Program: RIP-Based Inquiry and Statistics for Grades 6-12 Teachers at the University of Hawaii, Graduate Professional Development Seminar for Science Teachers 2002 Program evaluation submitted: 9-18-2002

The overall purposes of this graduate seminar were to review and strengthen the participants' understanding of and ability and confidence to use the research investigation process (RIP) used in scientific inquiry, and to introduce 6-12 grade teachers to research design, data handling and summary, and data analyses techniques and procedures as they are used in the RIP. Specifically, this three-day seminar was designed for teachers to explore the research investigation process; to use the inquiry process to learn how to design and conduct scientific research studies; to become familiar with techniques to assist in guiding students through the scientific inquiry process; understand and be able to obtain random samples; develop research investigations using independent and dependent designs; to learn how to represent and present data obtained from research investigations; to examine, practice, understand, and become competent in the ability to apply data analysis techniques, including the quantification of error and statistical tests for significance, to decision-making in science; and to increase confidence in using scientific research in their approach to instructing students in science and in addressing the scientific inquiry benchmarks and science inquiry content standards. The research investigation process (RIP) was reviewed and teachers were provided the opportunity to further develop their understanding of each of the elements of the RIP through their participation in and development of actual research investigations. Techniques in data summary, analysis and presentation were explored in the context of hypothesis testing and decision-making in science. Finally, numerous strategies for the teaching of science through true scientific inquiry were also emphasized. All aspects of this seminar were aligned with the State of Hawaii Science Content and Performance Standards.

The data for this graduate seminar evaluation were obtained from assessments of the 14 teacher-participants at the beginning of (Pre-Assessment) and again at the end (Post-Assessment) of the 3-day seminar. Items on the assessments required demonstration of knowledge and understanding about the scientific inquiry process, data analyses procedures, and decision-making in science. A number of these items required participants to demonstrate their knowledge and understanding through application. Self-report items measured teacher confidence levels in understanding and using data summary, representation, and analysis techniques in scientific inquiry conducted in the classroom, and in comprehending and applying the scientific inquiry content standards to their instruction. A concept inventory determined teachers' familiarity with and ability to teach elements of scientific inquiry, research design, and data summary and statistical analysis techniques. The pre-seminar and post-seminar assessment items were the same except for three additional self-report items included on the post-assessment. These additional items assessed the teachers' perceptions of how much their understanding of the research investigation process and scientific inquiry process improved, and understanding of application of statistics to data increased, as a result of participation in the seminar. The data were statistically analyzed using dependent *t*-tests to determine significant differences (indicating change) between pre- and post-assessment mean values. For comparisons in which the assumption of normality was violated, the

Wilcoxon Signed Rank Test (nonparametric *t*-test) was used to compare central tendencies. The Pearson Product Moment Correlation Coefficient was used to test for linear relationships. The criterion for statistical significance (α) was set at 0.05.

Scientific Inquiry, Scientific Research, and the Research Investigation Process (RIP)

This seminar focused on review and strengthening of teacher understanding, abilities, and confidence related to instruction of science through scientific inquiry, conducting scientific research, and engaging their students in scientific research. Although it was generally expected that teacher-participants would be familiar with these aspects of scientific inquiry, a pre-seminar phone survey of the participants' perceived knowledge and abilities indicated that it would be important to address the RIP before examining research design and analysis strategies and procedures. Specific emphases were placed on teacher demonstration of understanding the logic of organization of the RIP elements, as well as the components and concepts involved in each element.

Although participant self-reported familiarity with/understanding of the RIP appeared to slightly increase from its pre-seminar level by the end of the three-day seminar (Figure 1, below), the difference was not statistically significant. However, the power of the *t*-test was low and so the negative statistical finding should be interpreted cautiously (see Figure 1 caption for more details).

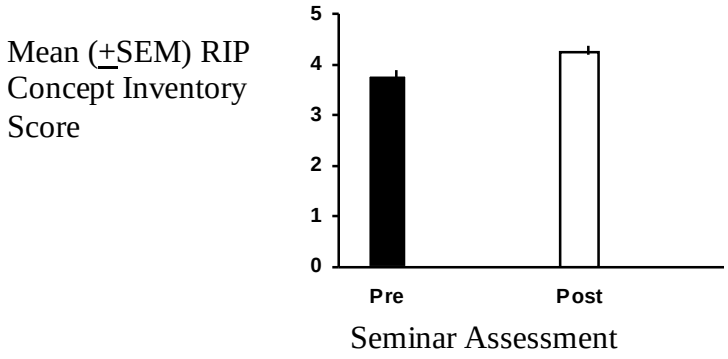

Figure 1. Familiarity with and understanding of concepts related to methodology in the RIP.

Mean post-assessment value did not differ from the mean pre-assessment value [t (13) = -1.99, p=0.068]. Note: Because the power of the performed statistical test (0.345) was below the desired power of 0.800, the results should be interpreted cautiously.

At first glance, the lack of a significant change in self-reported familiarity/understanding of the RIP concept appears surprising because participant-demonstrated knowledge and understanding, and self-reported confidence (discussed below) increased consistently for all of the RIP assessment items. However, both the pre- and post-assessment concept inventory mean values were relatively high and indicated that the participants felt that they were already very familiar with and had a good understanding of (could teach the concept to others) the RIP before participating in the seminar.

Post-seminar teacher-participant demonstrated knowledge and understanding of the RIP components and their contents (Figure 2, below) and of the organization of the RIP elements (Figure 3, below) significantly increased compared to pre-seminar levels.

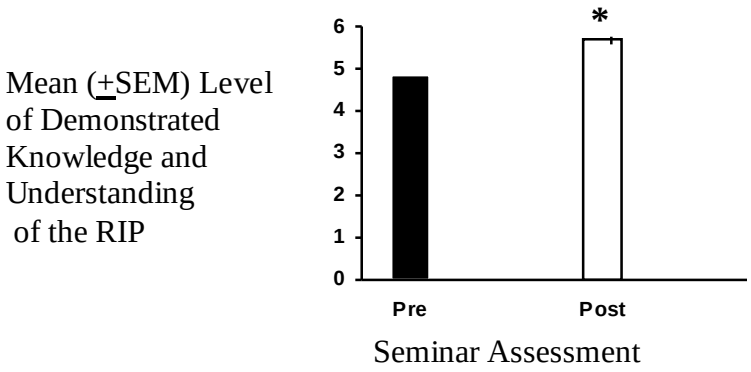

Figure 2. Knowledge and understanding of the research investigation process (RIP) components and content. (Highest possible value for knowledge and understanding was six.)

*****Mean post-assessment value differs from the mean pre-assessment value [*t* (13) = -3.29, p=0.006].

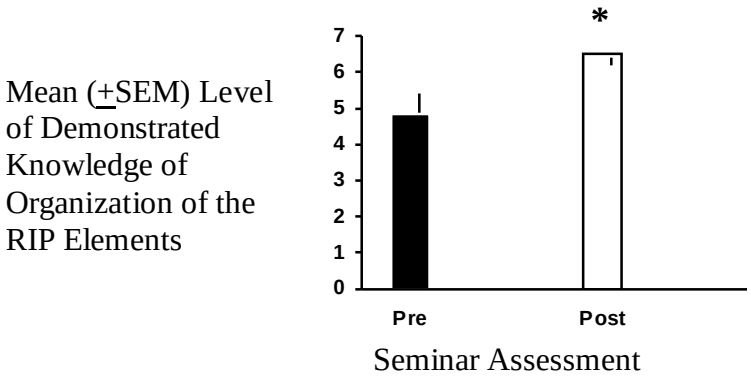

Figure 3. Knowledge and understanding of the organization of the elements of the research investigation process (RIP). (Highest possible level of knowledge was seven.)

*****Mean post-assessment value differs from the mean pre-assessment value [*t* (13) = -2.49, p=0.027].

By the end of the three-day seminar compared to pre-seminar levels, participants' self-reported confidence levels for both ability to use scientific inquiry in their instruction and their ability to teach and engage students in scientific research activities increased from "confident" to midway between "confident" and "very confident." Although these increases were only slight to moderate, they were both statistically significant (Figures 4 and 5, below).

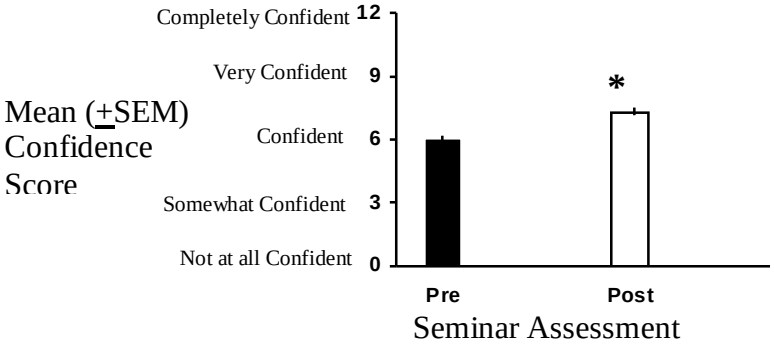

Figure 4. Self-reported confidence levels for ability to use scientific inquiry in instruction.

***** Mean post-assessment value is significantly greater than mean pre-assessment value [*t* (13) = -2.60, p=0.022].

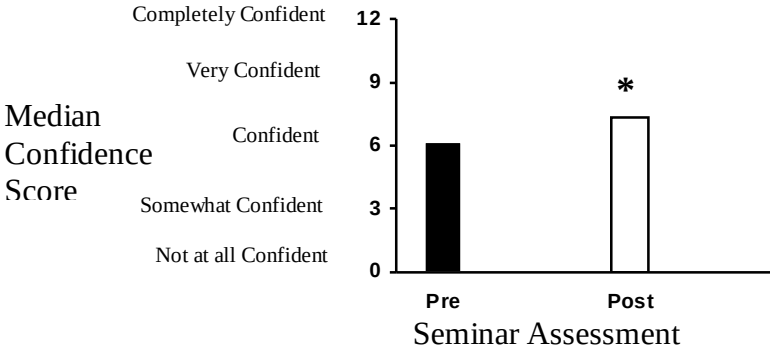

Figure 5. Self-reported confidence levels for ability to teach and engage students in scientific research activities.

***** Mean post-assessment value is significantly greater than mean pre-assessment value [*W* (N=14) = -54.0, p=0.034].

Design and Analysis

The seminar participants exhibited increases in their knowledge and understanding as well as in their confidence related to the elements involved in designing research investigations so that they can be analyzed using the appropriate statistical tests. By the end of the 3-day seminar, participants demonstrated a statistically significant increase in their knowledge and understanding of research designs, statistical concepts including, but not limited to, random sampling, error (variability), and statistical tests (Figure 6, below).

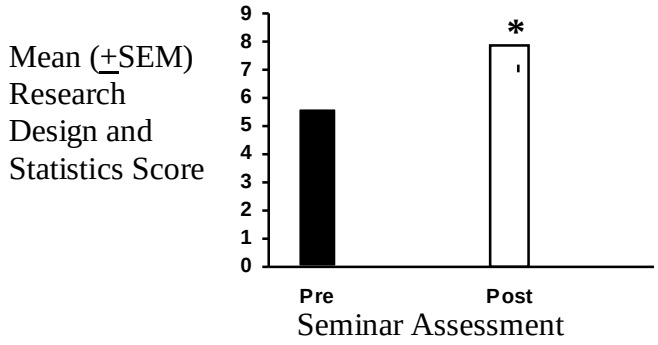

Figure 6. Demonstration of knowledge and understanding of research design and statistical concepts. (Scores were based on the number of items correct out of 10.)

***** Mean post-assessment value is significantly greater than mean pre-assessment value [*t* (13) = -4.70, p<0.001].

The post-seminar increase in teacher-participant knowledge and understanding of the research process was accompanied by a significant increase in teacher' self-reported familiarity and understanding of concepts related to research design and methodology (Figure 7, below) and data analysis including descriptive and inferential statistics (Figure 8, below).

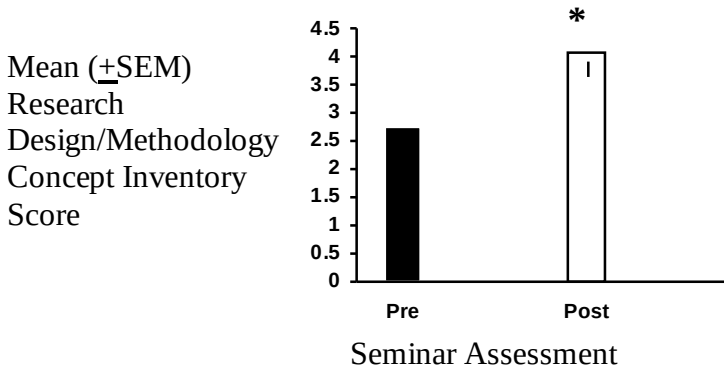

Figure 7. Familiarity with and understanding of concepts related to research design and methodology.

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = 6.38, $p<0.001$].

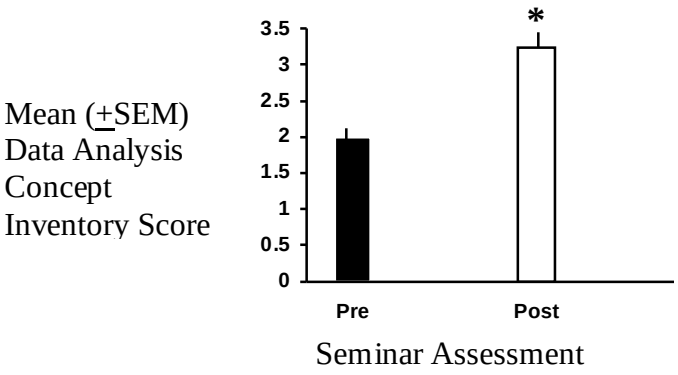

Figure 8. Familiarity with and understanding of concepts related to data analysis, including descriptive and inferential statistics.

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = -5.57, $p<0.001$].

By the end of the seminar, the average participant' response to the concept of research design and methodology rose from between "somewhat familiar, but do not really understanding what it means" and "familiarity with fair understanding of the concept" to "very familiar with concept and could teach it to others." Likewise, the average participant' response to the concept of data analysis rose from "somewhat familiar, but do not really understanding what it means" to between "familiarity with fair understanding of the concept" and "very familiar with concept and could teach it to others." These findings indicated that teachers recognized their increased knowledge and understanding related to research design and statistical concepts.

With the increase in knowledge and understanding, the teacher-participants also demonstrated an increase in self-reported confidence in their understanding of the application of basic statistics to analyze research data (Figure 9, below).

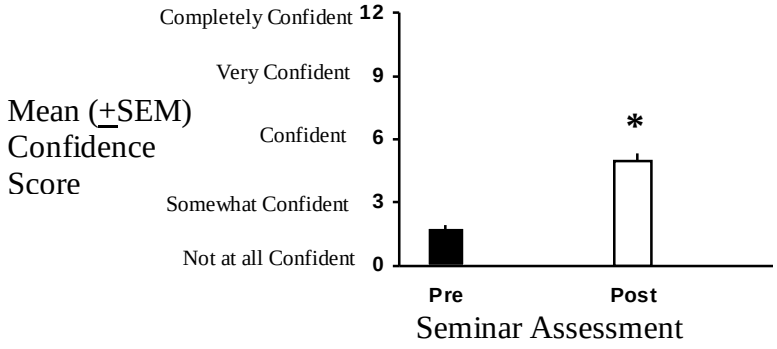

Figure 9. Self-reported confidence levels for understanding of the application of basic statistics to analyze research data.

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = 6.07, $p<0.001$].

By the end of the three-day seminar, the mean participant confidence score more than doubled, significantly rising from between "not at all confident" and "somewhat confident" to near "confident."

Teacher Understanding of and Ability to Apply Data Summary, Presentation, and Analysis techniques to Decision-Making in Science

By the end of the three-day workshop, seminar participants demonstrated a significant 33% increase in their ability to determine the appropriate statistic for describing the center of a group of data (Figure 10, below).

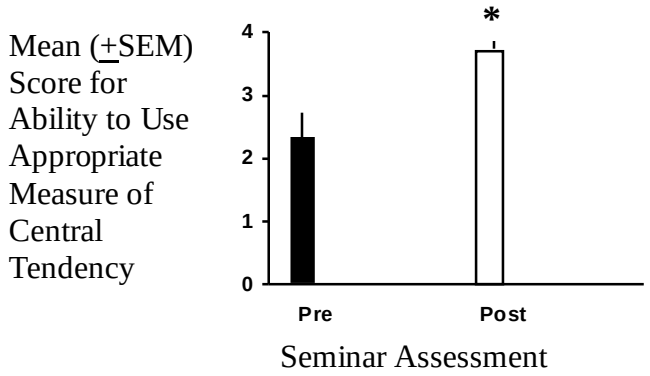

Figure 10. Demonstration of the ability to determine the appropriate measure of central tendency for a group of data. (Highest possible ability score was four.)

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = 2.79, p=0.015].

In addition to gains in understanding of the application of descriptive statistics, participants also demonstrated a post-seminar increase in knowledge of the procedures used to calculate the three measures of central tendency (Figure 11, below).

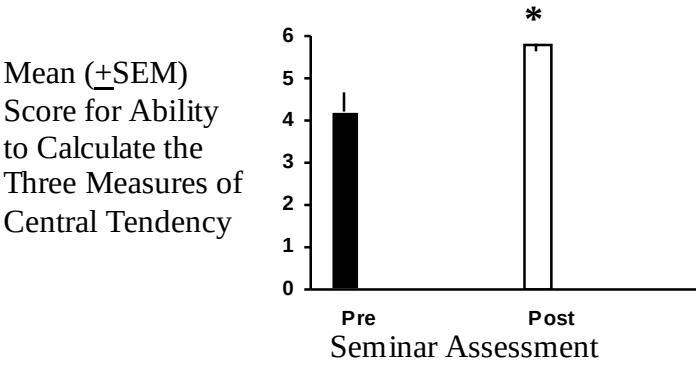

Figure 11. Demonstration of the ability to calculate the three measures of central tendency. (Highest possible ability score was six.)

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = 3.16, p=0.008].

The seminar participants' self-reported familiarity with, and understanding of the concepts of, the three measures of central tendency also significantly increased by the end of the three-day seminar (Figure 12, below). This increase coincided with the demonstrated increases in understanding and ability to calculate the measures of central tendency (both discussed above), indicating that the participants were able to accurately perceive and report their relative knowledge of and ability to summarizing groups of data.

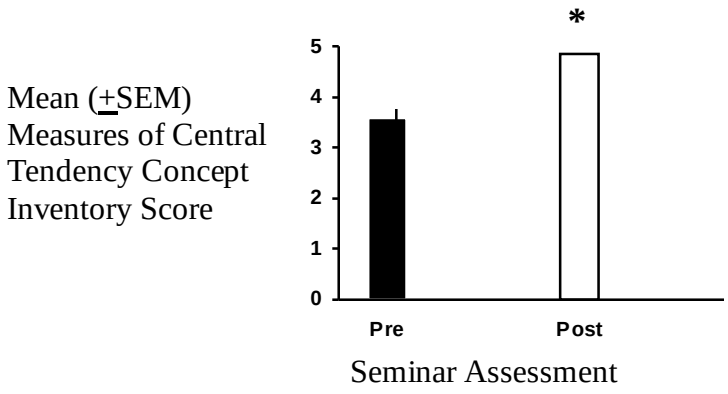

Figure 12. Familiarity with and understanding of concepts related to the three measures of central tendency.

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = 3.60, p=0.003].

Figure 13 (below) presents a scatterplot showing the pre- to post-seminar change in participants' familiarity/understanding of the concept of measures of central tendency plotted as a function of change in demonstrated participant knowledge of descriptive statistics. Pearson Product Moment Correlation Coefficient revealed a significant moderate positive relationship between these two variables (Figure 13).

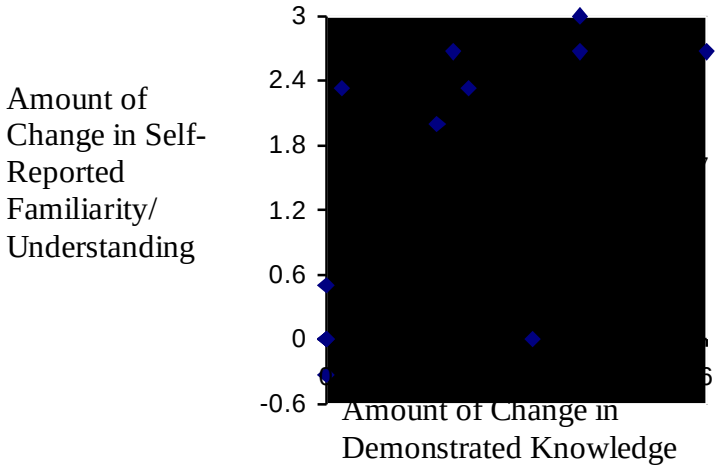

Figure 13. Scatterplot of pre- to post-seminar change in familiarity/understanding as a function of change in demonstrated knowledge of measures of central tendency.

By the end of the three-day seminar, participant-reported familiarity/understanding to the concept of error variance (standard deviation) steeply increased compared to the pre-seminar value (Figure 14, below). Before taking the seminar, the teacher-participants reported that the concept "standard deviation" was between "somewhat familiar" and "familiar," but have less than "a fair understanding of what it means." After participating in the seminar, teachers reported that they were "very familiar with this concept, but would have some difficulty teaching it to others."

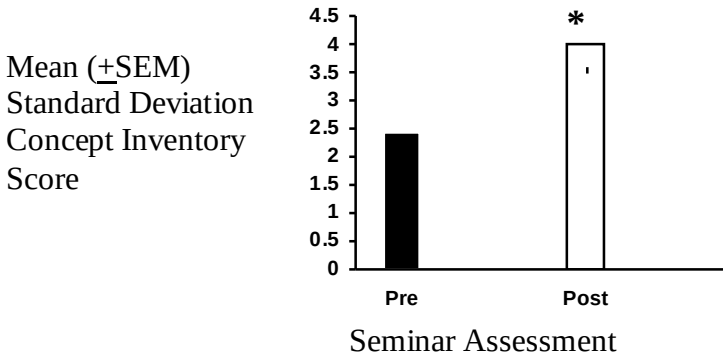

Figure 14. Familiarity with and understanding of the concept of standard deviation.

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = -7.78, $p<0.001$].

The participants confidence in their understanding of how to use statistics to describe the center and dispersion (variability) of a group of data also substantially increased from less than "somewhat confident" to slightly greater than "confident" by the end of the seminar (Figure 15, below).

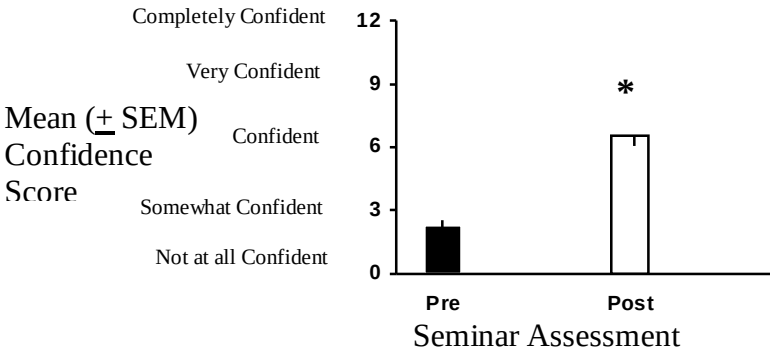

Figure 15. Self-reported confidence levels for ability to use statistics to describe the center of and variability for a group of data.

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = -4.52, $p<0.001$].

Seminar participants exhibited a statistically significant increase in their ability to correctly identify the purpose of, and accurately interpret data presented in graphs displaying central tendencies for two groups (Figure 16, below) and scatterplots (Figure 17, below).

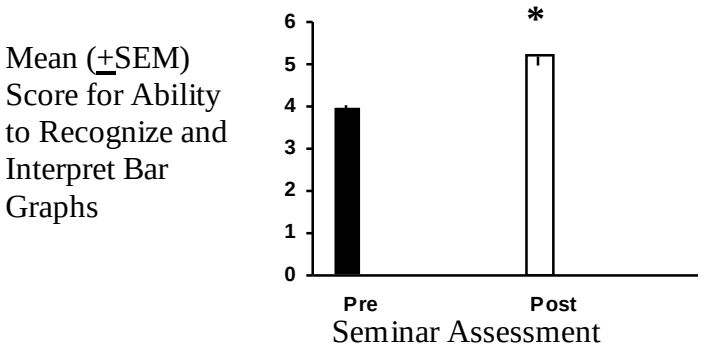

Figure 16. Demonstration of the ability to correctly recognize the purpose and accurately interpret data presented in graphs displaying the central tendencies of two groups. (Highest possible ability score was five.)

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = -2.81, $p=0.015$].

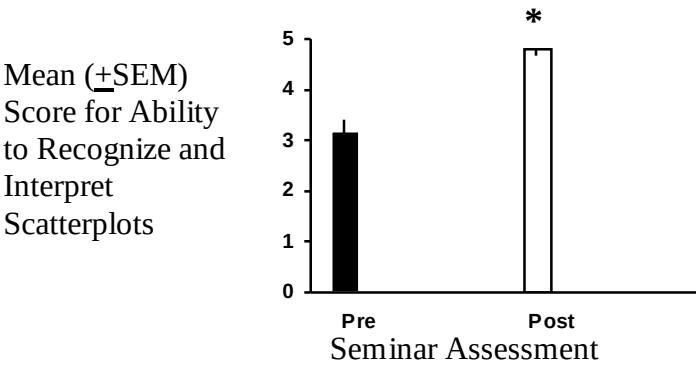

Figure 17. Demonstration of the ability to correctly recognize the purpose and accurately interpret data presented in scatterplots. (Highest possible ability score was five.)

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = -3.83, p=0.002].

Increases in the ability of participants to construct graphs for displaying of data and comparison of central tendencies also significantly increased by the end of the seminar (Figure 18, below).

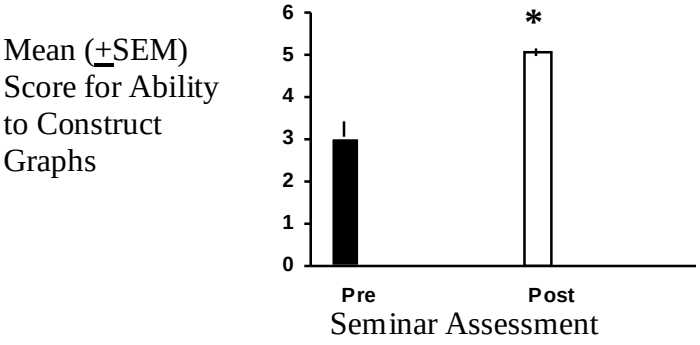

Figure 18. Demonstration of the ability to construct graphs for display of data and the comparison of central tendencies. (Highest possible ability score was five.)

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = -3.52, p=0.004].

Consistent with demonstrated increases in abilities to summarize data, identify, accurately interpret, and correctly construct tables and graphs, significant increases in participant self-reports of familiarity and understanding for concepts related to representations of data, including tables and graphs, were exhibited at the end of the three-day seminar (Figure 19). At the start of the seminar, teachers reported being "familiar with these concepts, with a fair understanding of what they mean." By the end of the seminar, the teachers reported being "very familiar with these concepts, but would have some difficulty teaching them to others."

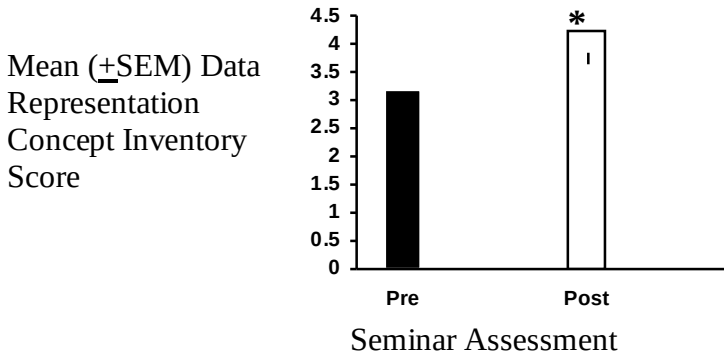

Figure 19. Familiarity with and understanding of concepts related to representing data in tables and graphs.

***** Mean post-assessment value is significantly greater than mean pre-assessment value [t (13) = -4.97, $p<0.001$].

Hawaii State Science Content Standards

Teacher confidence in ability to address science content standards relating to collecting, organizing, displaying and analyzing data in their classroom was also affected by the end of the seminar. Self-reported confidence in ability to address content standards in the classroom rose significantly from between "confident" and "somewhat confident" to above "confident" by the end of the seminar (Figure 20, below).

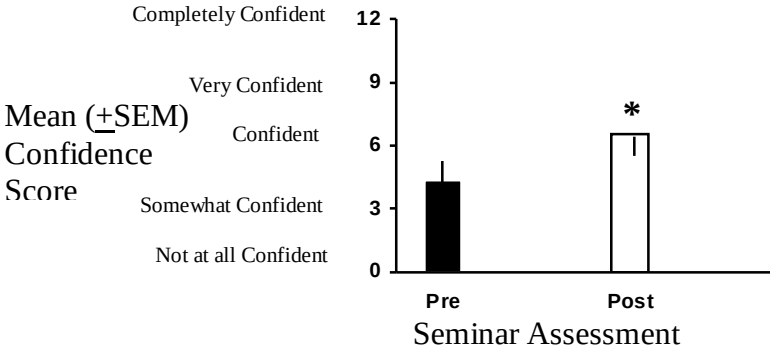

Figure 20. Self-reported confidence levels for ability to address data summary and analysis science content standards in the classroom.

* Mean post-assessment score is significantly greater than mean pre-assessment score [t (13) = -3.45, p=0.004].

Teacher Perceptions of Impact from their Participation in this Graduate Seminar

The post-assessment contained three additional self-report items designed to assess how much teacher-participants believed their understanding about the scientific inquiry process, data analysis, and the science inquiry standards improved as a direct consequence of their participation in the seminar. The results from these items are presented in Figures 21-23 below.

An overwhelming majority of the seminar-participants (10 of 14) claimed that their understanding of the research investigation process improved a large amount to completely as a result of their participation in this seminar, while three participants claimed it changed a moderate to a large amount (Figure 21, below). One teacher reported that his understanding improved slightly less than a moderate amount.

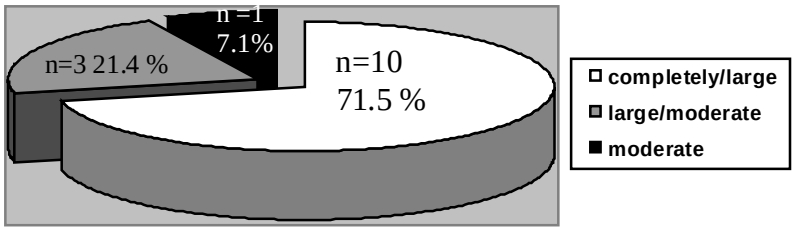

Figure 21. Pie chart representing teacher-participants' responses to "what extent, if any, did your understanding of the research investigation process improve as a result of your participation in this graduate seminar?" The scale for responses included none, a small amount, a moderate amount, a large amount, and completely.

A majority of the seminar-participants (9 of 14) claimed that their understanding of the application of statistics to analyze data obtained in a research investigation improved a large amount to completely as a result of their participation in the 3-day seminar (Figure 22, below). Four of the participants claimed it improved a moderate to a large amount as a result of their participation. One teacher reported only a small to moderate improvement on this item.

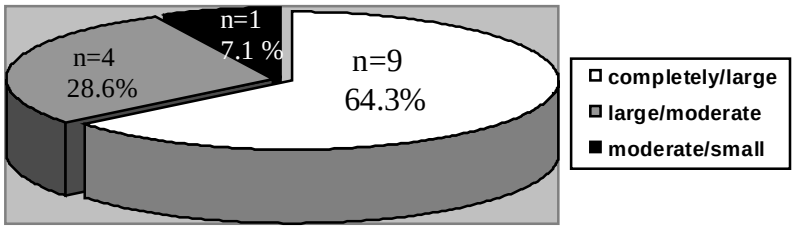

Figure 22. Pie chart representing teacher-participants' responses to "what extent, if any, did your understanding of the application of statistics for understanding the data obtained from a scientific research investigation increase as a result of your participation in this graduate seminar?" The scale for responses included none, a small amount, a moderate amount, a large amount, and completely.

Fifty percent of the seminar-participants (7 of 14) claimed that their understanding of the science inquiry standards improved a large amount to completely as a result of their participation in this seminar, five (about 36%) claimed it improved a moderate to a large amount, and two reported that it improved a small to moderate amount (Figure 23, below).

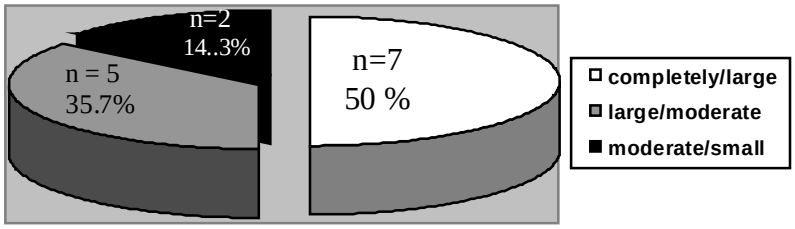

Figure 23. Pie chart representing teacher-participants' responses to "what extent, if any, did your understanding of the scientific inquiry standards improve as a result of your participation in this graduate seminar?" The scale for responses included none, a small amount, a moderate amount, a large amount, and completely.