**Scientific Inquiry through Critical Thinking Using the Research Investigation Process (RIP): Year 2004-2005 Implementation**

**Manoa Elementary School**

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**ANOVA Science Education Consulting**
**October 12, 2005**

This professional development program was designed to provide teachers at Manoa Elementary School with the opportunity to broaden their understanding and knowledge of how to engage students in true scientific inquiry through the Research Investigation Process (*RIP*). The RIP provides a framework in which integration of specific standards contribute to the authentic practices of critical thinking engaged by scientists in learning about the world. It addresses primarily the content standard of science and supporting standards of mathematics and language arts (reading, writing, and oral communication). This was the first year of the planned three-year implementation period and focused on teachers of grades 3-5. Although their grade levels were not targeted for this implementation year, one first and one second grade teacher also decided to participate.

The main goal for implementation of the RIP at Manoa Elementary School is to introduce K-5 teachers to the teaching of science through true scientific inquiry. Specifically, it is 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; to examine, practice, understand, and become competent in the ability to apply data analysis techniques to decision-making in science; and to increase confidence in using scientific inquiry in their approach to instructing students in science and in addressing the scientific inquiry benchmarks and science inquiry content standards; and to increase student interest in learning science.

The Research Investigation Process (RIP) was introduced to the targeted grade level teachers and they were provided the opportunity to further develop their understanding of each of the elements of the RIP through participation in bi-weekly two-hour training seminars during which specific activities supporting the components of scientific inquiry and critical thinking were introduced. Teachers also participated in a group development of an actual research investigation. Teachers were guided through a number of activities related to making observations; posing research questions; obtaining, examining, and evaluating background information; constructing hypotheses; and designing the methods for a research investigation. Techniques in data summary, analysis and presentation were explored in the context of hypothesis testing and decision-making in science. Teachers were then expected to introduce workshop-related concepts and activities learned into their classroom and guide their students in conducting their first guided RIP inquiry over the subsequent remainder of the academic year. During the seven-month implementation period, individual teacher-small group conference sessions were available to the participating teachers upon request. The individual teacher-small group sessions involved modeling of instructional techniques and practices with students, assisting teachers on curriculum development, and/or clarifying concepts presented in the initial two-day workshop-seminar session and the bi-weekly training seminars. Finally the participants implemented their own guided RIP inquiry with their students. All aspects of this program are aligned with the State of Hawaii Science Content and Performance Standards-III, the National

Science Education Standards (NSES), and promoted the achievement of the *NSES More Emphasis* conditions believed to be necessary to meet standards.

The data for evaluation were obtained from assessments of 11 teacher-participants at the beginning of (Pre-Assessment, n=11), following (Post-Assessment, n=10) a two-day intensive introductory workshop-seminar designed to inform teachers about how and why to teach through scientific inquiry, and at the end of the first year's implementation period implementation (Post-Implementation Assessment, n=7). Questionnaires were also administered along with the Post-Implementation Assessment (Post-Implementation Questionnaire). Items on the assessments required demonstration of knowledge about the scientific inquiry process, data analyses procedures, and decision-making in science. A number of these items required teachers to demonstrate their knowledge through application. Self-report items measured teacher confidence levels in understanding and using scientific inquiry in the classroom and in comprehending and applying the scientific inquiry content standards to their instruction. The response scale for the confidence items included "not at all confident" ('0'-value), "somewhat confident" ('3'-value), "confident" ('6'-value), "very confident" ('9'-value), and "completely confident" ('9'-value). A concept inventory determined teachers' familiarity with and ability to teach elements of scientific inquiry and data summary and analysis techniques. The answer scale for the concept inventory items included "I am completely unfamiliar with this concept" (value=1), "I am somewhat familiar with this concept, but do not really understand what it means" (value = 2), "I am familiar with this concept , and have a fair understanding of what it means" (value = 3), "I am very familiar with this concept, but would have some difficulty teaching it to others" (value = 4), and "I am completely familiar with this concept and could easily teach it to others" (value = 5). The pre- and post-workshop-seminar and the post-program implementation assessment items were the same except for five additional self-report items included on the Post-Assessment and Post-Implementation assessment. These additional items assessed the teachers' perceptions of how much their understanding of scientific inquiry changed and improved as a result of participation in the program. Finally, the Post-Implementation Questionnaire contained a number items related to the impact of the program on teacher implementation in the classroom and on the students.

One-way repeated measures ANOVAs were used to determine significant differences (indicating change) in means for the responses on items from the Pre-Assessment, Post-Assessment, and Post-Implementation Assessment. Following a significant effect, Tukey's Tests were used for multiple comparisons. Paired *t*-tests were used to determine significant differences (indicating change) between Post-Assessment and Post-Implementation Assessment mean values for the five additional items not on the Pre-Assessment. The criterion for statistical significance ($\alpha$) for all tests was set at 0.05.

Note that the ANOVAs were analyzed with missing data and that the sample sizes were small in general. Because the power of the statistical analyses was extremely low, negative findings especially where the means appear to differ, should be interpreted cautiously.

**Teacher Knowledge and Understanding of Scientific Inquiry, the Research Investigation Process (RIP), and Confidence in Teaching Scientific Inquiry**

Workshop participants demonstrated a large, statistically significant increase in their knowledge and understanding of the individual elements of the RIP at the end of the 2-day introductory workshop-seminar (Figure 1, below). This included the logical order of the RIP elements, understanding of components involved in each element, and demonstration of the ability to construct testable hypotheses. Although not statistically significant, compared with to the Post-Assessment, there was a further 2- point gain following the implementation period. Thus, the actual implementation had only a minor impact on furthering teacher understanding of scientific inquiry and the RIP.

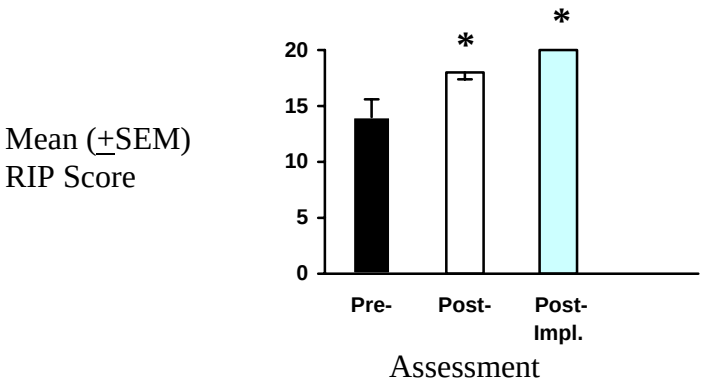


Figure 1. Demonstration of knowledge and understanding of the elements of the RIP on the Pre-Assessment, Post-Assessment and Post-Implementation Assessment.

There were a total of 25 points available on this portion of the assessment. Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15)=12.30, $p$<0.001].

***** indicates mean is significantly greater than mean Pre-Assessment mean

The post-workshop-seminar and post program implementation 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 the scientific research process in the concepts inventory (Figure 2, below). The average participant' response rose from below "familiar with a fair understanding of the concept" to "very familiar with the concept with some difficulty in teaching it to others" by the end of the implementation period. This showed that teachers recognized their increased knowledge and understanding.

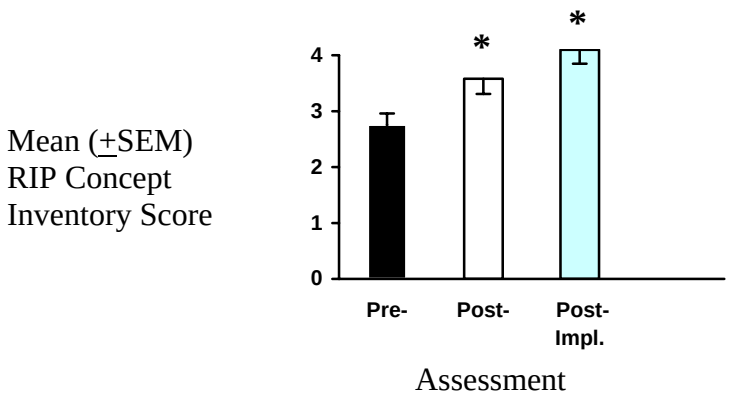


Figure 2. Familiarity and understanding of concepts related to elements of the RIP. The answer scale for the concept inventory items included "I am completely unfamiliar with this concept" (value=1), "I am somewhat familiar with this concept, but do not really understand what it means" (value = 2), "I am familiar with this concept, and have a fair understanding of what it means" (value = 3), "I am very familiar with this concept, but would have some difficulty teaching it to others" (value = 4), and "I am completely familiar with this concept and could easily teach it to others" (value = 5).

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15)=8.52, $p$<0.003].

***** indicates mean is significantly greater than mean Pre-Assessment mean

The extended training sessions and implementation of the RIP into the classroom resulted in statistically-significant impact on teacher confidence levels regarding scientific inquiry. By the end of implementation, participating teachers' self-reported confidence levels for their ability to use scientific inquiry, their ability to teach and engage students in scientific research activities, and their understanding of teaching science through inquiry appeared to increase, although the change for the latter item was not statistically significant (see Figures 3, 4 and 5, respectively). from less than "confident" to "confident" or higher.

Regarding their ability to actually use scientific inquiry as an instructional tool in the classroom (Figure 3), the teachers' confidence increased significantly from "somewhat confident" before implementation to "confident" by the end of the implementation period. However, the apparent higher mean confidence level by the end of the initial two-day workshop-seminar was not different from the pre-workshop-seminar mean.

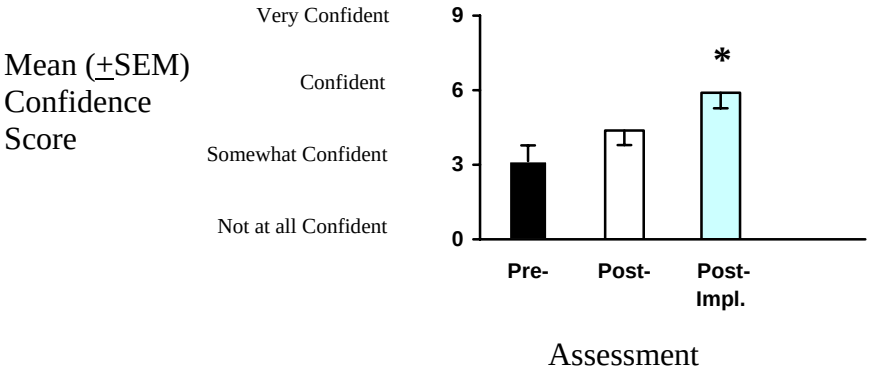


Figure 3. Self-reported confidence levels for ability to use scientific inquiry. The response scale for the confidence items included "not at all confident" ('0'-value), "somewhat confident" ('3'-value), "confident" ('6'-value), "very confident" ('9'-value).

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15)=5.13, $p$<0.03].

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By the end of the implementation, the teachers' felt indicated that their confidence in the ability to teach and engage students in scientific research activities had increased compared to pre-implementation levels (Figure 4). Similar to the previous question and consistent with the trend for them to demonstrate significantly increased knowledge about scientific inquiry and the RIP (Figure 1), again teachers showed a *significant increase* at the end of implementation, but not after the 2-day workshop-seminar initial sessions.

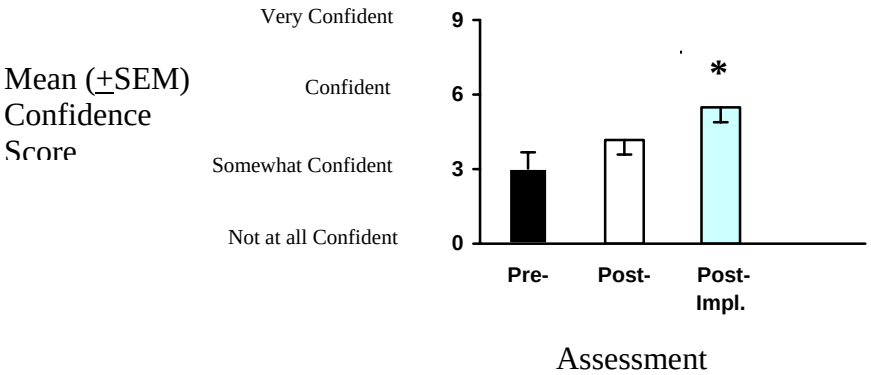


Figure 4. Self-reported confidence levels for ability to teach and engage students in scientific research activities. The response scale for the confidence items included "not at all

confident" ('0'-value), "somewhat confident" ('3'-value), "confident" ('6'-value), and "very confident" ('9'-value).

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15)=4.32, $p$=0.03].

***** indicates mean is significantly greater than mean Pre-Assessment mean

Self-reported teacher confidence levels for understanding instruction of science through inquiry also appeared to increase following participation in the program, especially following the implementation period (Figure 5). However, probably due to the small sample sizes and resulting low power of the statistical test, the apparent changes were not statistically significant.

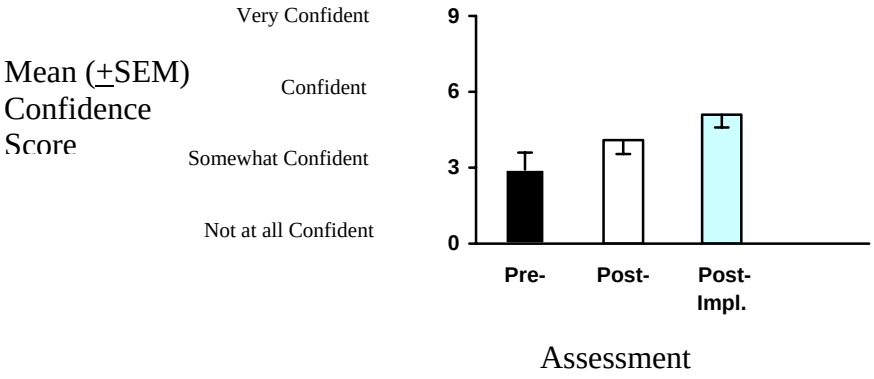


Figure 5. Self-reported confidence levels for understanding of teaching science through inquiry. The response scale for the confidence items included "not at all confident" ('0'-value), "somewhat confident" ('3'-value), "confident" ('6'-value), and "very confident" ('9'-value).

Statistical comparison of the three means did not indicate a statistically-significant difference [$F$ (2,15)=2.23, $p$>0.05].

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

In general, there was no clear effect of the program on teacher ability to organize data into tables and construct graphs. By the end of the workshop, participants demonstrated only a slight, overall statistically significant, change in their knowledge and ability to correctly organize data into a summary table and to construct a bar graph for comparing the central tendency for two groups of data (Figure 6, below). However, Tukey's multiple comparisons failed to indicate any significant mean differences. This again was due to the small size of the change in means together with the small sample sizes and low power of the statistical test.

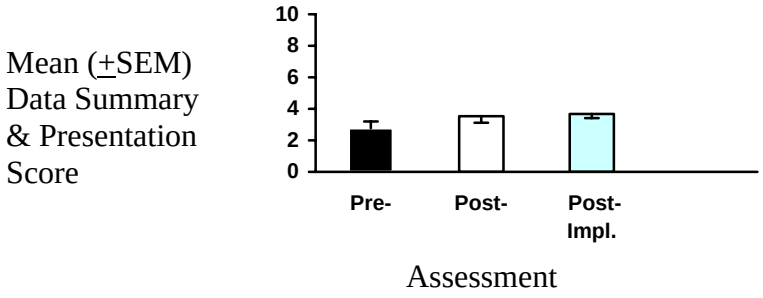


Figure 6. Demonstration of understanding and ability to apply data organization and presentation techniques to data. This section was worth a total of 10 points.

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15)=3.81, $p$<0.05]. However, no mean differences were found with Tukey's test.

In contrast to the lack of influence of program participation on data presentation skills of teachers, participants demonstrated a dramatic change in their knowledge and ability to apply data analysis techniques to research data. Comparison of the assessments revealed that by the they significantly increased their understanding of how to calculate descriptive statistics and their ability to determine which measure of central tendency is most appropriate for a group of data (Figures 7 and 8, below).

The teachers significantly increased their mean data analysis score by the end of the two-day initial workshop-seminar sessions and doubled the value of their Pre-Assessment score by the end of implementation of the program (Figure 7).

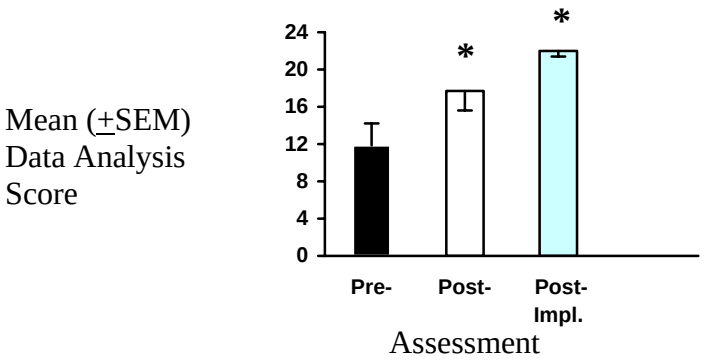


Figure 7. Demonstration of understanding of the calculations for descriptive statistics. This section was worth a total of 24 points.

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15) = 8.66, $p$=0.003].

***** indicates mean is significantly greater than mean Pre-Assessment mean

Although there was no significant difference between the pre- and post initial workshop-seminar assessments for teacher ability to determine the appropriate measure of central tendency to use for a group of data, teachers dramatically increased this ability by the end of the implementation period (Figure 8). Thus, it appears that the implementation of the RIP program had a profound affect on the teachers' data analysis capabilities.

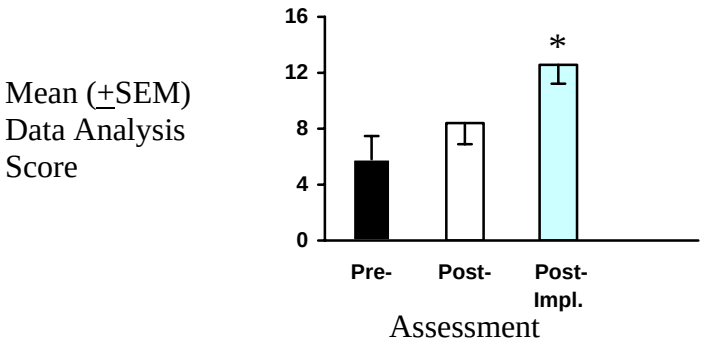


Figure 8. Demonstration of ability to determine the most appropriate statistic to represent central tendency for a group of data. This section was worth a total of 16 points.

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15) = 5.11, $p$<0.02].

***** indicates mean is significantly greater than mean Pre-Assessment mean

Participants demonstrated a statistically significant increase in their ability to interpret data presented in scatterplots and summarized in bar graphs, almost doubling their performance by the end of the program implementation (Figure 9, below). The mean post-implementation score, however, was only at about 66% of the total possible. Again, similar to their data analysis ability results, the teachers' post initial workshop-seminar assessment did not significantly differ from the Pre-Assessment.

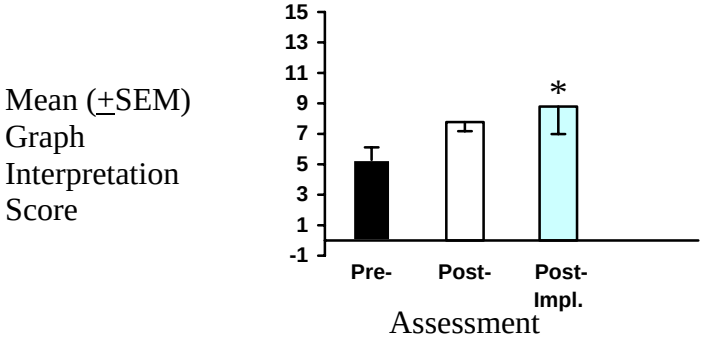


Figure 9. Demonstration of ability to interpret scatterplots and bar graphs. This section was worth a total of 15 points.

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15) = 4.48, $p$<0.03].

***** indicates mean is significantly greater than mean Pre-Assessment mean

Although the participants demonstrated increased knowledge of and ability to apply data presentation and analyses following implementation of the program, their self-perceptions did not always agree as they did not report a corresponding change in their self-reported familiarity and understanding of concepts related to data analysis in the concepts inventory (Figure 10).

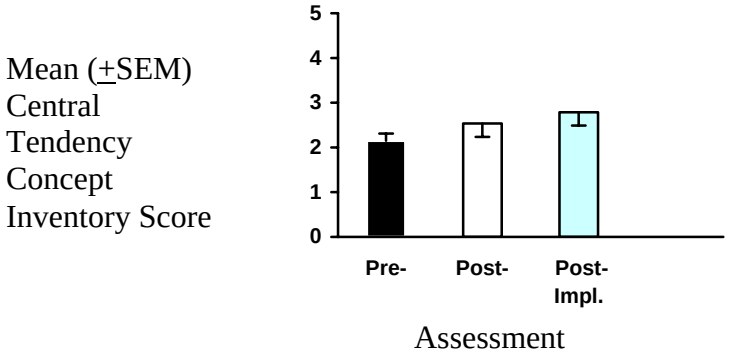


Figure 10. Familiarity and understanding of concepts related to measuring central tendency. The answer scale for the concept inventory items included "I am completely unfamiliar with this concept" (value=1), "I am somewhat familiar with this concept, but do not really understand what it means" (value = 2), "I am familiar with this concept, and have a fair understanding of what it means" (value = 3), "I am very familiar with this concept, but would have some difficulty teaching it to others" (value = 4), and "I am completely familiar with this concept and could easily teach it to others" (value = 5).

Statistical comparison of the three means did not indicate a statistically-significant difference [$F$ (2,15)=1.53, $p$>0.05].

However, by the end of the workshop, the average participant' response for organizing data using tables and graphs rose significantly from between "somewhat familiar with concept, but do not really understand what it means" and "I am familiar with this concept, and have a fair understanding of what it means" to between "I very familiar with this concept but would have some difficulty teaching it to others" and "I am completely familiar with this concept and could easily teach it to others (Figure 11).

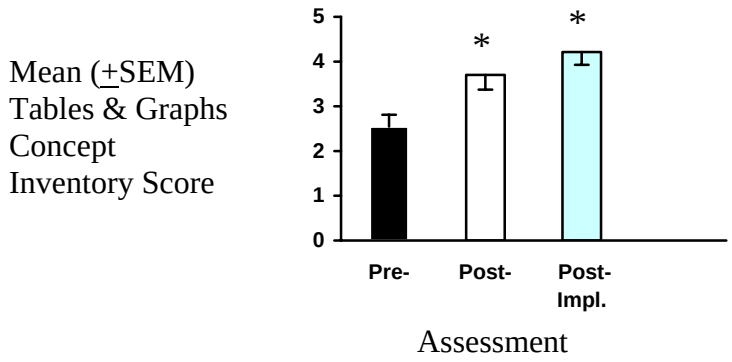


Figure 11. Familiarity and understanding of concepts related to tables and graphs. The answer scale for the concept inventory items included "I am completely unfamiliar with this concept" (value=1), "I am somewhat familiar with this concept, but do not really understand what it means" (value = 2), "I am familiar with this concept, and have a fair understanding of what it means" (value = 3), "I am very familiar with this concept, but would have some difficulty teaching it to others" (value = 4), and "I am completely familiar with this concept and could easily teach it to others" (value = 5).

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15)=13.01, $p$<0.001].

***** indicates mean is significantly greater than mean Pre-Assessment mean

**Benchmarks and Standards**

General teacher confidence in and awareness of ability to understand and apply scientific inquiry to the teaching of science, and in ability to successfully address the scientific inquiry standards, was enhanced by their participation in the RIP program. Participant self-reported confidence in ability to address content standards in the classroom rose significantly from less than "somewhat confident" to above "confident" by the end of the workshop (Figure 12, below). Although mean self-reported confidence appeared to increase from exposure to the introductory two-day workshop-seminar, this value did not significantly differ from the pre-workshop-seminar value.

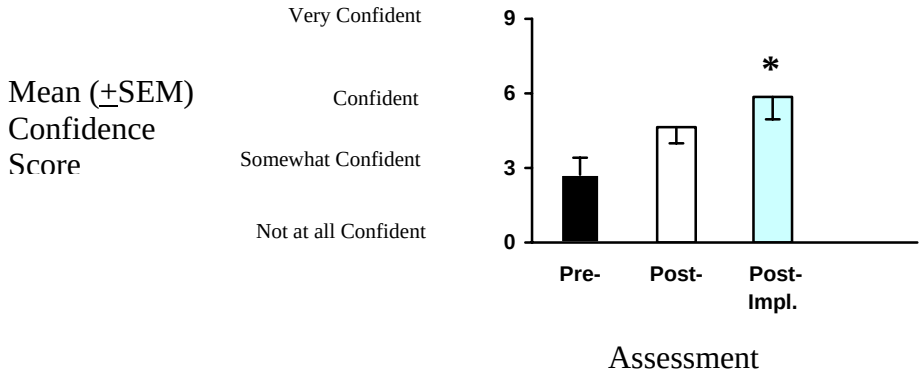


Figure 12. Self-reported confidence levels for ability to address content standards in the classroom. The response scale for the confidence items included "not at all confident" ('0'-value), "somewhat confident" ('3'-value), "confident" ('6'-value), and "very confident" ('9'-value).

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15)=4.61, $p$<0.03].

***** indicates mean is significantly greater than mean Pre-Assessment mean

Similarly, by the end of the implementation of the program, participant confidence about ability to accurately and completely address the scientific inquiry benchmarks and performance indicators increased from below "somewhat confident" to about "confident" (Figure 13, below).

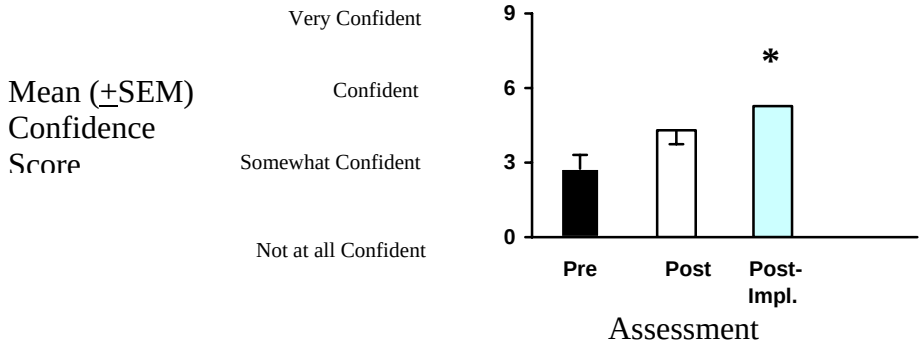


Figure 13. Self-reported confidence levels for ability to accurately and completely address the scientific inquiry benchmarks and performance indicators. The response scale for the confidence items included "not at all confident" ('0'-value), "somewhat confident" ('3'-value), "confident" ('6'-value), and "very confident" ('9'-value).

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15)=6.03, $p$<0.02].

* indicates mean is significantly greater than mean Pre-Assessment mean

Finally, by the end of the2-day introductory workshop-seminar and at the end of the program implementation, teachers significantly increased their self-reported familiarity and understanding of inquiry standards from between being "completely unfamiliar with this concept" and "somewhat familiar with this concept, but not really understanding what it means" to being between "familiar with this concept, with "a fair understanding of what it means" and "very familiar" with this concept, but "would have some difficulty teaching it to others." This increase was statistically significant and was consistent with the increase in teacher-participant confidence regarding scientific inquiry and addressing the inquiry standards (Figure 13, below).

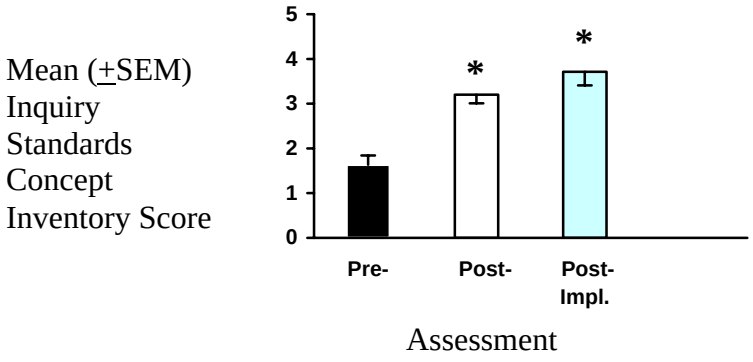


Figure 14. Familiarity and understanding of concept of inquiry standards. The answer scale for the concept inventory items included "I am completely unfamiliar with this concept" (value=1), "I am somewhat familiar with this concept, but do not really understand what it means" (value = 2), "I am familiar with this concept, and have a fair understanding of what it means" (value = 3), "I am very familiar with this concept, but would have some difficulty teaching it to others" (value = 4), and "I am completely familiar with this concept and could easily teach it to others" (value = 5).

Statistical comparison of the three means indicated a statistically-significant difference [$F$ (2,15)=44.35, $p$<0.001].

* indicates mean is significantly greater than mean Pre-Assessment mean

**Teacher Perceptions of Impact of their Participation in the RIP Program on Changes in Knowledge and Abilities**

The Post-Assessment and Post-Implementation Assessment contained five self-report items designed to assess how much teacher-participants believed their knowledge and abilities regarding the scientific research investigation process and scientific inquiry were impacted by their participation in this program. The results from these items are presented in Figures 15-20, below.

Five of the six participants who responded to this item claimed that their understanding of the scientific inquiry process was *changed* a "moderate amount", while one of the participants claimed that it was changed "a large amount", after the initial 2-day workshop. By the end of the program implementation, 50% of the participants reported that their understanding was "changed "a large amount". There was no difference in self-reported understanding between the two assessments (Figure 15).

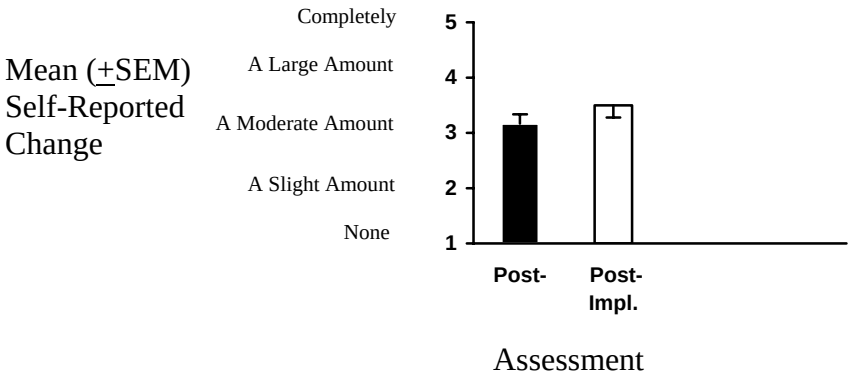


Figure 15. Teacher-participants' responses to the question, "To what extent, if any, did your understanding of scientific inquiry change as a result of your participation in this professional development program?"

No difference was found between the means [$t(5)=-1.58$, $p>0.05$]. Only N=6 teachers answered this questionnaire on both of the assessments.

Eighty-three percent (5 of 6) of the teachers claimed that their understanding of the scientific inquiry process *improved* a "moderate amount" as a result of their participation in the RIP professional development program following the two-day initial workshop-seminar session. At the end of the program implementation, half of the teachers attributed "a large amount" of improvement in their understanding of scientific inquiry to their participation in the RIP professional development program (Figure 16). There was no difference in self-reported improvement in understanding between the two assessments (Figure 16).

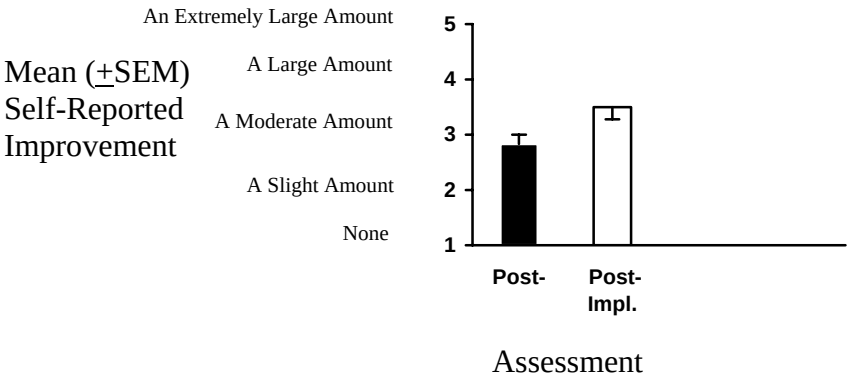


Figure 16. Teacher-participants' responses to the question, "To what extent, if any, did your understanding of scientific inquiry *improve* as a result of your participation in this professional development program?"

No difference was found between the means [$t(5)=-2.00$, $p>0.05$]. Only N=6 teachers answered this questionnaire on both of the assessments.

Similar to the previous item, eighty-three percent (5 of 6) of the teachers claimed that their understanding of the science inquiry standards and performance indicators *changed* a "moderate amount" as a result of their participation in the RIP professional development program following the two-day initial workshop-seminar session. And again, by the end of the program implementation, one-half of the teachers reported that their understanding of the standards had changed "a large amount" as a result of their participation in the program. (Figure 17). Although the reported change in understanding appeared to increase by the end of the implementation period, there was no significant difference in self-reported change in understanding between the two assessments (Figure 17).

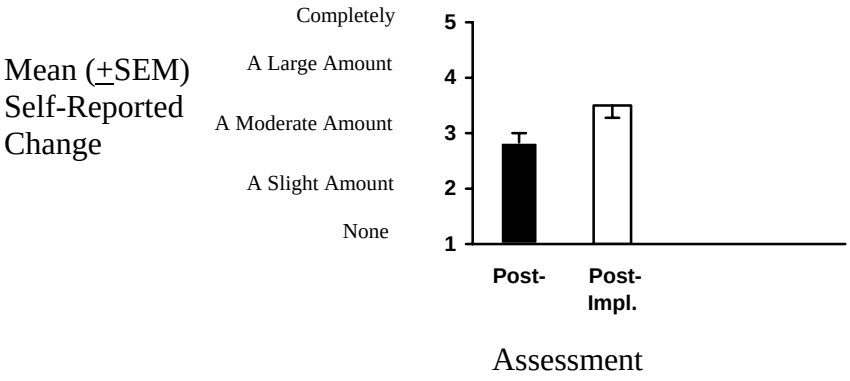


Figure 17. Teacher-participants' responses to the question, "To what extent, if any, did your understanding of the scientific inquiry standards and performance indicators change as a result of your participation in this professional development program?"

No difference was found between the means [$t(5)=-2.00$, $p>0.05$]. Only N=6 teachers answered this questionnaire on both of the assessments.

One-half (3 of 6) of the teachers claimed that their understanding of the scientific inquiry standards and performance indicators *improved* a "large amount, two a "moderate amount," and one a "slight amount" as a result of their participation in the RIP professional development program following the two-day initial workshop-seminar session. At the end of the program implementation, half of the teachers attributed "a large amount" and half a "moderate amount' of improvement in their understanding of scientific inquiry to their participation in the RIP professional development program (Figure 18). Again, there was no difference in self-reported improvement in understanding between the two assessments (Figure 18).

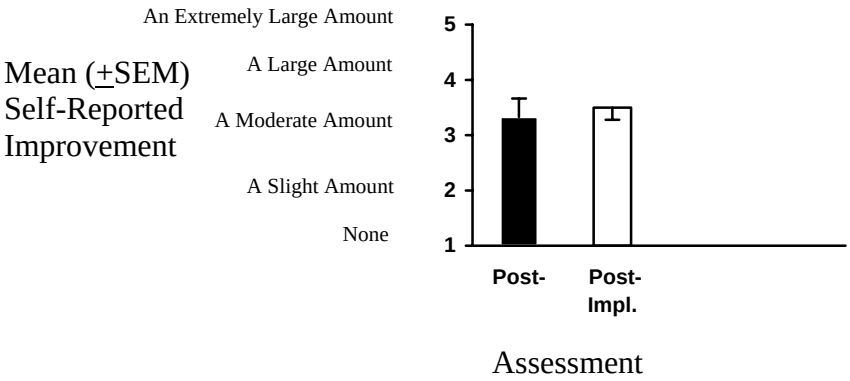


Figure 18. Teacher-participants' responses to the question, "To what extent, if any, did your understanding of the scientific inquiry standards and performance indicators *improve* as a result of your participation in this professional development program?"

No difference was found between the means [$t(5)$=0-.35, $p$>0.05]. Only N=6 teachers answered this questionnaire on both of the assessments.

Five of six teachers (83%) claimed their interpretation of inquiry-based instruction *changed* a "moderate amount" as a result of their participation in the RIP professional development program following the two-day initial workshop-seminar session. At the end of the program implementation, two-thirds of the teachers reported that their understanding of the standards had changed "a large amount" as a result of their participation in the program (Figure 19). The teacher reported change in interpretation of inquiry-based instruction by the end of the implementation period was significantly greater compared to after the two-day initial workshop-seminar session (Figure 19).

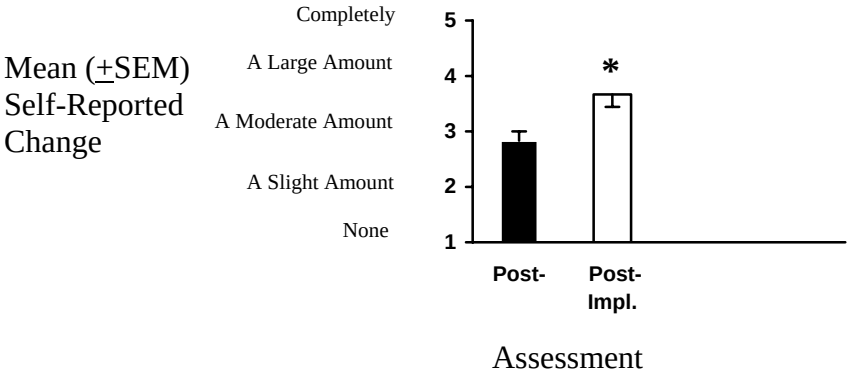


Figure 19. Teacher-participants' responses to the question, "To what extent, if any, did your interpretation of inquiry-based instruction change as a result of your participation in this professional development program?"

A statistically significant difference was found between the means [$t(5)$=-2.71, $p$<0.05]. Only N=6 teachers answered this questionnaire on both of the assessments.

* indicates mean is significantly greater than mean Post-Assessment mean

**Teacher Perceptions of Impact of Participation in the RIP Scientific Inquiry Program on Students in the Classroom**

Following the first year of implementation, the participating teachers completed a brief questionnaire designed to gather information on their perceptions of impact on their using scientific inquiry as an instructional tool in the classroom as well as their perception of the impact of learning through inquiry on their students' interest in learning science.

All of the teachers have increased their use of scientific inquiry as an instructional tool in the classroom. Six of the 7 teachers who responded to the questionnaire claimed that their use of scientific inquiry in the classroom "increased" since participating in the inquiry program and the remaining teacher felt that hers "greatly increased" (Figure 20).

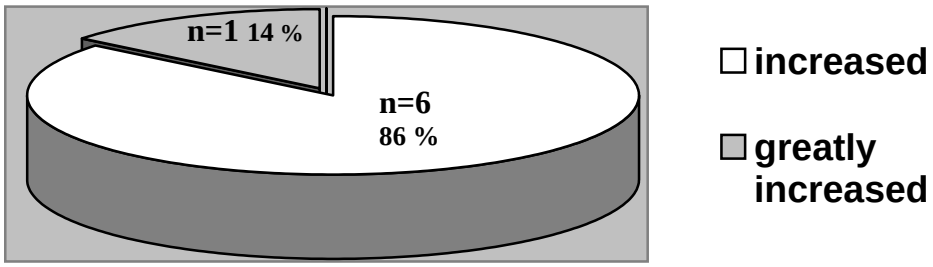


Figure 20. Pie chart representing 7 teacher-participants' responses to completion of, "Since participating in this inquiry program, my use of scientific inquiry (RIP) in the classroom has _____." The scale for responses included "greatly decreased," "decreased," "remained unchanged," "increased," "and "greatly increased."

The majority of the workshop-participants (6 of 7 or 86%) stated that learning science through inquiry has increased their students' interest in learning science (Figure 21). One teacher felt that her students' interest in learning science had not changed.

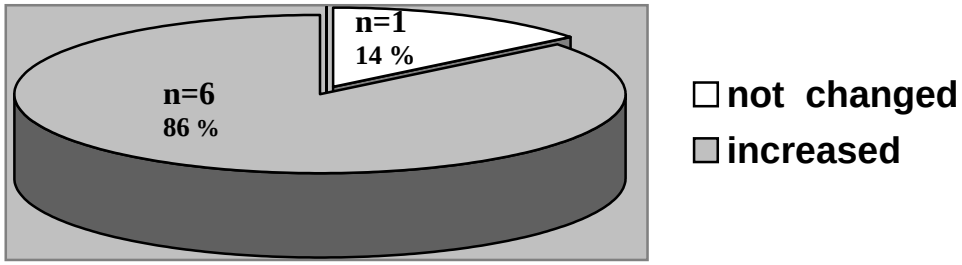


Figure 21. Pie chart representing 7 teacher-participants' responses to completion of, "Engaging my students in learning science through inquiry has _____ their interest in learning science." The scale for responses included "greatly decreased," "decreased," "not changed," "increased," "and "greatly increased."

Six of the teachers agreed, and one slightly agreed, that their involvement in this inquiry professional development program increased their ability to engage their students in standards-based science learning through scientific inquiry (Figure 22).

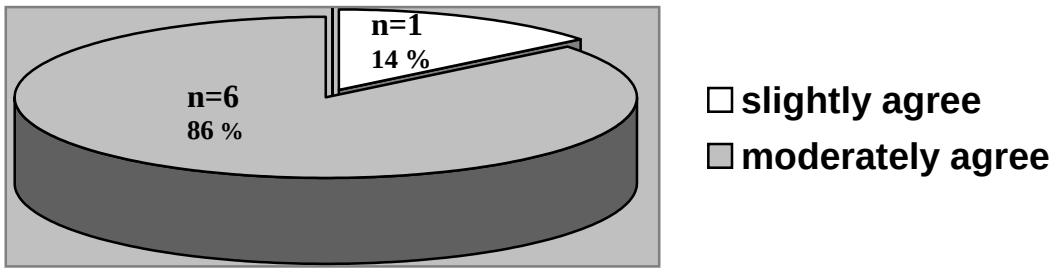


Figure 22. Pie chart representing 7 teacher-participants' agreement with the statement, "My involvement in this inquiry professional development program has increased my ability to engage my students in standards-based science learning through scientific inquiry." The scale for responses included "strongly disagree," "moderately disagree," "slightly disagree," "neutral," " "slightly agree," "moderately agree," and "strongly agree."

Finally, all but one of the participating teachers stated that their involvement in the professional development program increased their ability to develop a standards-based unit incorporating RIP scientific inquiry (Figure 23).

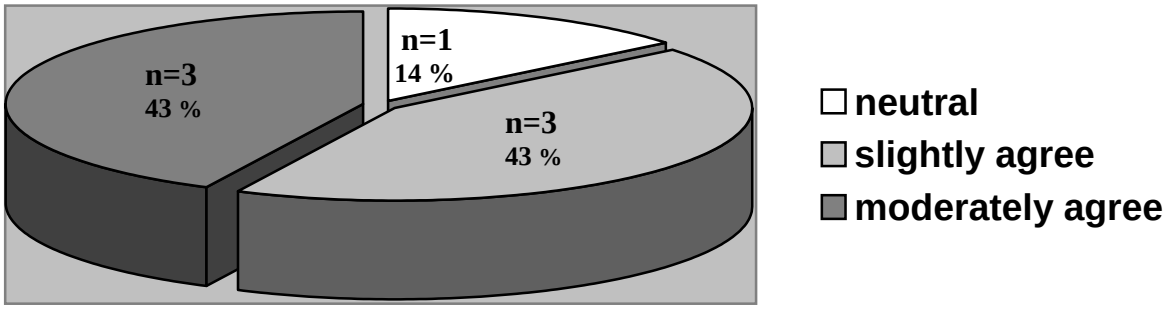


Figure 23. Pie chart representing 7 teacher-participants' agreement with the statement, "My involvement in this inquiry professional development program has increased my ability to engage my students in standards-based science learning through scientific inquiry." The scale for responses included "strongly disagree," "moderately disagree," "slightly disagree," "neutral," " "slightly agree," "moderately agree," and "strongly agree."

## Summary and Conclusions

Overall, the first year of RIP scientific inquiry at Manoa Elementary School was successful as it met the goals for which it was implemented. K-5 teachers were introduced to the teaching of science through true scientific inquiry. Teachers explored the research investigation process; used the inquiry process to learn how to design and conduct scientific research studies themselves and with their students; they learned activities and techniques to assist in guiding their students through the scientific inquiry process; they learned data analysis techniques for making decisions in science that are appropriate for elementary students; they felt increased confidence in using scientific inquiry in their approach to instructing students in science and in addressing the scientific inquiry benchmarks and science inquiry content standards; and they used scientific inquiry in the classroom as a tool to increase student interest in learning science.