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David Hoffa
David Hoffa Industrial Consulting, dwhoffa@gmail.com

Steven A. Freeman
Iowa State University, sfreeman@iastate.edu

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Keywords
Curriculum, Synopsis, Lab Reports, Teaching Methods, and Technical Writing

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David Hoffa
David Hoffa Industrial Consulting
Ankeny, Iowa, USA
dwhoffa@gmail.com

Steven Freeman
Iowa State University
Ames, Iowa, USA
sfreeman@iastate.edu

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Prior research demonstrated that writing synopsis laboratory reports (succinct syntheses of the experiment, lecture, and readings) instead of traditional laboratory reports, did not influence student learning as measured by comprehensive exam scores. This study extended this research by investigating the impact of these lab report formats on student learning as measured by laboratory report scores. Fifty-six Iowa State University industrial technology students were randomized into one of two groups that were required to write five synopsis reports followed by four traditional reports or vice-versa. The analysis of mean laboratory report scores using the paired-samples t-test revealed no significant difference between treatments. The analysis of the mean scores of the nine individual laboratory reports using two-sample t-tests revealed no treatment effect for seven of the nine reports. The results of an exit survey revealed that students believed the synopsis format helped them to achieve higher grades on their laboratory reports.

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Introduction

Many industrial technology programs incorporate both a lecture component and a laboratory (lab) component in order to help students increase their understanding of the curriculum. Felder and Peretti (1998) said, “a basic tenet of learning theory is that people learn by doing, not by watching and listening. Engineering laboratory courses are consequently crucial to the learning and retention of engineering principles (p. 1). Industrial technology accreditation requirements similarly emphasize the importance of laboratory experiences (National Association of Industrial Technology, 2003). While some researchers (Hart, Mulhall, Berry, Loughran, and Gunstone, 2000; Shapiro, 1991; Connor, 1977), question the value of lab experiments, there is no doubt that the lab experiment is a commonly employed teaching tool in industrial technology. The purpose of laboratory experiments in industrial technology is “to motivate, illustrate, and enlighten the presentation of the subject matter addressed in the lecture” (Gillet, Latchman, Salzmann, and Crisalle, 2001, p. 190).

A written report often follows the lab experiment in order to cause the student to reflect on, summarize, and quantify the laboratory experience. Lederman (1999) said that “the assumption that students are likely to learn the nature of science through implicit instruction (i.e. performance of scientific inquiry with no reflection on the nature of the activity) should be called into question" (p. 928). A well-designed lab report asks a student to reflect on the activity, the assigned readings, and the lecture content, and synthesize these into a new, succinct document. These are the primary goals of the synopsis lab report format.

Synopsis and Traditional Laboratory Reports

Synopsis Laboratory Reports

Synopsis reports, a model taken directly from industry[1], were restricted to a single page and focused on relating the content of the experiment to the curricular content. The report was to be written in a style similar to an abstract or executive summary; for example, the writer was not permitted to discuss experiment-specific material such as setup, procedures, or measurement results, and was to write in the passive voice and present tense. The synopsis format ignores the before and during, focusing on the after, or conclusion (Doumont, 2003). A synopsis is to be written devoid of all experiment-specific information (such as problems encountered, measured results, and procedures) and requires the writer to think deeply about the purpose of the experiment as it relates to the theoretical concept.

While interpretations of Bloom's Taxonomy vary (Bloom, 1956; Krumme, 2005) and others have revised/updated it (Krathwohl, 2002), the recombination and summarization of readings, class discussions, and laboratory experiences to produce an original work seems descriptive of the synthesis level of the taxonomy (the create level in Krathwohl's revision). The synopsis lab report is one method of bringing this type of writing into the curriculum and falls into the writing in the disciplines (WID) concept of the Writing Across the Curriculum movement (Brewster and Klump, 2004; Romberger, 2000; Boyd & Hassett, 2000). WID "is premised on the idea that students become better readers, thinkers, and learners in a discipline by [writing in] the forms and conventions specific to it" (Brewster and Klump, 2004, p. 19).

Traditional Laboratory Reports

The traditional lab report, for the purposes of this study, is defined as a report in which subjects may take as much space as they wish in order to introduce the experiment, display the results, discuss their findings, and draw conclusions about the experiment. This style of lab report is written chronologically, similar to other documents that have the purpose of reporting work. Students "present the reason for the work in an introduction (the before), detail this work in a body (the during), and report its outcome in a conclusion (the after)" (Doumont, 2003).

In the traditional format, the focus of the report is on the conduct of the experiment and the results the experiment produces. While the experiment itself may be on the application level of Bloom's Taxonomy (1956) or the apply level of Krathwohl's revision (2002), the traditional lab report format promotes the reiteration of the experimental procedure and results and does not seem to encourage deep thought regarding the purpose of the experiment and its relation to the curriculum. Therefore, the writer of a traditional lab report is likely operating at the comprehension (Bloom, 1956) or understand (Krathwohl, 2002) level, where students demonstrate their understanding of concepts by recalling what they have learned, translate and interpret findings, and explain expected and unexpected results (Krumme, 2005).

Need for the Study

The synopsis lab report format is a WID exercise based on the style of writing expected by technology students' future employers. The literature repeatedly reflects industry's desire for graduates who have solid written communication skills. Some examples:

- Nixon and Fischer (2001) found that

  > [a] lengthy review of the curriculum in the College of Engineering at the University of Iowa, conducted from 1997 to 2000 made it apparent that subjects were not gaining appropriate communications skills from the curriculum. It was apparent from both advisory board input and from ABET [Accreditation Board for Engineering and Technology] concerns that steps were needed to address this lack (p. T2G/1).

- Doumont (2002) said that "it was a well-known complaint from real-world companies that the young graduates they hire were ill-prepared for… communicating in the workplace" (p. 138).

- Baren and Watson (1993) also found a strong desire for engineering graduates with good communication skills (accreditation guidelines indicate the same desires for industrial technology students [2003]):

  > [A] cursory look through the classified section of any newspaper indicates that "good communication skills" were a requirement of most companies which hire engineers. Campus recruiters, members of [Temple University's] industrial advisory committees, senior design industry advisors and other practicing engineers continue to emphasize the need for young engineers 'who can communicate' (p. 432).

Hoffa and Freeman (2006) found that the synopsis report format resulted in significant time savings in both grading time and writing time. Hoffa and Freeman (2007) also found that the synopsis lab report format provides students with an equally effective learning experience as the traditional report format based on exam scores; however, that study did not address the direct impact of the lab report style on students' scores on the lab assignments themselves. This study further examines the efficacy of the synopsis lab report format (to determine if there is any impact on student learning as measured by lab assignment grades) by addressing the following two research questions:

1. Does the lab report format (synopsis vs. traditional) influence mean scores on lab assignments?

2. Does the lab report format (synopsis vs. traditional) influence students' scores on the nine individual laboratory assignments?

Methodology

Population and Sample

The population for this study was undergraduate industrial technology majors at Iowa State University. The convenience sample contained the students who enrolled in ITEC 140, Electrical Fundamentals, in both the Fall 2004 (30 students) and Spring 2005 (26 students) semesters, for a total sample size of 56 students. This course consisted of nine lab experiments/reports per semester. Each student was counted as one experimental unit.

This research was approved by the Iowa State University Human Subjects Internal Review Board. The students were required to complete all work associated with this study as a part of the requirements of the course; however, each student was given the option to have their individual data excluded from the research.

Each subject was randomized into one of two groups: Group 1 wrote five synopsis reports followed by four traditional reports; Group 2 wrote five traditional reports followed by four synopses; therefore, all students in both semesters completed all nine lab reports.

Data Collection

Each subject was required to perform all nine lab experiments. After each experiment, subjects were allotted one week in which to complete and submit a report based on that experiment. The instruments used for data collection included the nine lab reports from each subject (five synopses and four traditional reports or vice versa) and composite American College Testing (ACT) scores.

Assumptions

1. The participants worked to the best of their abilities on all lab experiments and lab reports.
2. The participants were representative of undergraduate industrial technology students at Iowa State University.
3. The concerns about engineering students' written communication skills closely paralleled those of students in industrial technology.
4. An abbreviated lab report format that does not impinge upon students' learning experiences concerning the technology content is desirable to both educators and students in the field of industrial technology.

Delimitations

1. Only subjects who enrolled in the Fall, 2004 and Spring, 2005 semesters of ITEC 140, Electrical Fundamentals, were invited to participate in the study.
2. Data regarding subjects' individual learning styles were neither gathered nor taken into account in the analysis.

Grading and Reliability

The use of grading rubrics provided reliability by ensuring that every lab report with a similar grade had attained a comparable level of achievement – traditional reports were graded on content, clarity, completeness, spelling, grammar, correctness of results, and adherence to format; synopsis reports were graded on content, clarity, completeness, spelling, adherence to format, and grammar, but the results of the lab were not considered as a part of the grade (the experiment results were checked for accuracy in the lab and approved by the instructor). The course materials (lecture content, textbook, homework assignments, lab experiments, exam content, and other handouts), as well as the course structure (rules, expectations and requirements, and weighting of graded materials), remained fixed for the duration of the study. To control instructor bias, every effort was made to grade every lab report anonymously.

Statistical Design

The statistical analyses were performed using SPSS for Windows version 11.0 (2001) statistical software. The two-sample t-test (equal variances not assumed), paired-samples t-test, regression analysis, and Analysis of Covariance (all using $\alpha = 0.05$) were used to discover whether the style of lab report influenced mean scores on lab assignments. To discover whether the lab report formats influenced students' scores on the nine individual lab assignments, the mean synopsis grade and the mean traditional report grade for each of the nine lab assignments were analyzed with the two-sample t-test (equal variances not assumed).

Findings

Does the Lab Report Format Influence Mean Scores on Lab Assignments?

One outlier was revealed when the data were analyzed with a boxplot; the data from the subject who provided the outlier was discarded from the set, which reduced the number of subjects for the following analyses to 55 (removing the outlier had a negligible effect on the outcomes of the statistical analyses).

Some subjects' ACT scores were unavailable because students who change majors or transfer from other universities are not required to report their ACT scores for admission into the industrial technology program – this reduced the total number of subjects available for all analyses involving ACT scores to 48. The range of ACT scores for the sample was between 16 and 29. All of the following data are in units of 'points out of ten'.

For Set 1 (each student's mean score for labs 1-5), the mean lab report score of synopsis report writers was 7.93 and the mean lab report score of traditional report writers was 7.79 (see Table 1, Figure 1). The two-sample t-test analysis of Set 1 revealed no statistically significant difference in mean lab report scores between synopsis report writers and traditional report writers ($p = 0.542$, confidence interval = -0.312; 0.587).

Table 1

Descriptive Data of Lab Report Scores (in points out of 10).

	Overall		Synopsis Reports		Traditional Reports	
Set	Mean	Range	Mean	Range	Mean	Range
1	7.81	6.30-9.80	7.93	6.70-9.20	7.79	6.30-9.80
2	8.15	6.38-9.88	8.08	6.38-9.88	8.25	6.63-9.63

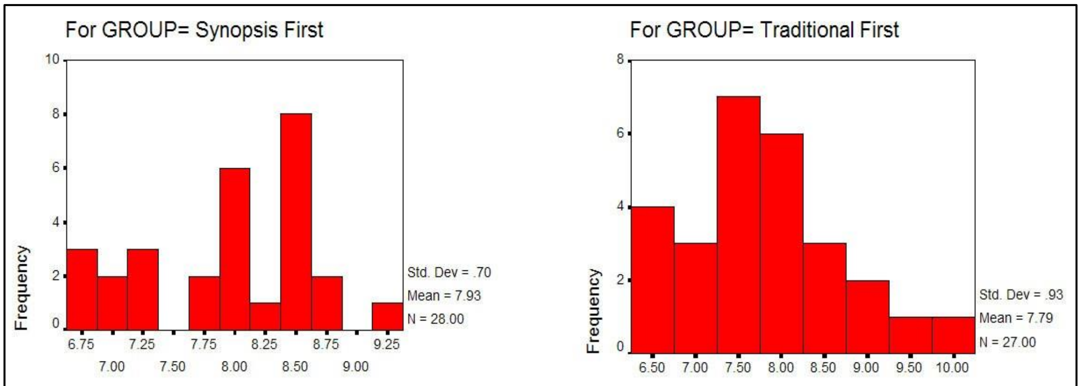

Figure 1. Histograms for Set 1 Lab Report Scores (in decimal score).

Analysis of Covariance revealed no significant effect for

Analysis of Covariance revealed no significant effect for Group * ACT for Set 1 ($F(9,47) = 0.746$, $p = 0.664$). Since the Group * ACT interaction had no significant effect, it was removed from the model, which was then reanalyzed using ACT as a covariate. It was then revealed that ACT scores had no influence over the students' success on the first five lab reports ($F(1,47) = 0.054$, $p = 0.817$).

For Set 2 (each student's mean score for labs 6-9), the mean lab report score of synopsis report writers was 8.08 and the mean lab report score of traditional report writers was 8.25 (see Table 1, Figure 2). The two-sample t-test analysis of Set 2 revealed no statistically significant difference in mean lab report scores between synopsis report writers and traditional report writers ($p = 0.443$, confidence interval = -0.274; 0.617). Analysis of Covariance revealed no significant effect for Group * ACT for Set 2 ($F(9,47) = 0.936$, $p = 0.513$). Since the Group * ACT interaction had no significant effect, it was removed from the model, which was reanalyzed using ACT as a covariate. It was then revealed that ACT scores had a significant positive relationship with the mean scores of lab reports 6-9 ($F(1,47) = 8.076$, $p = 0.007$). Regression analysis of the Set 2 data revealed that ACT scores had a positive relationship with students' Set 2 mean scores ($F(1,47) = 8.264$, $p = 0.006$, $B = 0.0859$). The 95% confidence interval of the regression analysis revealed that every one point of increase in ACT score resulted in an increase in Set 2 lab report scores between 0.026 and 0.146. This indicates that an Iowa State University industrial technology student with an ACT score of 29 could be expected to earn a Set 2 mean between 0.26 and 1.46 points higher than a student with an ACT score of 19. There is no clear explanation for why there is a significant relationship between ACT scores and Set 2 lab report scores, but not the Set 1 lab report scores; one possible explanation could be that Set 2 contained only four lab reports, whereas Set 1 contained five.

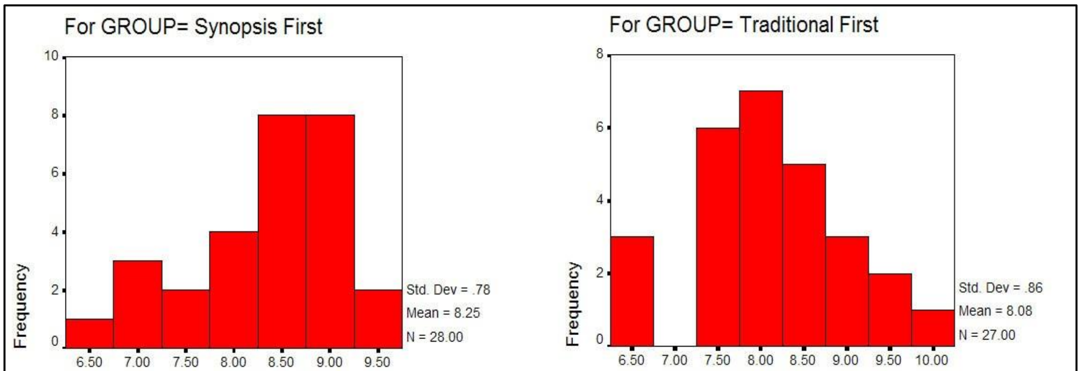

Figure 2. Histograms for Set 2 Lab Report Scores (in decimal score).

The paired-samples t-test analysis of the mean lab report scores grouped by lab report type (the main effect of treatment) revealed the synopsis lab report writers' mean score was 8.01 and the traditional lab report writers' mean score was 8.03. No statistically significant difference between treatments was discovered ($p = 0.843$, confidence interval = -0.252; 0.207). It is important to note that the confidence interval here is narrower than the smallest grading increment used by the instructor (1/2 point) – this strongly indicates that any actual differences in mean lab report scores between treatments is small enough to be considered unimportant. There was a statistically significant correlation (0.486, $p < 0.001$) between each student's mean synopsis report grade and mean traditional report grade,

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which indicates that the students' performances were similar in both treatments. Regression analyses of the lab report grades grouped by treatment revealed that ACT scores did not have a significant relationship with the mean scores of synopsis report writers ($F(1,47) = 3.415$, $p = 0.071$, confidence interval = -0.005; 0.121) or traditional report writers ($F(1,47) = 0.861$, $p = 0.358$, confidence interval = -0.039; 0.105).

When the Set 1 and Set 2 means from each student were averaged, it was revealed that the mean score of Group 1 (synopsis reports first) was 8.09 and the mean score of Group 2 (traditional reports first) was 7.94. The two-sample t-test revealed that the order in which the two styles of lab reports were written had no statistically significant effect on mean lab report scores ($p = 0.427$, confidence interval = -0.236; 0.548). The Analysis of Covariance of the averaged Set 1 and Set 2 scores revealed that the interaction effect Group * ACT was not significant ($F(9,47) = 0.675$, $p = 0.723$). Since the Group * ACT interaction had no significant effect, it was removed from the model, which was then reanalyzed using ACT as a covariate. It was then revealed that ACT scores did not have a significant relationship with order ($F(1,47) = 2.597$, $p = 0.114$).

When the difference (Set 1 minus Set 2) between each student's Set 1 and Set 2 means is analyzed, the mean difference score of Group 1 was -0.321% and the mean difference score of Group 2 was -0.286%. Analysis of the interaction effect treatment * order with the two-sample t-test revealed that the mean difference scores between groups were not significantly different ($p = 0.871$, confidence interval = -0.468; 0.398). The Analysis of Covariance of the difference of each student's Set 1 and Set 2 scores revealed that the interaction effect (Group * ACT) was not significant ($F(9,47) = 1.388$, $p = 0.248$). Since the Group * ACT interaction had no significant effect, it was removed from the model, which was then reanalyzed using ACT as a covariate. It was then revealed that ACT scores had a significant relationship with the students' changes in lab report scores from one set to the other ($F(1,47) = 6.778$, $p = 0.012$). Regression analysis revealed a significant negative slope ($F(1,47) = 7.517$, $p = 0.009$, $B = -0.081$), which indicates that higher ACT scores resulted in more consistent mean lab report scores. The 95% confidence interval revealed that the mean lab report scores of a student with an ACT score of 29 should be 0.22 to 1.41 points closer together than those of a student with an ACT score of 19.

Does the lab report format influence students' scores on the nine individual laboratory assignments?

This question was addressed by applying the two-sample t-test (without assuming equal variances) to the data of each of the nine individual lab reports. The units are 'score out of 10 points'. As a result of missing data and/or outliers (as identified via boxplot analyses), the initial sample size of 56 students (29 in Group 1 and 27 in Group 2) was reduced in each case to the sample sizes indicated in Table 2. Again, the removal of these outliers had negligible effects on the statistical analyses. A compilation of the results of the nine t-tests appears in Table 3.

Table 2

Sources of Reduction in Sample Size for the Nine Two-sample t-tests

	Group 1			Group 2			
Report	Missing Data	Outliers	Final n	Missing Data	Outliers	Final n	Total n
1			29		3	24	53
2		2	27			27	54
3		2	27			27	54
4		1	28			27	55
5			29	3		24	53
6	1	1	27			27	54
7	1		26	1		28	54
8	2		24	3		27	51
9		3	26	1		26	52

Note. Group 1 had an original sample size of 29 and Group 2 had an original sample size of 27.

Table 3

Outcomes of the Nine Two-sample t-tests (outliers removed)

	Synopsis		Traditional			
Report	n	Mean	n	Mean	df [a]	p [b]
1	**29**	**7.12**	**24**	**7.90**	**44.51**	**0.018**
2	27	8.46	27	8.13	45.34	0.226
3	27	7.7	27	7.69	40.37	0.959
4	**28**	**8.61**	**27**	**7.56**	**43.46**	**<0.001**
5	29	7.88	24	8.27	50.26	0.176
6	27	8.19	27	8.26	48.28	0.796
7	26	7.96	28	8.29	50.92	0.25
8	24	8.15	27	8.09	43.00	0.859
9	26	8.19	26	8.58	43.19	0.197

Note. [a]Equal variances are not assumed.
[b]Bolded rows indicate a significant difference.

The analysis of Lab 1 revealed a mean synopsis score of 7.12 and a mean traditional score of 7.90. The two-sample t-test analysis of the data set revealed a statistically significant difference between the mean synopsis report score and the mean traditional report score ($p = 0.018$, confidence interval = -1.41; -0.142), which is likely the result of unfamiliarity with the synopsis format – informal surveys revealed that the students in the sample had no exposure to the synopsis lab report format prior to their involvement in the study and there may have been confusion or trepidation regarding their first report. By the second attempt at writing a synopsis report, the students had received feedback from the instructor and had a better grasp of the expectations for the assignments. It is worthwhile to note that the 95% confidence interval discovered that the mean of synopsis reports could be worse than the mean of traditional reports by as much as 1.41 points or as little as 0.142 points.

The analysis of Lab 4 revealed a mean synopsis score of 8.61 and a mean traditional score of 7.56. The two-sample t-test analysis of the data set revealed a statistically significant difference between the mean synopsis report score and the mean traditional report score ($p < 0.001$, confidence interval = 0.525; 1.578), the source of which is unclear. The root cause may lie in the topic of the experiment, in the way the experiment handout was written, or perhaps there is truly something about Lab 4 that lent itself to the synopsis lab report format. It is worthwhile to point out that the 95% confidence interval revealed that the actual difference between Lab 4 group means could be as large as 1.578 points or as small as 0.525 points.

Summary and Conclusions

Together, the lab report mean score analyses strongly indicate (with 95% confidence) that in terms of lab report grades, the students in the sample who wrote their lab reports in the synopsis format learned the material just as well as those who wrote their lab reports in the traditional format. Therefore, one can assume that synopsis lab reports would have no negative impact on the learning of laboratory content (as measured by the scores of lab reports) for industrial technology students if implemented elsewhere in the curriculum. The ACT score covariance and regression analyses indicate that when comparing the two types of lab reports, students with higher composite ACT scores have no advantage over lower-scoring ACT examinees, but they could be expected to achieve consistently higher mean report scores.

Furthermore, the report type was found to have no impact on student learning (in terms of mean lab report scores) on the majority of individual lab assignments (7 of 9). In the first assignment, when students were most unfamiliar with the synopsis report format, there was a slight advantage to using the traditional format. In the other assignment where a difference was found, students performed better using the synopsis format.

Conclusions

Based on the results of this study, the following conclusions can be drawn:

- The statistical analyses of lab report grades revealed that the synopsis lab report format provided an equivalent learning experience in terms of mean lab assignment scores.
    - The type of report had no impact on mean lab report grades.
    - The order in which students wrote the two report types had no impact on lab report grades.
    - Composite ACT score covariance analysis indicated that neither report format favored students with ACT scores of a particular range; however, higher ACT scores were a good predictor of higher grades in the Iowa State University industrial technology program.
- The statistical analyses of individual lab report grades revealed that the type of lab report had no influence on student scores on seven out of nine individual lab assignments.

Hoffa and Freeman (2006) found that in a semester with 10 lab reports from each of 25 students, not only does the synopsis lab report format free up at least 5 ½ hours per student of out-of-class writing time for other assignments, but it also saves instructors at least 18 hours of grading time. Hoffa and Freeman (2007) also discovered that the synopsis lab report format provided an equivalent learning experience in terms of comprehensive exam scores. This study's findings – that the synopsis lab report format provided an equivalent learning experience in terms of lab report scores – provides additional evidence that the practical benefits of the synopsis lab report format are such that faculty teaching laboratory courses can consider adoption of the synopsis format without concern for their students' learning.

Recommendations for Future Studies

Repetition of this study with a larger sample size (to reduce the spread of the confidence intervals) is recommended to verify or refute the significance of these findings. It is also recommended that the study be repeated in other universities and in other content areas and curricula (e.g. engineering) with laboratory components, which will confirm or refute the effectiveness of the synopsis format in content areas other than Electrical Fundamentals. The cause(s) of the significant differences between groups for the scores of lab experiments 1 and 4 also needs to be investigated because the source(s) of the significant difference between group means for these two lab experiments is unknown.

Hypothetically, the synopsis format requires students to work at the synthesis level and the traditional format requires students to work at the application level. Further investigation into whether the synopsis lab report format actually encourages students to develop abilities at higher levels of Bloom's Taxonomy than the traditional format is needed. Since the relationship between student learning styles and student success on lab report format is unknown, additional studies need to investigate this relationship using tools such as the Kolb Learning Style Inventory (Kolb and Kolb, 2005). Finally, future studies need to investigate the effects of demographic factors such as age, student socio-economic status, first-generation/traditional, underclassman/upperclassman, gender, race, etc., on success with the synopsis format.

[1] The authors were first introduced to the synopsis lab report format in an educational setting by Dr. John R. Wright, Jr., former Technical Manager at TENERGY, L.L.C., and as an industrial manager and consultant, the lead author continues to recognize the emphasis placed on written communication in the workplace that is similar to the synopsis format.

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