

The Effect of Using Vee Maps Versus Standard Laboratory Reports on Achieving Student Content Knowledge

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Instruction in laboratory settings is a component of the total agricultural education program. This teaching environment provides several opportunities for student learning, yet it also brings along several challenges for the instructor. One paramount challenge is authentic student assessment in this distinctive situation. This quasi-experimental, counter-balanced design study investigated the effect of two formative assessment techniques on student content knowledge achievement. The effect of traditional written laboratory reports was compared to the use of the Vee map in 18 agriscience education classes found within nine different secondary schools. Utilizing student pretest score as a covariate, there was a statistically significant difference between groups on the posttest. Regardless of replication in the study, student mean posttest scores were always higher in classes utilizing the Vee map.

Keywords: agriscience, vee map, laboratory report, assessment

Introduction

Laboratory instruction is essential to science education (Roth, 1990). Because agriculture is a science, (True, 1929; Vaughn, 1993) laboratory instruction is essential to quality agriculture education (Baker, Thoron, Myers, & Cody, 2008). Teaching in a laboratory setting has been a part of the agricultural education curriculum for over 115 years (McBryde, 1901; Nolan, 1911; Winslow, 1891). More recently, an emphasis on teaching using experiments has emerged (Osborne, 1994). One challenge teachers face when implementing laboratory instruction, especially when teaching with experiments, is student assessment. Traditional assessment measures often fail to fully and adequately evaluate student learning in these situations (Coffman & Riggs, 2006; Dilger, 1992; Edwards, Luft, Potter, & Roehrig, 1999; Gowin, Mutkowski, & Novak, 1981; Harwood, 2004; Hofstein & Lunetta, 1982; Lebowitz, 1998; Novak, 1998; Novak & Gowin, 1984; Novak, Gowin, & Johnsen, 1983; Roehrig, Luft,

& Edwards, 2001; Roth, 1990; Rutherford, 2007).

Toulmin (1972, p. 161) stated, “If we learn only the words and equations of a science, we may remain trapped in its linguistic superstructure; we come to understand the scientific significance of those words and equations, only when we learn their application.” Although the educational value of the hands-on laboratory experience is known to be an exceptional teaching tool, reviewing and assessing student grades remains more challenging. The need to finding a better way to assess learning and direct learning in the laboratory setting is among the top priorities of the profession (National Research Council [NRC], 2006). Driver (1995) stated that interventions and expectations set by the teachers promote understanding and those expectations are communicated through assessment techniques.

A common laboratory instruction assessment tool is the written laboratory report. Traditional laboratory reports provide a context where learners show their ability to provide a

title, purpose, steps taken to complete, data collected, and answers to a series of concluding questions (Roehrig et al., 2001). Teachers then grade lab reports assessing the students' abilities to follow directions, collect data, and provide the correct answers to conclusion questions (Novak & Gowin, 1984). However, this leads to the typical laboratory report being more of an account of activity than a description of knowledge gained, thus having little ability to enhance conceptual knowledge or learner understanding of the nature of science (Roehrig et al., 2001). Many times laboratory reports fail to develop deep understanding because students are simply creating a document to turn in for a grade (Lebowitz, 1998). Yet Diederer, 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. Furthermore, a deepened epistemological structure can be created by students engaged in quality laboratories with proper assessments (Novak et al., 1983).

An evaluation tool that will facilitate better knowledge gain is needed. One possible teaching tool that is both teacher and student friendly is a device known as the Vee map. The Vee map was first developed by Gowin in 1977 to help instructors and students understand the process of constructing their own knowledge during laboratory experiences (Roehrig et al., 2001). This formative assessment tool provides a framework to guide learners through the steps involved in scientific reasoning methods. The Vee map allows for learners to develop their own inquiry question, or one can be provided with the laboratory activity.

The Vee map acts as a scaffolding device following Kolb's (1984) model of experiential learning as it guides learners through the reflective learning process. Although an important part of the learning process, reflection is often overlooked in high school classrooms (Dilger, 1992). The Vee map accomplishes this

by connecting lecture/discussion instruction and laboratory instruction through steps which force knowledge-level recall. Rosenshine and Furst (1971) noted the importance of recall and repetition toward learning. Dilger (1992) added that students are better able to synthesize information when this clear connection between concepts discussed in the laboratory and lecture/discussion components of a course is made.

When utilizing the Vee map, students no longer conduct laboratory activities to just answer questions on a report. Students experiment and form their own conclusions, rather than try to reproduce the experiment to receive the same answers as their peers or what they read from the book. Through Vee maps and inquiry instruction, students are allowed to formulate their own decisions and create their own graphic organizer which fits their learning style (Roehrig et al., 2001). Through the use of a graphic organizer and student-developed data tables, Vee maps also incorporate the work of Gardner's (1983) multiple intelligences.

The Vee map is designed to replace the traditional lab report (Roehrig et al., 2001) when appropriate (Thoron & Myers, 2006). The Vee map contains seven sections that encourage the progression from lower to higher levels of Bloom's (1956) taxonomy (Novak et al., 1983). Dilger (1992) divided the Vee map into two broad components: philosophy of the activity and methodology of the activity. Philosophy on the left-hand side provides incorporation of the learner's background knowledge and construction of thought processes. Methodology on the right-hand side is the result of the background knowledge and content learned (see Figure 1). A electronic or virtual form of the Vee map, suggested by Coffman and Riggs (2006), provided text boxes which cannot be altered by the students, forcing them to employ reading strategies in the selection of words to describe their findings (Thoron & Myers, 2006).

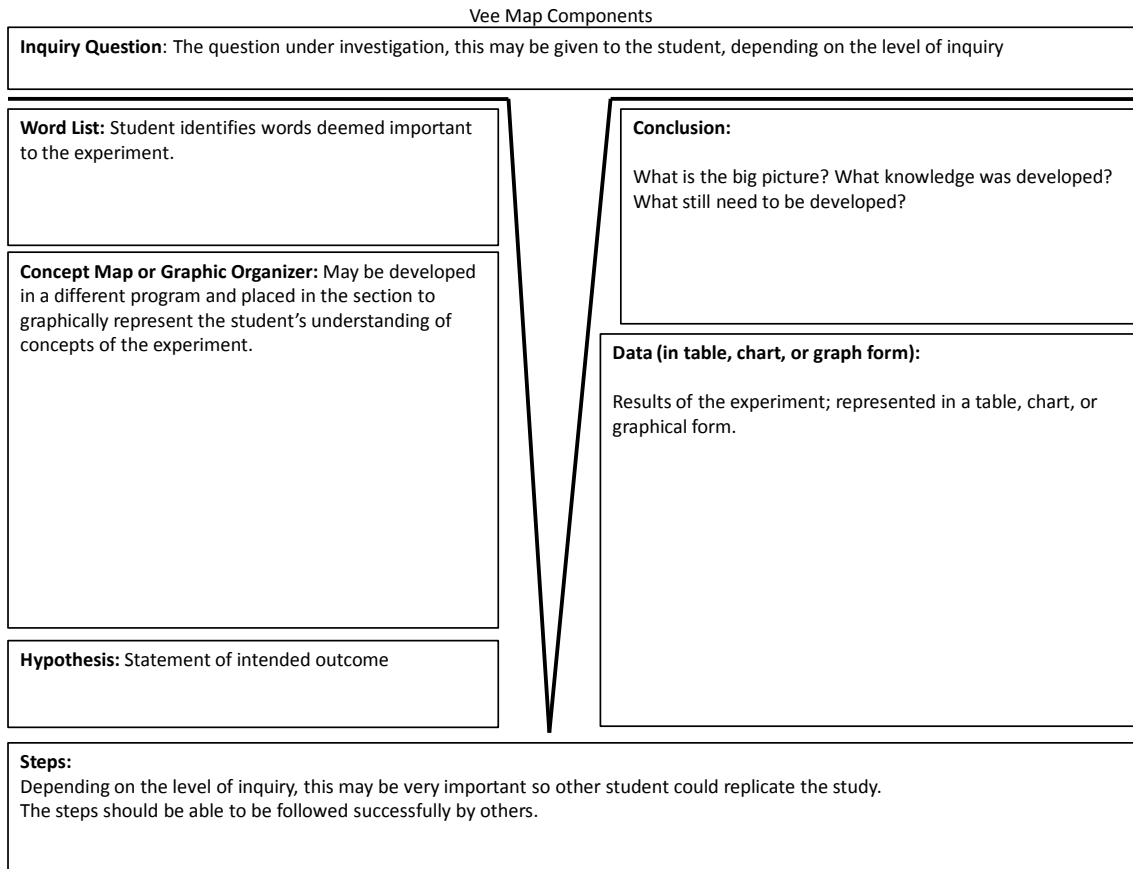


Figure 1. Vee map components.

Teachers can vary the degree of inquiry and still effectively use the Vee map. For example, a teacher can provide the inquiry question to supply a focus or the teacher could present a problem and have the students develop the inquiry question and procedure.

The Vee map begins with the identification of the problem to be investigated. Students then form their investigation by creating an inquiry question. Following completion of the question, students develop a list of key words significant to the activity. The third portion of the map is vital to visual and innovative learners as they are allowed to develop their own concept map or graphic organizer. Within the first three steps not only are students reflecting on the laboratory activity in which they participated, but they

are developing cross curricular skills in reading strategies (Snow, 2002) and developing higher order thinking skills in a scientific context (Thoron & Myers, 2006).

The subsequent steps involve development of a hypothesis and completion of the steps to complete the laboratory activity. The sixth step allows learners to arrange their collected data in the form of a chart, table, or graph. This data step allows for the use of applied technology and empowers students to formulate their data in a graphic form that is not predetermined. Lastly, the students are asked to form a conclusion of the laboratory activity, identify limitations and create recommendations for further investigation.

The Vee map is developed from Gowin's (1979) interest in the "structure of knowledge." These epistemological

concerns are part of a larger theoretical development in the act of educating (Gowin, 1981). Figure 2 illustrates completed elements of a student's epistemology structured into the Vee map. The central idea of the Vee is each section is interdependent. "The fundamental assumption is that knowledge is not

absolute, but rather it is dependent upon the concepts, theories, and methodologies by which we view the world" (Novak et al., 1983, p. 628). A complete discussion of the Vee map is beyond the scope of this manuscript; for a more complete discussion and further information on the Vee map see Gowin (1981).

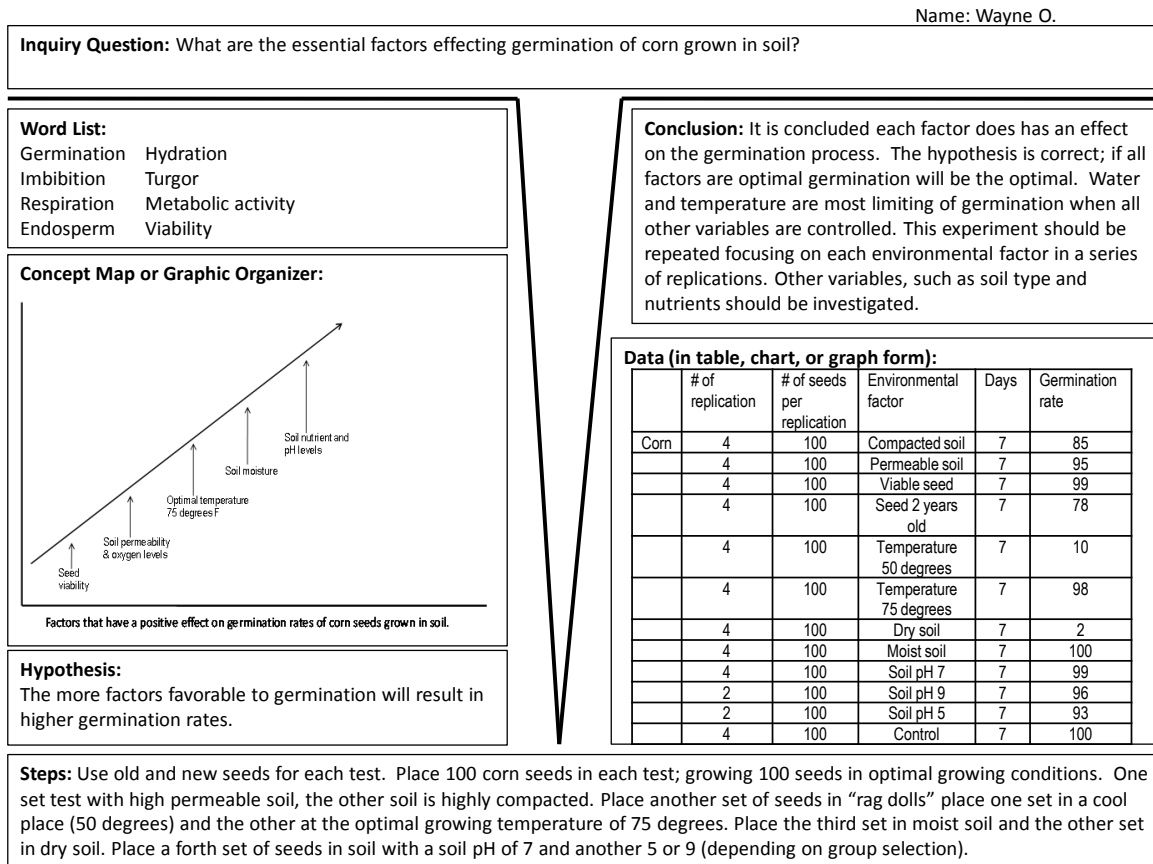


Figure 2. Completed Vee map example.

Teachers can use Vee maps to formatively assess student learning. Studies show assessment that takes place while instruction is in progress creates a positive effect on student learning (Atkin & Coffey, 2003; Black & Harrison, 2001; Black & William, 1998). The National Academy of Science (1996) encouraged formative assessment stating it is essential to fulfilling the mission of the National Science Education Standards. Furtak and Ruiz-Primo (2008) found open-format formative assessment to be more effective when

compared to specific prompting questions. Furtak and Ruiz-Primo (2008) note effective formative assessment tools can be quick to use and assess. The Vee map provides the teacher an understanding of knowledge gaps through a one page document. Novak and Gowin (1982) stated it is a more efficient use of time than many other assessment methods. Furthermore, allowing students to construct their learning is more favorable to retention of knowledge (Furtak & Ruiz-Primo, 2008).

Many teachers who have taught science agree that convincing students to complete a laboratory report can be an arduous task (Lebowitz, 1998). Once students create the report then teachers have the time consuming activity of grading and commenting on multiple student laboratory reports (Thoron, Swindle, & Myers 2008). However, teachers have been programmed through their own experiences to only pose a series of questions that require students to reflect on methods used, data collected, and concepts learned with minor variations from teacher to teacher (NRC, 2006).

A tremendous need exists for modernizing instructional techniques used in educational laboratories (NRC, 2006). Students in high schools today become confused as to whether they are actually experimenting during the laboratory experience or simply following directions of the laboratory manual (Millar, 2004). The heart of student inquiry in the laboratory is the opportunity for students to develop their own conclusions following the steps of the scientific process. When a student's focus shifts toward the procedure of the experiment, for the "correct" answer, it becomes clear they are uncertain about what they are learning when conducting the activity (NRC, 2006). A Vee map offers exciting solutions to many of the issues clouding traditional laboratory exercises.

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 et al., 1983, p. 625). From the basis of Ausubel's learning theory, potential success in meaningful learning is the framework of concepts the learner is able to develop into their epistemological structured Vee.

America's Lab Report (NRC, 2006) outlines 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 main 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 users. Through the use of graphic organizers and the need for students to show connections of concepts in the laboratory experiences, students are able to accomplish NRC goal three of understanding the complexity and ambiguity of empirical work. The hands on nature of the exercises and structure, in which the lessons were taught, aid in developing practical skills. Employing team work through laboratory investigations and asking student opinions of their utilization of the formative assessment tools brings 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 two formative assessment tools on student content knowledge achievement. The specific objectives guiding the study were to:

1. Describe the population of the study.
2. Compare the impact of traditional laboratory reports to Vee map reports on student content knowledge achievement.

The null hypothesis, H_0 : no significant difference in student content knowledge achievement based on formative assessment tool used (laboratory reports or Vee Map lab assessments), guided the analysis of the second objective.

Procedures

The population of this quasi-experimental, counter-balance design study was composed of students at nine Florida high schools offering agriscience education ($N = 291$). Each participating high school agriscience program was required to have two sections of introductory agriscience.

Upon meeting these criteria, schools were selected by a panel of experts on the development and administration of integrated agriscience curriculum. The order

in which sections at each school received the treatment (Vee map) or control (laboratory report) was randomly selected (See Table 1).

Table 1
Description of Counter Balance Design

Replication	Treatment	
	Vee map	Laboratory report
1	Class 1	Class 2
2	Class 2	Class 1
	Column mean	Column mean

All students were administered a pretest to establish a baseline before each replication to measure content knowledge levels in the subject matter to be taught (soil science) and to serve 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, Jacobs, Razavieh, and Sorensen (2006), 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 knowledge level 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 the University of Florida. The post test 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 percent for test one and 63.6 percent 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. Researchers determined *a priori* 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 dataset.

Findings

The first objective sought to describe the population of the sample. The total group consisted of 297 students from nine Florida high schools. A majority (60.6%) of students involved in this study were in the ninth grade, followed by the tenth grade (21.9%), eleventh grade (12.5%), and twelfth grade (5.1%). The majority of students in the study were male (60.3%) and “White, non-Hispanic” (68.7%), followed by “Hispanic” (17.5%), “Black” (12.5%) and “Other” (1.3%) (See Table 2).

Table 2
Demographics of the Population of the Study

Gender/Ethnicity	<i>f</i>	%
Male	179	60.3
Female	118	39.7

Black	37	12.5
Hispanic	52	17.5
White	204	68.7
Other	4	1.3

Note. *N* = 297 Each student self-identified gender and ethnicity.

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. Researchers determined the gender or ethnic

make-up of the group was not compromised due to this procedure. No gender or ethnic group saw a notable change in representation (See Table 3).

Table 3
Demographics of the Sample After Removing Students Determined to Not Have Received the Treatment

Gender/Ethnicity	<i>f</i>	%
Male	157	58.6
Female	111	41.4

Black	37	13.8
Hispanic	43	16
White	184	68.7
Other	4	1.5

Note. *N* = 268 Each student self-identified gender and ethnicity.

The second objective sought to determine the impact of two formative assessment tools on student content knowledge achievement. 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 the formative assessment tool used. The analysis of covariance technique was used to analyze the data. Student pretest score was utilized as a covariate to adjust for achievement prior to the treatment. Following the first replication, students who used the Vee map reported a mean posttest score of 73.96 (*SD* = 15.67) and those using traditional laboratory reports having a mean score of 54.90 (*SD* = 13.59). This difference in posttest scores was found to be statistically

significant, $F_{(1, 265)} = 94.43, p \leq .001, r = .54$. (See Table 4).

For replication two, treatment and control groups were switched, with those that used the Vee map in replication one using the traditional laboratory report and vice versa. Students in the group that used the Vee map formative assessment had a mean posttest score of 70.95 (*SD* = 17.03) with the control group having a mean of 64.01 (*SD* = 17.01). This difference in posttest scores was also found to be a statistically significantly different, $F_{(1, 265)} = 14.39, p \leq .001, r = .20$.

Following the completion of data collection, posttest score means for each treatment, regardless of replication, were calculated (Ary, Jacobs, Razavieh, & Sorensen, 2006). A statistically significant

difference was found due to treatment effect, thus the null hypothesis was rejected.

Table 4
Posttest Scores by Treatment (n = 268)

Instrument	Mean Test Score					
	Treatment			Control		
	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>
Posttest 1	73.96	15.67	146	54.90	13.59	122
Posttest 2	70.95	17.03	122	64.01	17.01	146

Conclusions and Recommendations

The null hypothesis of the study was rejected, thus indicating that there was a statistically significant difference in student content knowledge achievement between students who completed the Vee map and those that completed the traditional laboratory report. Students who completed the Vee map scored higher than those who completed the traditional laboratory report. Therefore, when educators are developing the laboratory component of the agriscience classroom, Vee maps should be considered as a formative assessment tool.

The Vee map is an interactive tool that promotes higher-level thinking skills for the student, greater freedom for the instructor to interact with the students, and less evaluation time for the instructor. The Vee map allows teachers more time with students in actual laboratory instruction and guides students away from just trying to report the correct answer on the laboratory report. While providing teachers with more freedom during lab instruction, Vee maps also allow for less preparation of laboratory questions, and reduce grading time for each laboratory to 10–15 minutes per map compared to traditional laboratory reports, which may take 30–50 minutes each (Coffman, & Riggs, 2006). Furthermore, students conceptualize their learning better because they see how their scientific knowledge is developed as the Vee map guides the students through reflection (Kolb, 1984).

The implications of streamlining laboratory exercises, reviews, and grading could be of great value for science and agriscience teachers. Having a better tool available for student assessment could also encourage teachers to use more laboratory investigations in their instruction. Additional research on Vee map utilization is still needed. In addition to the impact this tool demonstrated on student content knowledge achievement, future research should investigate its impact on student attitude toward science and agriscience, reading proficiency, critical thinking, and scientific reasoning. Professional development on the Vee map is also needed to inform agriscience educators (inservice, preservice, and teacher educators) on how to properly implement this teaching tool. Development of attitudinal measures toward the use of the Vee map is needed to more fully understand the keys to the adoption of this tool in agriscience classrooms. Future research in inquiry based instruction should continue to be an interest of agriscience education. Studies which investigate effective methods of science integration should also be pursued by the agriscience education community. The findings of those studies should also be used to guide the development and delivery of educator professional development. Development of students which have science process knowledge and the ability to apply the knowledge to situations faced later in life can lead to a more successful agriscience industry.

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