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SciVerse ScienceDirect
Procedia - Social and Behavioral Sciences 46 (2012) 379 – 383
Procedia Social and Behavioral Sciences

WCES 2012

Analyzing senior science student teachers' environmental research projects of scientific inquiry: a preliminary study

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Abstract

The aim of this study is to assess a group of senior science student teachers' (SSSTs) environmental research project reports as an indicator of their ability to do scientific inquiry. The SSSTs conducted their own environmental research projects with innovative technologies after they were taught the Technology-embedded Scientific Inquiry (TESI) model. A total of 29 environmental research project reports were assessed using Scientific Inquiry Ability rubrics. The SSSTs' environmental research projects generally reflected attainment of various levels of scientific inquiry abilities. The study implies that the science education classes that integrate innovative technologies focus on developing the sophisticated attributes of scientific inquiry so that SSSTs put forth a conscious effort in attaining higher levels of proficiency when they engage in environmental research projects.

Keywords: Scientific Inquiry, Innovative Technologies, Environmental Chemistry, Science Student Teacher, Research Project

1. Introduction

The National Science Education Standards promote learners to use technology as a tool in conducting scientific inquiry (NRC, 1996). This means that learners use a variety of innovative technologies for scientific investigation, which include hand tools; measuring instruments and calculators; electronic devices; and computers for the collection, analysis, and display of data. This standard is in line with a technology performance indicator advocated by the International Society for Technology Education (ISTE), which states students should attain "research and information fluency" (ISTE, 2008). Both science and technology standards may be accomplished by integrating various technologies in classrooms. Specifically, this preliminary study critically focuses on the use of high-end

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1877-0428 © 2012 Published by Elsevier Ltd. Selection and/or peer review under responsibility of Prof. Dr. Hüseyin Uzunboylu
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technologies in scientific inquiry, e.g., calculator-based laboratory learning, Geographic Positioning System (GPS), sensors and probes by a group of SSSTs in a science education course in a University in Northern Turkey.

This study only includes some of the preliminary data from an extensive project entitled 'Technological Embedded Scientific Inquiry (TESI): Modeling and Measuring Pre-Service Teacher Knowledge and Practice'. This project involves the education of senior science student teachers to know and able to do scientific inquiry consistent with the principles of scientific inquiry outlined in reform documents (AAAS, 2001; Minstrell & Van Zee, 2000; NRC, 1996, 2000), and research studies (e.g., Ayvacı, Özsevgeç & Aydın, 2004; Krajcik, Blumenfeld, Marx, & Soloway, 2000; Ebenezer, Kaya & D.L. Ebenezer, 2011; Ebenezer, Columbus, Kaya, Zhang & Ebenezer, 2011). This project is unique in that 'environmental chemistry' elective course is used as a vehicle to educate and train the pre-service science teachers in the application of the Technology-embedded Scientific Inquiry (TESI) model developed and published by Ebenezer, Kaya and D.L. Ebenezer (2011). The TESI model consists of three hallmarks: 'technology embedded scientific conceptualization,' 'technology embedded scientific investigation,' and technology embedded scientific communication. The current study primarily concentrates on assessing SSSTs' quality of the 'technology embedded scientific investigation.'

1.1. Purpose of Study

The purpose of this study is to assess the senior science student teachers' (SSSTs) environmental research project reports as an indicator of their scientific inquiry ability.

2. Methodology

This study adopted a content analysis research design that allows an in-depth, systematic analysis of the SSSTS' research project reports. Content analysis is a method for studying the characteristics of written or visual communications (Ary, Jacobs, Razevieh & Sorensen, 2006; Erdogan, Marcinkowski & Ok, 2009).

2.1. Data Collection

After the TESI model was taught to the SSSTs, in self-created small groups of two or three, they were engaged in conducting their own environmental research projects using innovative technologies, i.e., Ph sensor, calculator-based laboratory instrument, Geographic Positioning System (GPS) etc. At the end of the environmental research project, 29 environmental research project reports were handed in by 71 senior science student teachers enrolled in the 'Environmental Chemistry' elective course.

2.2. Data Analysis

In analyzing data, the authors employed 'Scientific Inquiry Rubrics' consisting of eleven criteria developed by Ebenezer et al. (2011a). In this process, five of the authors scored the project reports separately to confirm inter-rater consistency. All disagreement points were resolved through a process of negotiation. Cronbach alpha co-efficient for this rubric was found to be 0.761, which is higher than the acceptable value (0.70) suggested by Hair, Black, Babin, Anderson and Tatham (2006).

3. Results

Mean scores of students' scientific inquiry ability for each criterion in the rubric were taken into account using the following categories: Missing (0–0.74), Beginning (0.75–1.49), Developing (1.50–2.24) and Proficient (2.25–3.00). Mean scores of the descriptive analysis showed that the research project reports attained *proficient level* for two criteria based on the Scientific Inquiry Rubrics: formulate a statement of purpose and/or scientific question (Criterion 2), and use a variety of technologies for investigation (Criterion 8). The project reports attained *developing level* for criteria 6, 7 and 9, and *beginning level* for criteria 1, 3, 4, 5 and 11. Only one criterion (Criterion

10--Communicate through scientific paper for replication and enhancement) was categorized under *missing level*. As represented in Table 1, mean score of the scientific inquiry rubrics for the environmental projects was 1.43 and the standard deviation value was 0.90. The mean value for all criteria was classified under *beginning level.*

Table 1. Descriptive statistics for the scientific inquiry rubrics concerning the SSSTs' generated projects

	Criterion	**Mean**	**Standard Deviation**
1	Define a scientific problem based on personal or societal relevance with need and/or source	1.34	1.23
2	Formulate a statement of purpose and/or scientific question	2.45	0.87
3	Formulate a testable hypothesis and propose explanation(s)	0.97	1.24
4	Demonstrate logical connections between scientific concepts guiding a hypothesis and research design	1.07	1.13
5	Design and conduct scientific investigations related to the hypothesis—methods and procedures are logically outlined; proper measuring equipment are used; safety precautions are heeded; and sufficient repeated trials are taken to validate the results	1.31	1.31
6	Collect and analyze data systematically and rigorously with appropriate tools	1.93	0.84
7	Make logical connection between evidence and scientific explanation	1.55	1.06
8	Use a variety of technologies for investigation	2.90	0.31
9	'Use mathematical tools and statistical software'' means students should use these for collecting, analyzing, and displaying data in charts and graphs and for doing statistical analysis	1.48	0.91
10	Communicate through scientific paper for replication and enhancement	0.00	0.00
11	Defend scientific arguments connected with investigation, evidence, and scientific explanation	0.76	1.02
	Mean for all criteria	1.43	0.90

4. Conclusions and Recommendations

The SSSTs' environmental research project papers generally showed various levels of scientific inquiry abilities attained by the SSSTs. However, mean score for all criteria pointed out that the SSSTs' environmental project reports were at the *beginning level.* Phrased differently, their scientific inquiry abilities revealed an inverse U-shaped developmental curve since the expected scientific inquiry ability was proficient level (see Figure 1).

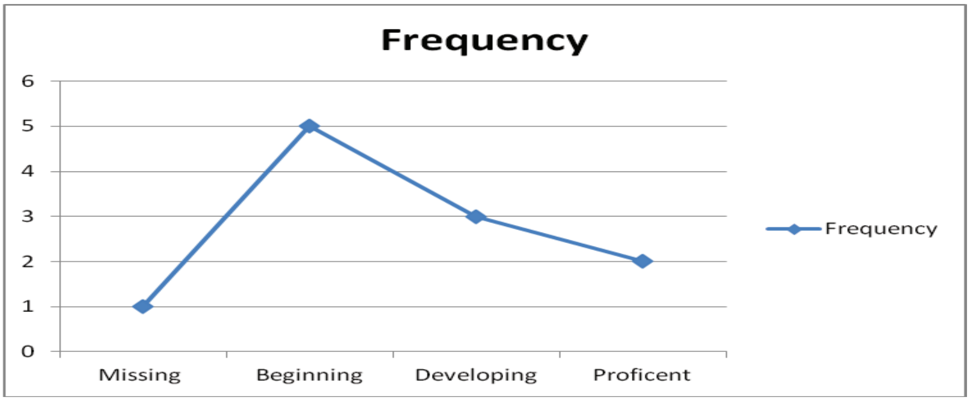

Figure 1. Frequency for each scientific inquiry level with regard to the SSSTs' environmental research projects

As pointed by Ebenezer et al. (2011a), two out of the 11 scientific inquiry emphases--criterion 10 (communication) and criterion 11 (argumentation)—are contemporary higher order scientific inquiry abilities. Because of this reason, the SSSTs may have scored lower in these two new dimensions of epistemology of science, particularly with reference to criterion 10 (see Table 1). As well, about half of the project reports fell into the *beginning level* measured by the Scientific Inquiry Ability rubrics. This may be as a result of competitive structure of Turkish Education System (i.e. Çalık & Ayas, 2005; Ayas, Özmen & Çalık, 2010). That is, the student teachers in their senior years primarily focus on the subject specific national examination instead of the courses offered by the Faculty of Education in order to be employed in public schools. The same explanation applies to courses such as Environmental Chemistry that are excluded in the nation-wide examination. Because Ebenezer et al. (2011a) reported that their participating students' scientific inquiry abilities improved year by year during a three-year project, we need to re-conceptualize how to improve the abilities of the SSSTs who will take part in our real study. For instance, we are in the process of preparing a booklet with aims of the TESI project, its theoretical framework, the SSSTs' role in this project, sample environmental research papers, and scores assigned to the project reports through a critical analysis, and the usage of the TESI's web-site. By drawing the SSSTs' attention to the significance of this booklet for the development of their scientific inquiry abilities, we are confident that they will improve in conducting environmental research projects and writing reports that will reflect greater level of proficiency. Finally, this study implies that a course such as the Environmental Chemistry should explicitly show ways how the SSSTs may improve their scientific inquiry abilities from low level to proficient level.

Acknowledgements

This study was granted by The Scientific and Technological Research Council of Turkey (TÜBİTAK) (Project Number: 110K109)

Appendix. Some of list of the SSSTs' research projects

Effects of industrial gases released from factories on the environment
Quality of common drinkable water
Investigation of sources of water pollution in rural and industrial areas
Effects of industrial areas on river soil and stream water
Impact of water quality of a local lake on trout species
Identifying swimmable areas in Black Sea region in regard to water qualities
Effects of acidity, temperature and relative humidity of soil on plant growing
Investigating effect of CO_2 in the air on air pollution

Measuring pH levels for various soap trademarks
Effect of soil pH change on photosynthesis

References

American Association for the Advancement of Science. (2001). *Atlas of science literacy*. Washington, DC: AAAS & NSTA

Ary, D., Jacobs, L., Razevieh, A. & Sorensen, C. (2006). *Introduction to research in education*. Belmont, CA: Wadsworth.

Ayas, A., Özmen, H. & Çalık, M. (2010). Students' conceptions of the particulate nature of matter at secondary and tertiary level. *International Journal of Science and Mathematics Education*, 8(1), 165-184

Ayvacı, H.Ş., Özsevgeç, T. & Aydın, M. (2004). Data logger cihazının Ohm kanunu üzerindeki pilot uygulaması. *The Turkish Online Journal of Educational Technology – TOJET*, 3(3), 108-114.

Çalık, M. & Ayas, A. (2005). A comparison of level of understanding of grade 8 students and science student teachers related to selected chemistry concepts. *Journal of Research in Science Teaching*, 42(6), 638-667.

Ebenezer, J.V., Kaya, O.N. & Ebenezer, D.L. (2011a). Engaging students in environmental research projects: Perceptions of fluency with innovative technologies and levels of scientific inquiry abilities. *Journal of Research in Science Teaching*, 48(1): 94-116.

Ebenezer, J.V., Columbus, R., Kaya, O.N., Zhang, L. & Ebenezer, D.L. (2011b). One science teacher's professional development experience: A case study exploring changes in students' perceptions of their fluency with innovative technologies. *Journal of Science Education and Technology* Published Online First at http://www.springerlink.com/content/q03j2118040t6863/

Erdogan, M., Marcinkowski, T. & Ok, A. (2009): Content analysis of selected features of K-8 environmental education research studies in Turkey, 1997–2007. *Environmental Education Research*, 15:5, 525-548

Hair, J. F. Jr., Black, W. C., Babin, B. J., Anderson, R. E., &Tatham, R. L. (2006). *Multivariate data analysis*, 6th ed., New Jersey: Prentice-Hall International.

International Society for Technology in Education. (2008). *National Educational Technology Standards for Students*. Retrieved September 12, 2008, from http://www.iste.org/Content/NavigationMenu/NETS/ForTeachers/2008Standards/NETS_for_Teachers_2008.htm

Krajcik, J.S., Blumenfeld, P., Marx, R.W., & Soloway, E. (2000). *Instructional, curricular, and technological supports for inquiry in science classrooms*. In J.Minstrell & E.H.v.Zee (Eds.), Inquiring into inquiry learning and teaching in science (pp. 283–315). Washington, DC: American Association for the Advancement of Science.

Minstrell, J., & van Zee, E. (Eds.). (2000). *Inquiring into inquiry learning and teaching in science*. Washington, DC: American Association for the Advancement of Science

National Research Council (1996). *National science education standards*. Washington, DC: National Academy Press.

National Research Council (2000). *Inquiry and the National Education Standards.* Washington, D.C.: National Academy press