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Impact of Gender, Ethnicity, Year in School, Social Economic Status, and State Standardized Assessment Scores on Student Content Knowledge Achievement When Using Vee Maps as a Formative Assessment Tool

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The National Research Council has recognized the challenge of assessing laboratory investigation and called for the investigation of assessments that are proven through sound research-based studies. The Vee map provides a framework that allows the learners to conceptualize their previous knowledge as they develop success in meaningful learning when they utilize the Vee map to guide their thinking and the process of experimentation. Previous research has shown that using the Vee map as a formative assessment tool positively affects student content knowledge. The purpose of this study was to compare the impact of student demographic variables on student content knowledge achievement when using the Vee map as a formative assessment tool. The population of this quasi-experimental, counter-balance design study was composed of students at nine high schools that offered agriscience education. The results of this study indicated the Vee map is unbiased based on gender, grade, and ethnicity. It was also concluded that the Vee map does not provide either remedial or non–remedial readers with a significant advantage, thus allowing the assessment to focus on the content rather than a student's reading ability.

Keywords: agriscience, vee map, assessment, formative assessment, demographics

Introduction

The secondary level of the United States educational system has adopted higher graduation requirements in the areas of English, math, and science. As a result, many states experienced a shift of focus toward the core content areas and experienced an increase in overall assessment scores through the 1990s (USDE, 2009). Progression of student driven achievement during the 1990s led to the establishment of academic standards and goals, and the National Center for Education Statistics (NCES) reported stable performance in the science and math subjects and modest gains in reading (USDE, 2000). This focus prompted agricultural education to conduct several studies to demonstrate the science connections in agricultural education and the teachers' willingness to provide agricultural education as an integrated science in the secondary educational curricula (Myers, Thoron, & Thompson, 2009).

However, in the early twenty–first century, No Child Left Behind (NCLB) legislation has remained a driving factor in measuring student achievement (USDE, 2009). In 2000, 82% of the nation's twelfth graders performed below the proficient level on the National Assessment of Education Progress (NAEP) science assessment. The document stated, "the longer students stay in the current system the worse they do. According to the 1995 Third International Mathematics and Science Study, U.S. fourth graders ranked second. By twelfth grade, they fell to 16th…" (USDE, p.1).

Stagnant and lowering scores in science achievement have caused concern throughout the nation. The USDE (2009, paragraph 13) stated, “Researchers have scientifically proven the best ways to teach reading. We must do the same in science. America’s teachers must use only research–based teaching methods and the schools must reject unproven fads.” Educational researchers have responded to the call by NCLB and the USDE. There have been numerous efforts to improve teaching and learning in the secondary setting (Atkin & Coffey, 2003). Continued efforts to provide research–based evidence have produced research in the areas of teaching and learning with experimental designs based on standardized testing (Anderson, 2002).

One specific way, identified by the National Research Council (NRC), to increase student performance and scientific knowledge is by shifting a greater focus to hands–on (laboratory) instruction in the science curriculum (NRC, 1996, 2000). Laboratory investigation is widely accepted as good educational practice (Baker, Thoron, Myers, & Cody, 2008; Esche, 2006; Ornstein, 2006) and teaching agriculture in a laboratory setting has been an integral part of agricultural education for many years (Winslow, 1891). Osborne’s (1994) publication built upon this foundation and placed a greater emphasis on teaching using experiments in the agriscience context. Diederen, Gruppen, Hartog, and Voragen (2006) noted that one of the benefits of laboratory instruction is its use as a means to increase a student’s understanding and ability to apply knowledge.

While hands-on laboratory experience has been accepted as good teaching, finding assessments that are meaningful to the learner and user-friendly to the teacher remains a challenge (Thoron & Myers, 2010). The National Research Council recognized the challenge of assessing laboratory investigation and called for the investigation of assessments that are proven through sound research-based studies (NRC, 1996). Driver (1995) stated that interventions and expectations set by the teachers promote understanding and those expectations are communicated through assessment techniques.

Thoron and Myers (2010) stated that laboratory reports are commonplace during laboratory experiments. However, once students create a laboratory report teachers have the time-consuming task of grading and commenting on the lengthy reports (Thoron, Swindle, & Myers, 2008). Thoron and Myers also reported that teachers are challenged with the amount of time spent grading laboratory reports and that may lead to fewer experiments being conducted or no assessment of student learning during laboratories. Laboratory reports remain useful, but teachers are essentially assessing the students’ abilities to follow directions, collect data, and provide the correct answers to conclusion questions (Novak & Gowin, 1984) and fail to develop deep understanding because students are immersed in the steps and writing required to complete the laboratory report and turn the report in to receive a grade (Lebowitz, 1998). Furthermore, Novak, Gowin, and Johansen (1983) stated that a deepened epistemological structure can be created by students engaged in quality laboratories with proper assessments. Therefore, examination of empirical evidence supportive of an alternative to the laboratory report is the focus of this study.

Baxter, Shavelson, Goldman, and Pine (1992) stated that dissatisfaction of current assessments, advances in research on cognition and instruction, and reforms in science curricula continue to lead alternative assessment measures for experiments. Shavelson, Baxter, and Pine (1991) stated that continued focus on constructivism lends itself to finding alternative meaningful assessments. The authors stated that educational research should focus on educational measures that go beyond correct responses to reports and focus on conceptual understanding, problem-solving, and application.

Gowin’s (1979) Vee map is an assessment tool that can aid in the development of deeper student understanding and a time-friendly formative assessment for teachers to utilize during laboratory investigations (Roehrig, Luft, & Edwards, 2001). The Vee map is a scaffolding tool that applies Kolb’s (1984) model of experiential learning and allows for student manipulation of experiments (Thoron & Myers, 2010). The Vee map does not just require knowledge recall of an experiment, but requires students to formulate a question of investigation, identify key terms, include steps of investigations, create graphic organizers, incorporate data tables, and draw conclusions upon the student guided investigation (See Figure 1). The Vee map may be used in place of a traditional laboratory report (Roehrig et al., Vee Map Components

Inquiry Question: The question under investigation, this may be given to the student, depending on the level of inquiry

Word List: Student identifies words deemed important to the experiment.

Concept Map or Graphic Organizer: May be developed in a different program and placed in the section to graphically represent the student's understanding of concepts of the experiment.

Hypothesis: Statement of intended outcome

Conclusion:

What is the big picture? What knowledge was developed? What still need to be developed?

Data (in table, chart, or graph form):

Results of the experiment; represented in a table, chart, or graphical form.

Steps:
Depending on the level of inquiry, this may be very important so other student could replicate the study.
The steps should be able to be followed successfully by others.

Theoretical Framework

Ausubel's (1963) learning theory acted as a guide for this study. Ausubel places a central emphasis on learners' prior knowledge and the influence created on meaningful learning. “Meaningful learning results when a person consciously and explicitly ties new knowledge to relevant concepts or proposition they already possess” (Novak, Gowin, & Johansen, 1983, p. 625). Ausubel stated there is interplay between affective learning and cognitive learning and he built his theory for the meaning of each concept. Ausubel identified seven concepts along a continuum. Each concept builds on the previous that takes the learner from incorporation of information verbatim, to building knowledge and linking the relevant concepts together. As a result, learning becomes “less rote” and “more meaningful” through the planned instructional practice that supports learners. Novak (1980) stated that in order for learners to be successful in this theory the material must be inherently meaningful, the learner must link new knowledge with existing and relevant knowledge, and the learner must know relevant concepts involved in the scientific investigation. The Vee map provides the frame work that allows the learners to form the basis of Ausubel's learning theory as they develop success in meaningful learning when they develop the Vee map as a diagram of their thinking and process of experimentation. The Vee map provides a structure for students to exhibit their scientific foundation, investigate without following a laboratory verbatim, and have the ability to incorporate their previous knowledge.

America’s Lab Report (NRC, 2006) outlined goals for laboratory experiences in educational settings. These goals served as the framework of the study. Goal one is to enhance mastery of subject matter. The study’s objective was to compare the impact on content knowledge achievement of two different formative assessments in laboratory instruction. Developing scientific reasoning is another goal in the report. The Vee map is a tool specially designed to develop the scientific thinking skills of the learners (Gowin, 1979). Goal three is for students to exhibit connections between laboratory experiences and empirical work. The Vee map quantifies student experience through the use of graphic organizers and guides students to draw upon empirical data to form conclusions and recommendations. Finally, employing team work through laboratory investigations and asking student opinions of their utilization of the formative assessment tools bring all the goals outlined in the NRC report into this study.

Purpose and Objectives

The purpose of this study was to compare the impact of student demographic variables on student content knowledge achievement when using the Vee map as a formative assessment tool. The specific objectives guiding the study were to:

1. Determine the impact of gender on student content knowledge achievement when using a Vee map.
2. Determine the impact of ethnicity on student content knowledge achievement when using a Vee map.
3. Determine the impact of grade level on student content knowledge achievement when using a Vee map.
4. Determine the impact of social economic status on student content knowledge achievement when using a Vee map.
5. Determine the impact of a state standardized test on student content knowledge achievement when using a Vee map.

The null hypothesis, H_o: There is no significant difference in student content knowledge achievement based on gender, ethnicity, grade level, social economic status, and state standardized test when using the Vee map as a formative assessment tool.

Procedures

This study is part of a larger study conducted by Thoron and Myers (2010). Thoron and Myers reported the population of this quasi-experimental, counter-balance design study was composed of students at nine Florida high schools that offered agriscience education (N = 291). Each participating high school agriscience program was required to have two sections of *Introduction to Agriscience*. Schools were then purposively selected by a panel of experts on the capacity to integrate science into the curriculum. The Vee map is referred to as the treatment and the comparison (control) was determined to be the laboratory report. The order in which the intact groups received the treatment and comparison was determined randomly. Ary, Jacobs, and Sorensen (2010) stated that a counter-balance design is appropriate for use with intact groups. A counter-balanced design provides the ability to rotate out any differences that might exist between groups (Ary, Jacobs, & Sorensen, 2010).

Each student was administered a pretest to establish a base line before each replication to measure content knowledge in the subject matter being taught (soil science) and served as a covariate measure. All sections were taught the same subject matter content by the same teacher and taught using the same teaching techniques and methods. Control section participants completed the laboratory report outlined by Osborne (1994) in his text *Biological Applications in Agricultural Education* following the completion of a laboratory activity. Participants in the treatment group completed the Vee map. Following the data analysis procedure for counter balanced design suggested by Ary et al.(2010), column means were calculated for each treatment. Those means were then compared using a univariate analysis of covariance.

Pretest and posttest instruments were developed by the researchers using content knowledge questions in the form of thirty multiple choice items. The instruments contained a specific number of questions based upon the determined percentage of time to be spent teaching each objective of the unit. The testing instruments were validated by a panel of agriscience education experts from a state land grant university and were determined to be valid. The posttest questions were asked in a randomly selected order to reduce testing effect (Campbell & Stanley, 1963). Test–retest reliability was determined with a summated test score mean of 74.4% for test one and 63.6% for test two. Reliability coefficients for the knowledge level assessments were .99 and .99, respectively.

To help control for teacher variance, each school had a counter balance design and each teacher participated in a tutorial which explained teaching techniques, format and structure of the laboratory and Vee map reports. Upon completion of the tutorial, teachers received continuing professional development credit. Each teacher taught the selected lessons for four weeks. Based from the study of Thoron and Myers (2010) it was determined that the intervention was not fully administered if a student missed 25% or more of instruction in the unit. Therefore, students missing more than four days of school during the study period were removed from the data set.

Table 1

Twenty–nine students were removed from the study due to missing 25% or more of the instructional unit. Thus the original sample was narrowed to $n = 268$. All replications contained two lessons and before the lessons were taught a pretest was given to serve as a covariate to adjust for achievement prior to the treatment. Analysis for each objective utilized a covariate technique to analyze the data. Following the completion of data collection, posttest score means for each treatment, regardless of replication, were calculated (Ary et al., 2010).

Findings

The first objective sought to determine the impact of gender on student content knowledge achievement when using a Vee map. The analysis of the data for this objective was guided by the null hypothesis that there is no significant difference in student content knowledge achievement based on gender. All scores were based out of a possible score of 100. Following the first replication, males reported a posttest score of 69.03 (SD = 16.65) on posttest 1 and females reported a posttest score of 64.43 (SD = 17.99) on posttest 1 (See Table 1). This difference in posttest scores was found to not be statistically significant, $F(234.44) = 2.91$, $p = .09$, $r^2 = .13$. Following the second replication, males reported a posttest score of 63.42 (SD = 17.99) on posttest 2 and females reported a posttest score of 67.91 (SD = 16.59) on posttest 2. This difference in posttest scores was also found to not be statistically significant, $F(234.25) = 3.49$, $p = .06$, $r^2 = .13$. No statistically significant differences were found in the replications, thus the null hypothesis failed to be rejected.

Posttest Scores of Vee Map by Gender (n = 268).

	Mean Test Score					
	Posttest 1			Posttest 2		
Gender	*M*	*SD*	*n*	*M*	*SD*	*n*
Male	63.43	17.99	157	69.03	16.65	157
Female	67.91	16.59	111	64.43	17.99	111

The second objective sought to determine the impact of ethnicity on student content knowledge achievement when using a Vee map. The analysis of the data for this objective was guided by the null hypothesis that there is no significant difference in student content knowledge achievement based on ethnicity. Following the first replication on posttest 1, black students reported a posttest score of 63.27 (*SD* = 14.91), Hispanic students reported a posttest score of 65.88 (*SD* = 18.35), white student reported a posttest score of 65.18 (*SD* = 17.81), and students that self-identified as other scored 82.25 (*SD* = 14.15) (See Table 2). This difference in posttest scores was found not to be statistically significant, $F(189.22) = 1.069$, $p = .36$, $r^2 = .08$. Following the second replication and completion of posttest 2, black students reported a posttest score of 67.84 (*SD* = 16.99) on posttest 2, Hispanic students reported a posttest score of 65.05 (*SD* = 15.44), white students reported a posttest score of 67.38 (*SD* = 17.85), and students that were self-identified as other scored 71.25 (*SD* = 20.14). This difference in posttest scores were found not to be statistically significant, $F(180.84) = 0.58$, $p = .63$, $r^2 = .07$. No statistically significant differences were found in the replications, thus the null hypothesis failed to be rejected.

Table 2
Posttest Scores of Vee Map by Ethnicity (n = 268).

	Mean Test Score					
Ethnicity	Posttest 1			Posttest 2		
	M	*SD*	*n*	*M*	*SD*	*n*
Black	63.27	14.91	37	67.84	16.99	37
Hispanic	65.88	18.35	43	65.05	15.44	43
White	65.18	17.81	184	67.38	17.85	184
Other	82.25	14.15	4	71.25	20.14	4

The third objective sought to determine the impact of grade level (year in school) on student content knowledge achievement when using a Vee map. The analysis of the data for this objective was guided by the null hypothesis that there is no significant difference in student content knowledge achievement based on grade level. Following the first replication and submission of posttest 1, ninth grade students reported a posttest score of 65.91 (*SD* = 17.19), tenth grade students reported a posttest score of 62.67 (*SD* = 18.82), eleventh grade students reported a posttest score of 63.77 (*SD* = 17.52), and twelfth grade students scored 73.64 (*SD* = 14.10) (See Table 3). This difference in posttest scores was found not to be statistically significant, $F(229.17) = 1.28$, $p = .28$, $r^2 = .09$. Following the second replication and completion of posttest 2, ninth graders reported a posttest score of 65.72 (*SD* = 18.17), tenth grade students reported a posttest score of 70.09 (*SD* = 14.99), eleventh grade students reported a posttest score of 69.46 (*SD* = 17.91), and twelfth grade students scored 65.09 (*SD* = 12.79). This difference in posttest scores were found not to be statistically significant, $F(217.34) = 1.75$, $p = .16$, $r^2 = .13$. No statistically significant differences were found in the replications, thus the null hypothesis failed to be rejected.

Table 3

Posttest Scores of Vee Map by Grade (n = 268).

	Mean Test Score					
	Posttest 1			Posttest 2		
Grade level	*M*	*SD*	*n*	*M*	*SD*	*n*
9th	65.97	17.19	164	65.72	18.17	164
10th	62.67	18.82	58	70.09	14.99	58
11th	63.77	17.52	35	69.46	17.92	35
12th	73.64	14.01	11	65.09	12.79	11

The fourth objective sought to determine the impact of social economic status (SES), through the use of the school lunch program guidelines, on student content knowledge achievement when using a Vee map. The free and reduced school lunch program (FRSLP) was used as a proxy to SES based on the work of Stone and Lane (2003) that described linkage between SES and ability to participate in a state's FRSLP on student performance. The analysis of the data for this objective was guided by the null hypothesis that there is no significant difference in student content knowledge achievement based on SES. Following the first replication and submission of posttest 1, students not eligible to participate in the school lunch (reduced or free) program reported a posttest score of 65.32 (*SD* = 17.61), students eligible to participate in the reduced school lunch program reported a posttest score of 73.20 (*SD* = 13.18), students eligible to participate in the free lunch program reported a posttest score of 60.67 (*SD* = 18.12) (See Table 4). This difference in posttest scores was found to be statistically significant, $F(253.83) = 5.434$, $p = .01$, $r^2 = .25$. Following the second replication and completion of posttest 2, students not eligible to participate in the lunch program reported a posttest score of 68.87 (*SD* = 17.72), students eligible for a reduced lunch reported a posttest score of 69.73 (*SD* = 14.17), and students eligible for a free lunch reported a posttest score of 61.70 (*SD* = 17.15). This difference in posttest scores were found to be statistically significant, $F(239.96) = 3.29$, $p = .04$, $r^2 = .20$ Statistically significant differences were found; thus the null hypothesis was rejected.

Table 4
Posttest Scores of Vee Map by SES (n = 268).

	Mean Test Score					
Ability to participate in	Posttest 1			Posttest 2		
the lunch program	*M*	*SD*	*n*	*M*	*SD*	*n*
Not able to participate	65.32	17.60	158	68.87	17.72	158
Reduced lunch	73.20	13.18	40	69.73	14.17	40
Free lunch	60.67	18.12	70	61.70	17.15	70

The fifth objective sought to determine the impact of state standardized tests through the use of standardized assessment scores for reading, math, and science on student content knowledge achievement when using a Vee map. The analysis of the data for this objective was guided by the null hypothesis that there is no significant difference in student content knowledge achievement based on a state standardized test. Following the first replication and submission of posttest 1, students considered remedial readers reported a posttest score of 65.08 (*SD* = 17.25), students not considered remedial readers reported a posttest score of 74.36 (*SD* = 14.08), students in the same categories for posttest 2 scored 53.66 (*SD* = 14.45) and 61.57 (*SD* = 15.94) respectively (See Table 5). This difference in posttest scores was found to be statistically significant in both cases. Posttest 1 reported, $F(246.60) = 12.314$, $p = .00$, $r^2 = .27$, posttest 2 reported, $F(129.81) = 9.637$, $p = .00$, $r^2 = .25$, respectively (See Table 5). Statistically significant differences were found in the replications, thus the null hypothesis was rejected.

The state science score comparison of posttest 1 students remedial in science reported a posttest score of 67.54 (SD = 16.74), students not remedial in science reported a posttest score of 75.03 (SD = 13.78). This difference in posttest scores were found to be statistically significant, $F(171.01) = 3.72$, $p = .01$, $r^2 = .24$. The second replication and submission of posttest 2, students remedial in science reported a posttest score of 54.76 (SD = 14.93), students not remedial in science reported a posttest score of 63.89 (SD = 13.64). This difference in posttest scores were found to be statistically significant, $F(126.74) = 8.20$, $p \leq .00$, $r^2 = .30$. Statistically significant differences were found in the replications, thus the null hypothesis was rejected (See Table 5).

The state math score comparison of posttest 1 students remedial in math reported a posttest score of 68.00 (SD = 18.78), students not remedial in math reported a posttest score of 71.71 (SD = 13.09). This difference in posttest was not found to be statically significant, $F(234.29) = 3.39$, $p = .01$, $r^2 = .11$. The second replication and students' completion of posttest 2, students remedial in math reported a posttest score of 53.34 (SD = 14.32), student not remedial in math reported a posttest score of 61.11 (SD = 15.15). The difference in posttest was found to be statically significant $F(111.24) = 6.62$, $p \leq .00$, $r^2 = .25$. Statistically significant differences were found in one replication, thus the null hypothesis was rejected (See Table 5).

Table 5
Posttest scores of Vee map by SES (n = 268).

State Standardized Test	Mean Test Score – Remedial						Mean Test Score – Non Remedial					
	Posttest 1			Posttest 2			Posttest 1			Posttest 2		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Reading	65.08	17.25	101	53.66	14.45	101	71.36	14.08	167	61.57	15.94	167
Science	67.54	16.74	173	54.76	14.93	173	75.03	13.78	95	63.89	13.64	95
Math	68.00	18.78	89	53.34	14.32	89	71.71	13.09	179	61.11	15.15	179

Conclusions and Recommendations

The Thoron and Myers (2010) study indicated that the Vee map, as a formative assessment tool, was more effective in the agriscience classroom when compared to the laboratory report. The Vee map is an interactive teaching/evaluation tool to be considered for classroom use. This study's results indicated the Vee map is not affected by gender, ethnicity, or grade level. However, this study does report a statistically significant difference in SES status. Further examination of the SES status revealed students receiving reduced lunch scored better during both replications. Students receiving free lunch scored the lowest each replication. The researchers suggest further examination of qualities that reduced lunch students' possess that influence the findings. Further investigation and consideration of the theoretical model guiding this study suggest emphasis on learners' prior knowledge and the influence created during meaningful learning (Ausubel, 1963). As Novak (1980) stated, in order for learners to be successful through the Ausubel theory the material must be inherently meaningful. Therefore, further investigation seeking knowledge if agriscience education and laboratories are more meaningful to students that qualify for reduced lunch status. Also, are students at lower socioeconomic status levels (eligible for reduced lunch program) bringing in more practical knowledge and are thus able to apply it with a Vee map? Further investigation may provide a link for student motivation in the classroom for students in this demographic.

Significant differences were found in reading and science when comparing remedial and non–remedial learners. It can be concluded that the Vee map does not provide either remedial or non–remedial learners with a significant advantage. Therefore, the Vee map may not aid in closing the gap that exists between the two groups. More importantly however, is the Vee map does not provide a disadvantage to students struggling to read. A tool that assesses scientific measures and not reading ability is increasingly important. Furthermore, the examination of math scores reported mixed results and further investigation should be conducted.

Finally, this study does not provide evidence that the formative assessment tool provides an advantage over one group or another when based on grade, gender, or ethnicity. The United States Department of Education called for assessments that are research based and provide for measures that do not place an advantage on specific demographic groups (Anderson, 2002). Further investigation of student attitudes toward the use of Vee maps should be investigated. Further investigation is warranted to find if the Vee map provides a way to motivate females and minorities to become enthused about science.

Although this study has limitations based on a purposive selected sample, Vee maps should be considered a meaningful tool in the agriscience profession. Inservice and preservice teachers and teacher educators should examine this tool and consider it an effective way to assess experiments in the agriscience classroom. Baxter, Shavelson, Goldman, and Pine (1992) stated there is a dissatisfaction of current assessments, leading to a further developed need to reform curriculum and advance student thinking and understanding. This tool provides for better thinking when measuring student content knowledge achievement (Thoron & Myers, 2010) and this study indicated it is unbiased based on gender, grade, and ethnicity. Shavelson, Baxter, and Pine (1991) stated that the educational research should focus on educational measures that go beyond correct responses to reports and focus on conceptual understanding, problem-solving, and application, the Vee map provides the profession with that avenue.

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