term action-research project investigating the teaching of the science of transportation to high school students using the case study or experiential method. Other aspects integrated with the project-oriented study are the use of Constructivist theory, the Socratic Method, and the incorporation of competitiveness and accountability as experienced more typically in a business rather than an education environment. The authors describe the role of the Institute, the need for intervention, and the framing of assignments to make a broad range of topics in engineering, science, and management among others within reach of 9th to 12th grade high school students. By constantly monitoring students' comprehension of complex material, the faculty, staff and professionals got new insight into their own practice as teacher educators. The ongoing action research intends to follow students after the completion of the program to measure the sustainability of their learning experience.

INTRODUCTION

Our research investigates the ways in which 9th to 12th grade high school students at one university have come to excel in a subject area related to science and engineering through project based assignments. These assignments have been, and continue to be, developed through long-term action research on our own role as educators of a broad spectrum of individuals, spanning high school, college, and adult training programs. Our objective is to improve in three areas: understanding of our own teaching effectiveness, the teaching practice itself, and the situation in which that practice occurs (Kemmis & McTaggart, 1988). Through this action research, we aim to build on the literature regarding experiential learning and to bridge the gap between teaching strategies in business, law, medicine and education. The students' presentations, their final reports, and interviews with them provide qualitative data. In addition, questionnaires distributed at the beginning and end of the program provide quantitative data on the degree of change. We focus on questions such as "How does a project based methodology assimilate with theories commonly used in the field of education?" and "What did we learn from these assignments that we can use to design course material for other areas." The data is used not only to inform central aspects of our "findings" about the role of experiential learning, but they are the basis for developing material for other training programs.

Delaware State University (DSU) with the assistance of the Federal Highway Administration (FHWA), and Delaware Department of Transportation (DelDOT), conducted Summer Institutes in 2005 and 2006 with the primary objectives of instilling inquiry and project-based learning to the field of transportation. Students in grades 8-11 were engaged in a major over-arching project designed to enhance their science, engineering, communications, and critical thinking skills. Specific content areas were civil engineering, environmental sciences, transportation planning and finance, and Geographic Information Systems (GIS). The teachers were university faculty, and professionals with varied years of experience. Classroom activities included lectures, assignments, presentations, and field trips with the focal point being a capstone project.

In addition to student-based learning, enhancing and informing the pedagogy of the teachers and participating professionals was also integral to the objectives of the Institute. "The Project" became the focal point around which project directors, faculty and support staff coordinated their activities. Teachers, guest lecturers and staff were all advised to structure their teaching activities with the capstone in mind (backward planning) and with the underlying emphasis on instilling the critical thinking skills of the students. Student engagement was reinforced with competitive teams, team mentors, and rewards.

The Institute does not come to a sudden halt at the end of the month-long session designated for the academic segment of the Institute. Project directors continue to engage in follow up sessions during the school year to gauge the long-term impact and future directions of the program. The post-audit is as critical as the actual program itself, and is held over a 2 day period in Atlanta, Georgia. The meeting enables each participating institution the opportunity to discuss the strengths and weaknesses facing the individual Institute as well as the bigger threats facing the program such as the financial aspects of the grant.

Background of Summer Transportation Institute

The Summer Transportation Institute is funded by the U. S. Department of Transportation. Students spend four weeks at several universities and colleges across the country engaged in practical workshops on subject areas such as mathematics, engineering, science, and communications. The students are at an age when young people are beginning to think about careers and academic paths to pursue in college. The expectation is that exposure to non-traditional subjects like transportation in a non-school environment would pique their interest and enthusiasm. We hope to plant the seeds for students to consider taking advanced science, mathematics, and management courses in high school that would prepare them for post-secondary education and, ultimately, to select a major that is transportation-related.

Students come from the surrounding area high schools and are screened based on GPA and letters of recommendation from teachers and counselors. The program at Delaware State University has been in place for ten years and the summer of 2006 was the 10^{th} anniversary for the Institute. In years prior to the 2005 summer program, the program was residential and followed a set format of guest speakers, field trips, and classroom lectures in English Grammar, Science, and Computer Skills. There was no unifying project and the only rubric for accountability purposes was an essay judged by an off campus board member. The major motivator was one out of town weekend field trip from Dover, Delaware to Boston, Ottawa, New York or some other city.

The STI planning team introduced structure and accountability in 2005 because there was need for intervention in the administration of a summer program that was haunted each year with anecdotes of horrible fights and bad behavior. The index of horror that was discussed by faculty, staff, and students was who should be dismissed from the program that day. The topic for the 2005 program became the extent of progress each group was making and who was going to win the prize. The turnaround is the subject of this paper.

We begin by grounding our work in the literature on the topic of improving educational performance. After describing the reasons for intervention to save the program, we outline major aspects of the methodology. We then present results of the quantitative and qualitative analysis related to developing and supporting student learning based on the experiential method. Finally we present some of the limitations of our approach and provide observations of how we intend to proceed with our agenda for action research on project based learning.

Literature Review

A large and growing body of scholarship has indicated the concern for improving the effectiveness of pedagogy to make education more appealing to a broader population of students. Some authors have gone so far as to express the concern that the lack of interest in the sciences hampers the growth of a nation, Kinkead (2003). In this article, "science education" is used as a proxy for "transportation education" since it is similar in content and there is more research on this topic. Malcom (2006) stated that, "non-existent or poor early science instruction can affect students' attitudes toward science and their future willingness to take elective courses in science." Introducing

students to the science and engineering associated with transportation in an interesting and activity-oriented environment should motivate them to consider this as an option for future employment.

Meanwhile, Saphier (2005) is of the opinion that student achievement, interest, and motivation "hinges on improving the teaching expertise of the individual teachers who work with the children." Generally the population served by the Summer Transportation Institute consists of students from low socio economic environments. Darling-Hammond (1996) has stated that that "too few of our teachers have enough expertise and our poorest children have the largest share of low-expertise teachers." The Summer Transportation Institute is another forum provided by Delaware State University, a member of the Historically Black Colleges and Universities, to resolve the problems facing the neediest in society as well their educators. The faculty and staff for the "Revised Institute" are members of the College of Education and are aware of the importance of designing their lectures for the multicultural as well as the inclusive classroom. As James Banks (2001), a leading expert in multicultural expert points out, growing ethnic and cultural diversity requires rethinking school curricula.

Research adapting science to community engagement includes the work of Hammond (2001) who collaborated with teachers and Hmong parents to develop a culturally relevant science project. The focus of her work was to transform content in science to make it more multicultural and feminist in content. The onus for the developers of the content material for the Institute was to get the students more engaged in a major transportation project that was community based. Since most of the students were minorities, multicultural issues and experiences were integrated into the discussions wherever relevant. In another study, Angela Calabrese Barton (1999), a science teacher educator, demonstrated from her research how students' understandings of science improved based on community involvement and an emphasis on meeting the needs of diverse populations.

Moving from the teaching of science to a more global perspective, recent efforts to improve learning and education as a whole have emphasized experiential learning and action research. John Dewey (1938) described this as "the need for forming a theory of experience in order that education may be intelligently conducted upon the basis of experience". The curriculum for the Institute had grown stale and was too passive in its approach. The study of an area like transportation was a great facilitating mechanism for testing the theories of Dewey and the progressives who emphasized that schools should teach learners how to solve problems and inquire about their natural and social environments. (Gutek, 1997)

This article presents a conceptual framework for the Revised Institute as well as the results of a case study of a program that needed intervention. As a tribute to the success, the methodology is being strongly considered by another institution as a benchmark to follow. The four major changes were in the use of the project-based or case study method, the Socratic techniques for inquiry, techniques pertaining to the education theory of "Constructivism", and reinforcement of the need for assessment and accountability. A description of each of these follows.

CONCEPTUAL BACKGROUND

The Case Study Approach

The case study method is being used increasingly to teach sophisticated techniques in business such as marketing, strategic management and finance. "A surprisingly wide range of professional schools, including Harvard's law, business, and medical schools, have concluded that the best way to teach these skills is by the case method." (Garvin, 2003). The case or "project" was designed by the planning committee to act as the springboard for presenting complex issues around a major transportation problem in the State of Delaware. It served as a catalyst for learning. Students were divided into teams since the team protocol goes hand in hand with the case study method. MBA classes at Harvard usually have around nine hundred students, who are divided into sections and take classes together. Being in a team is not voluntary, it is mandatory. In addition to promoting bonds and networking, students prepare, discuss, and present findings to faculty and top executives of the organizations being studied.

Cases depict descriptions of unique and difficult problems that organizations, usually companies, need to resolve or face severe consequences. The analysis and recommendations of the teams with guidance by a faculty

member is an integral part of the learning process. The challenge is to whet the appetite of the participants by encouraging them to be creative and to be critical thinkers. As one professor said to a student called at random, "Do not reiterate what is in the case. Tell me something I do not know. Be creative". Developing the aptitude to see "the big picture"; grappling with the major issues; and developing timely and realistic recommendations are the main objectives of case study method of teaching.

The Socratic Method

The Socratic Method, which is "Teaching by asking instead of by Telling" according to Rick Garlikov (2006), was the focal point of the pedagogy modification conducted at the Institute. In an experiment conducted in a third grade class in a suburban elementary school, Mr. Garlikov demonstrated how he used the Socratic Method to teach a difficult subject like binary arithmetic to children and also capture their enthusiasm. In its purest form, only questions are used to arouse curiosity in a logical and incremental manner. The objective is to parse out very complex subject matter by enabling students to figure out answers and to develop insights. The role of the planning committee for the Summer Transportation Institute at Delaware State University in 2005 was to use this method in a modified form, that is, to pose a problem or state a situation, and to guide the students when they got stuck. Once they became excited about the topic then they used their own initiative to find solutions.

The challenge posed to the faculty members of Delaware State University (DSU); and transportation professionals of Delaware Department of Transportation (DelDOT) and the Federal Highway Administration (FHWA); was how to conduct a one month program on a subject area that students are not inclined to be interested in, especially during their summer break. The Socratic Method provided an effective mechanism for getting and holding their attention.

Constructivism

The instructional program used for the Institute was strongly influenced by research related to the theory of constructivism, which is based on the principle that individuals cannot simply be given knowledge, but must create knowledge based on restructuring prior knowledge and experience (Armstrong et al, 2005). Leading theorists in constructivism, Jean Piaget (Piaget & Inhelder, 1958) and Lev Vygotsky (1962) were of the opinion that learners actively engage the environment and seek to derive personal meaning from this involvement. Conditions for learning must be learner-centered and problem-centered for learners to construct and understand their own knowledge.

The challenge for the Institute was to pose complex, complete, and "authentic" problems related to transportation and provide guidance to help the students gain the knowledge needed to solve them. Parsley & Corcoran, 2003 expressed a similar idea of providing students with opportunities to engage new content actively, interact with others in their attempts to arrive at new understandings, and engage in efforts to test and modify their perceptions in light of these experiences. Having students determine the optimum places to locate ramps on Interstate 95 for commuters to access the "Riverfront", a major development project in the State of Delaware, is quite complex. By embedding the problem or project in the larger context of land, air, and sea transportation, the objective was to utilize a single, integrated process. Students had a real need to know the content to develop responses to questions posed, and to determine alternatives for the placement of roads and bridges. The onus was on them to do research, ask questions, and seek out answers from the faculty, staff, and visiting professionals from the transportation agencies. This meant that they were actively engaged in the learning process.

In addition, the social network generated from the team structure, and the competitive nature of the assignment, meant that they had to share ideas. The project was deliberately challenging making it unlikely for any one individual to find the solution working alone. Overall, the assignment was designed around constructivism principles which meant having a learning environment filled with discussions, lab activities, and field trips.

Assessment and Accountability

One of the most important changes in the program was the incorporation of assessment and accountability measures. The integration of the project based or case study approach, the Socratic Method, and Constructivism principles would not have been complete without the incorporation of these measures. Cunningham (1997) has stated that the process of ascertaining what students learn is a continuous and on going process. To instill a culture of discovery and learning, the faculty and staff emphasized the importance of solving problems instead of traditional testing techniques which measure how much they memorized.

Another measure of learning was to ensure that each student made progress. Taking into account differences in prior knowledge is a key component of constructivism. The faculty and staff differentiated tasks and instruction. For example, knowledge of Power Point, ability to read maps, and knowledge of mathematics were just some of the areas that differed among the students. The challenge was to ensure that each individual in this mixed group of 9th to 12th graders was able to engage with other team members, participate actively, increase learning, and be an integral part of the success of the group.

CONTEXT FOR AND NATURE OF ASSIGNMENTS

The education literature has been promoting the idea of teachers as initiating research in the classroom rather than being passive consumers of research. Teachers have always practiced a multiplicity of techniques to increase student performance. The major education theories such as “constructivism” and “multiple intelligences” are not terms that all teachers might be acquainted with but in their own way they have always been creative and flexible in presenting information to students. The problem is teachers have never taken the time to set up formal research studies and to collect and analyze data.

The project in 2005 originated from a real life scenario on which the Delaware Department of Transportation was working, that is traffic congestion in the city of Dover, as well as finding the most feasible development plan for a 200-acre farm that was the last remaining tract of open space in the city. The farm had recently been sold and the planners at DelDOT knew that they had to be proactive in determining the type of land use that made sense for the community given the fast rate of growth taking place in the city of Dover as well as in Kent County in which Dover is located.

The main theme was the connection of two roadways and was called “The West Dover Connector”. The students were divided into teams of five each. Each team had to develop the most feasible route by developing five alternatives taking into account all aspects of transportation planning such as the political, environmental, archaeological, and legal among others. The civil engineer who masterminded the assignment broke the project into four parts reflecting the four weeks that the students were on campus for the STI.

During the first week or phase one the students had to determine the major stakeholders, why they felt they were important, their contact information, and why they were significant to this situation. In phases two and three, they had to make suggestions for the different alternatives for connecting Salisbury Road to Route 13. Each alternative had its pros and cons but in the final analysis, they had to find a way to use the least amount of land and money while preserving the wildlife.

The thematic organizer used by the DelDOT professionals for each alternative was, “concepts”. Each concept had its unique factors and the impacts on the following, property usage, flood plains, streams, wetlands, farmland, forests, roadways, and bridges, were just some of those that the students identified. Each “impact” had cost implications based on the complexity of the factors listed above. As part of the final presentation the students had to determine their choice among the “concepts” and map out the type of roadways they thought were appropriate.

Some of the questions that arose were: the relocation of schools and residential areas; the legal issues related to eminent domain; disturbance of well established environmental property; construction of new bridges; and traffic congestion. The determination of metric data based on each “concept” required the detailed understanding of maps

and their accompanying legends. Questions that needed to be resolved were as follows: the number of lanes for a proposed highway; should it have a median; number of ramps and curbs; the width of shoulders and sidewalks; should there be bike paths; etc.

The final presentation had to include an "Environmental Impacts Data Matrix", which chronicled the number of acres of farmland that would be affected under each alternative; the number of acres of forests affected and finally the roadway length. This matrix showed the "complexity" of each alternative, which was used as a proxy for cost. The program was too short to delve into complex cost estimation. In addition to the quantitative factors, qualitative factors such as environmental, legal, archaeological and other aspects were incorporated as part of the final determination for the ranking of alternatives.

Transportation professionals and invited guests judged the final presentation based on several factors: presentation style, quality of research, depth of knowledge, teamwork and leadership skills.

Need for Intervention

There was need for intervention to save the program. The appalling behavior and lack of interest on the part of the students in prior years had had a very negative impact on funding authorities as well as on the professionals who were volunteering their time and effort every summer to get high school students interested in careers in transportation. All of these individuals held high-level positions in their agencies and had very busy schedules. However, they had stated emphatically that they were no longer interested in dedicating time to a summer program that they felt was not yielding any positive benefits. The university stood to lose close to $80,000 each year in direct as well as in-kind funding. There was a crisis and therefore need for an intervention in every aspect of the program.

After discussions with all interested parties, the project director brought all the team players to the table with the promise that there would be a change in direction as well as in the basic structure of the Institute. First and foremost, the program was changed from being a residential to a non-residential program. This is important because the students had free bus passes to get to the university but they had to dedicate an additional hour to hour and a half for travel time. This meant they really wanted to be part of the project or else would not want to make the sacrifice to get out of bed during their summer vacation to attend a program that was a good distance away from their friends and summer entertainment. One student who had his own transportation had the option of attending to test the program and then decide whether to return. At the closing ceremony, his mother, a schoolteacher who appreciated what her son derived said. "Kyle *wanted* to come in every day." He was hooked on the academic as well as the social aspects, a very positive outcome, given the diverse composition of the group primarily along ethnic and social class lines.

Change in focus

The major change, however, was in the focus of the Institute where the final outcome was "The Project". The lead transportation professional laid out the overall segments for the four-week time period and all the activities, lectures, field trips and assignments were integrated with that learning experience. The students were never told what the correct answer was, since there was no one solution, but when they got stuck they received suggestions and explanations to enable them to move forward. In the more difficult areas, such as real estate law or engineering math, the presenters prepared the students with sufficient background information to arouse their curiosity and provided support where and when it was needed.

METHOD, PARTICIPANTS, AND DATA SOURCES

Throughout 2004, 2005 and 2006, the project director and staff collected and refined data on the level of knowledge of the students, both prior to and on completion of the Institute. The data used to inform this study came from 50 students, 18 the first year, 15 the second year and 17 the third year. Data sources included students' preparation documents, observations of in-class presentations, written reflections, final reports, videotapes and one on one interviews. We used standard qualitative data analysis techniques through coding to examine the data sources to understand how much the students had improved. Faculty and staff notes, in-class presentations, interviews and

videotapes as well as reflective journals were the primary data sources for qualitative data. Throughout the analysis of data, we asked, did they understand the assignment? Did they do adequate research? Did their presentation adequately represent what they had learnt? The main criteria used for assessment and analysis were technical competencies, communications skills, teamwork, and leadership.

The data was coded using narrative and epiphanic analysis (Denzin, 1989) to identify significant changes in knowledge and expertise. We looked for broad categories and recurrent themes. We also identified aspects relevant to the approaches used to promote learning such as constructivism or the Socratic Method.

DATA ANALYSIS

The performance criteria for the students were quantitative and qualitative. They measured the difference between what they knew about these topics both when they entered and when they exited the program. Measurements were based on specific knowledge both from interrogation after the lectures, presentations, and comprehensive reports given by the students. An analysis of the ratings of each speaker, as well as reflections by the students on the overall program enabled us to triangulate the findings.

The subject areas examined for improvements in performance are listed below.

Subject Areas

- Materials Sciences
- Transportation Law
- History of U.S. Highway System
- Transportation Finance
- Engineering Math
- Environmental Issues
- Archaeological Issues
- Real Estate Issues
- Contract Administration Issues
- Public Relations Issues
- Geographic Information Systems

Quantitative Review

Table 1 and Figure 1 below show the variables and the box plot. Since the box plot for the post-test does not intersect with the box plot for the pretest for each variable measured, the box plot, as defined in Figure 1 below, shows that the average post- test score is significantly greater than average pretest scores for each variable. In Figure 2, since the box plots, for the differences in the posttest and pretest scores, do not contain zero, the average post- test score is significantly greater than average pretest scores for each variable. For all the variables measured, using the paired comparison t test, the average or median posttest score was significantly larger than the average or median pretest scores ($p < .0001$). (DeVeaux et al (2006), and MINITAB). In summary, the students improved their posttest score significantly from the pretest scores in all areas. In other words, the findings add credibility to the qualitative data about the overall effectiveness of the project based approach to the Institutes both in 2005 and 2006.

Qualitative Review

The Students

Most of the students were unclear about the careers they were planning to pursue when they left high school but their reflection statements at the end of the program indicated a deep interest in areas of science and management related to transportation, something that was not the case when they began. It will take a few years to follow this cohort to ascertain whether the career interests are as passionate as when they left the program but the intervention of

the educational approach definitely had an impact in their thought process. One very brilliant student who was unclear about the type of career he would pursue said the following, "Before I came to this 2005 Transportation Camp, I was completely unaware of the many career opportunities that exist in the field of transportation" He then went on to name the career opportunities that he had become aware of such as public relations, bridge design and construction, materials research, management, computer science, and traffic control. A testimony to the effectiveness of the interest that was generated was the comment on bridge design, "We all travel on bridges, but if it had not been for the project we did in class with designing and trying to keep the costs down at the same time, I would never have considered the finances of these things".

Another student came in with great expectations, and it was very satisfying to read in her reflection statementthat they were fulfilled. She stated the following, "I planned to learn as much as possible about the following areas through this program; Leadership; Management; Group Work; and Transportation. As a participant, I enjoyed the program to the fullest. I had a lot of words of encouragement from faculty member, program directors, and academic aides. I will always recommend people to go to a summer program like this. I really appreciate what the program has done for me. I am glad that at the end of the program I was able to achieve all the goals I had set for myself." Most of the students wanted to return to the Institute the following year but of course new students had to get first preference.

Professionals from the granting agency

Another performance measure was the excitement and interest of all the DelDOT and FHWA professionals who participated. They were very positive about the whole process and the feedback they received from everyone. They felt satisfied that they had made a contribution and wanted to begin planning for next year's program earlier so they could have even more of an impact. As stated earlier, the Public Relations coordinator at interest in the area over the long term. There has been anecdotal data to suggest that we have DelDOT had very poor feedback from participating professionals the previous year and was nervous about asking these very busy high-level individuals to spend so much time if the students were not showing any signs of improvement. Currently the new 2007 STI is about to be launched and all the funding agencies, faculty, and transportation professionals are planning and looking forward to a successful and interesting venture for the new cohort of students.

CONCLUSIONS, LIMITATIONS, AND QUESTIONS TO CONSIDER

Our findings about the lessons learned by constructing project-based assignments for the high school transportation students are optimistic. As is typical with action research projects, we have a better understanding of some areas, but despite the obvious success we have questions about the sustainability of the knowledge received and the made some inroads, but the time line is too short. This action research project, which aims to improve our own practice, will follow up with questionnaires and interviews over the course of the year rather than measuring impact only over the summer. By continually adjusting and adapting the pedagogy and the structure of the curriculum to be more experiential we hope to ensure the longer term success of the program.

The results of the creation and implementation of these project based assignments based on real life inquiry means that the findings are limited to particular situations. However, our critical reflection will continue to seek to address the major concern, are the students getting the kind of knowledge that would spark an interest in pursuing careers in transportation? This quest for understanding and on-going research is not esoteric. It is meant to engage students, improve pedagogy, and provide opportunities for the long term changes in attitudes towards science and science-based careers, such as those in transportation.

REFERENCES

1. Armstrong, D. J., Henson K. T., Savage, T. V. (2005) *Teaching Today: An Introduction to Education* (7th ed). Pearson Merrill Prentice Hall.
2. Banks, J. (2001). *An introduction to multicultural education* (3rd ed.). Boston: Allyn & Bacon.

3. Barton, A. C. (1999), Crafting multicultural science teacher education: A case study, *Journal of Teacher Education*, 50(4), 303-314.
4. Cunningham, G. (1997). *Assessment in the classroom*. Routledge (UK).
5. Darling-Hammond, L. (1995). Equity issues in performance-based assessment. In M. T. Nettles & A. L. Nettles (Eds.), *Equity and excellence in educational testing and assessment* (pp. 89–114). Boston, MA; Kluwer Academic.
6. Denzin, N. K. (1989) *Interpretive interactionism*. Newbury Park, CA:Sage.
7. DeVeaux, Richard D, Velleman Paul F., and Brock, David, E. (2006). *Intro Stats*, 2nd Edition, Addison Wesley.
8. Dewey, T. (1938), *Experience and Education*, New York: Macmillan.
9. Garlikov, R. (2006), The Socratic Method: Teaching by Asking Instead of by Telling. www.garlikov.com/Soc.
10. Garvin, D. A. (2003), Making the case: Professional education for the world of practice, *Harvard Magazine, September-October 2003.*
11. Gutek, G. L. (1997), *Historical and philosophical foundations of education: A biographical introduction*, (2nd ed.) Upper Saddle River, NJ: Merrill/Prentice Hall.
12. Hammond, L. (2001). Notes from California: An anthropological approach to urban science education for language minority families. *Journal of Research in Science Teaching*, 38(9), 983-999.
13. Kemmis, S. & McTaggart, R. (Eds.). (1988). *The action research planner*. Victoria, Australia: Deakin University Press.
14. Kinkead, J. (2003), Valuing and Supporting Undergraduate Research, *New Directions for Teaching and Learning*, Volume 2003, Issue 93, Pages 5 – 18. Wiley Periodicals Inc.
15. Malcom, S. M. (1991). Equity and excellence through authentic assessment. In G. Kulm & S. M. Malcom (Eds.), *Science assessment in the service of reform*. Washington, D.C.: American Association for the Advancement of Science Press. (Now published by Lawrence Erlbaum).
16. MINITAB Statistical Software (Release 14 for Windows). https://www.uvm.edu/software.
17. Parsley, K. & Corcoran, C. A. (2003). The classroom teacher's role in preventing school failure. *Kappa Delta Pi Record*, 39(2), 84-87.
18. Piaget, J. & Inhelder, B. (1958), *The growth of logical thinking from childhood to adolescence: An essay on the construction of formal operational structures* (A. Parsons and S. Milgram, Trans.). New York:Basic Books.
19. Saphier, J. & Gower, G. (1997). The Skilful Teacher, *Journal of Pedagogy*, Pluralism & Practice, 1. Lesley College, Cambridge, MA.
20. Vygotsky, L. (1962). *Thought and Language*. Cambridge, MA: MIT Press.

Table 1

Variables List

Materials Sciences posttest = MS2
Materials Sciences pretest= MS1
Transportation Law posttest = TL2
Transportation Law-pretest = TL1
History of U.S. Highway System posttest = HHS2
History of U.S. Highway System pretest = HHS1
Transportation Finance posttest = TF2
Transportation Finance pretest = TF1
Engineering Mathematics posttest = EM2
Engineering Mathematics pretest = EM11
Environmental Issues-posttest = EI2
Environmental Issues-pretest = EI1
Archaeological Issues-posttest = AI2
Archaeological Issues pretest = AI1
Real Estate Issues posttest = RE2
Real Estate Issues pretest = RE1
Contract Administration Issues posttest = CAI2
Contract Administration Issues pretest = CAI11
Public Relations Issue posttest = PRI2
Public Relations Issues pretest = PRI1
Geographic Information Systems posttest = GIS2
Geographic Information Systems pretest = GIS1

Figure 1

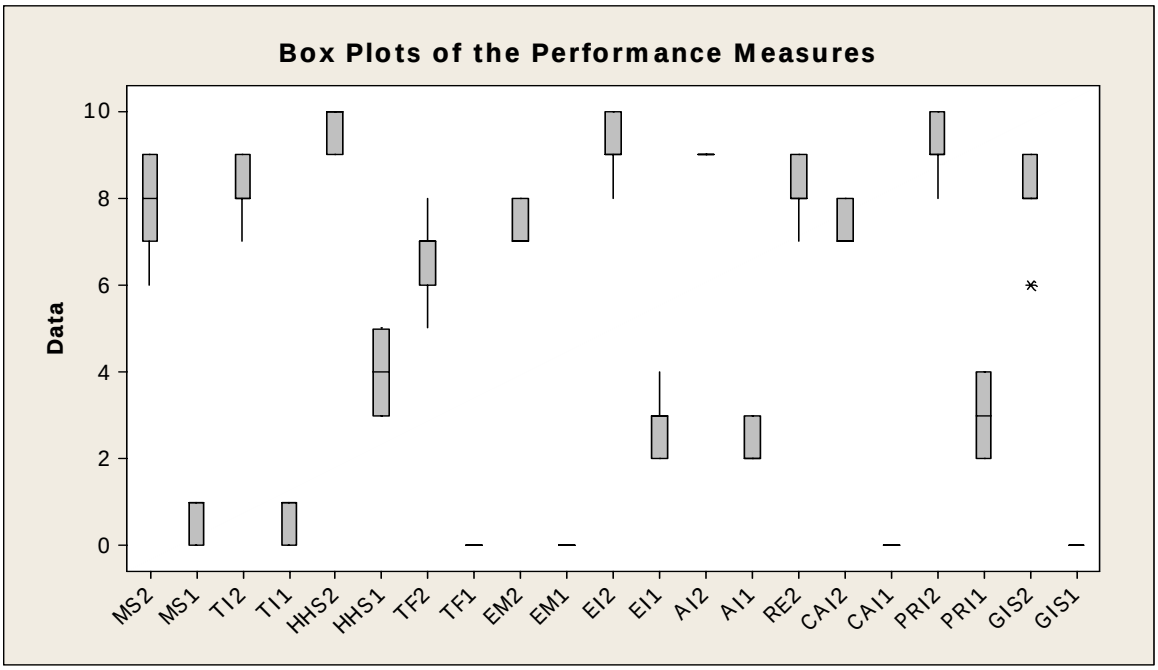

Figure 2