V. Evidence for RIP Program Impact on Teachers and Students and the Achievement of the *More Emphasis* Conditions

The indicators for success of the RIP Program meeting more emphasis conditions at HLCS are comprised primarily of on-going evaluation in the form of formative assessments and student, teacher, and parent questionnaires, but also include evidence of exemplar student products up to the current point of implementation. The indicators for success at AAST include student products (publications, research talks) and their accolades, post-high school education opportunities, and follow-up student, teacher, and parent questionnaires to examine the long-term impact of the program on student participants.

HLCS-Nature of the Evidence

The impact of the RIP Program on science education at HLCS was evaluated over the period Fall 2002 through 2003. Success indicators include results from teacher and student pre- and post-RIP implementation assessment comparisons; student, teacher, and parent questionnaire responses; and "authentic" assessment of student performance and products in the form of Ho`ike ("to show or "display") presentation assessment/evaluation by a diversified community audience composed of parents, students, teachers, elders, community leaders, and scientists (Table 2).

Table 2. HLCS Assessment Summary and Analyses

Item #	Type	Scale	Descriptive Statistics (mean ± SEM; range)	Statistical Test Results
	Student Post-RIP Questionnaire			
1	enjoyment of learning through the RIP	4 point: none (1) to very much (4)	N=30: 2.25 ± .11; 3	
2	RIP as a help for learning	4 point: none (1) to very much (4)	N=30: 2.63 ± .10; 3	
3	current academic progress versus one-year ago (pre-RIP)	4 point: none (1) to very much (4)	N=30: 3.13 ± .10; 3	
	Parent Questionnaire: opinions comparing current (post-RIP) to one year prior (pre-RIP)			
4	students' confidence in communication	7 point: much less (1) to much more (7)	N=24: 6.33 ± .15; 2	
5	students' interest towards academics	7 point: much less (1) to much more (7)	N=24: 6.40 ± .16; 2	
6	students' responsibility towards completing assignments	7 point: much less (1) to much more (7)	N=24: 6.15 ± .22; 4	
7	interest in attending school	7 point: much less (1) to much more (7)	N=24: 6.54 ± .17; 3	
8	improvement in handling responsibility at home	7 point: much less (1) to much more (7)	N=24: 5.85 ± .24; 4	
9	academic progress	7 point: much less (1) to much more (7)	N=24: 6.56 ± .16; 3	
	Student Pre and Post-RIP Training Assessments			
10	knowledge & understanding scientific inquiry process	Total = 20 points	9.58 ± .75 (pre), 15.48 ± .59 (post)	$t(30) = -9.70$, $p < 0.001$
11	scientific inquiry concepts score	5 point: none (1) to complete (5)	2.43 ± .23 (pre), 3.04 ± .23 (post)	$t(26)^* = -3.80$, $p < 0.001$
12	confidence: understanding scientific inquiry	9 cm, 4 anchor: not at all (0) to completely (9)	4.09 ± .43 (pre), 5.38 ± .36 (post)	$t(30) = -3.55$, $p = 0.001$
13	confidence: conduct scientific inquiries	9 cm, 4 anchor: not at all (0) to completely (9)	4.30 ± .42 (pre), 5.64 ± .36 (post)	$t(30) = -3.11$, $p = 0.004$
14	confidence: learning science through inquiry	9 cm, 4 anchor: not at all (0) to completely (9)	4.25 ± .41 (pre), 5.47 ± .33 (post)	$t(30) = -3.19$, $p = 0.003$
15	data organization & presentation skills	Total = 10 points	1.48 ± .39 (pre), 2.52 ± .52 (post)	$t(30) = -2.96$, $p = 0.006$
16	application of mathematics to science	Total = 10 points	1.34 ± .37 (pre), 4.02 ± .60 (post)	$t(30) = -5.44$, $p < 0.001$
17	central tendency concept score	5 point: none (1) to complete (5)	2.24 ± .20 (pre), 3.14 ± .25 (post)	$t(26)^* = -4.38$, $p < 0.001$
18	probability & statistics concept score	5 point: none (1) to complete (5)	1.44 ± .18 (pre), 2.69 ± .22 (post)	$t(26)^* = -5.02$, $p < 0.001$
19	confidence: ability to learn science	9 cm, 4 anchor: not at all (0) to completely (9)	4.91 ± .39 (pre), 5.87 ± .36 (post)	$t(30) = -2.19$, $p < 0.04$
20	RIP produces more learning than traditional lab	3 choice: 1=no, 2=unsure, 3=yes	N=29: 1=3%, 2=21%, 3=76%	no pre-assessment
21	predict that RIP will help as general learning tool	3 choice: 1=no, 2=unsure, 3=yes	N=29: 1=3%, 2=28%, 3=69%	no pre-assessment
22	enjoys learning science through the RIP	3 choice: 1=no, 2=unsure, 3=yes	N=29: 1=10%, 2=24%, 3=66%	no pre-assessment

*4 students did not complete the concept inventory

Table 2 (continued). HLCS Assessment Summary and Analyses

Item #	Type	Scale	Descriptive Statistics (mean ± SEM; range)	Statistical Test Results
	Teacher Pre- versus Post-RIP Training Assessments			
23	knowledge & understanding scientific inquiry process	Total = 20 points	9.50 ± .61 (pre), 13.67 ± .45 (post)	t (11)=-6.66, p <0.001
24	scientific inquiry concepts score	5 point: none (1) to complete (5)	3.62 ± .25 (pre), 4.25 ± .28 (post)	t (11)=-3.12, p <0.01
25	confidence: conduct scientific inquiries	12 cm, 5 anchor: not at all (0) to completely (12)	4.99 ± .88 (pre), 7.87 ± .99 (post)	t (11)=-5.16, p <0.001
26	confidence: understanding of teaching science through inquiry	12 cm, 5 anchor: not at all (0) to completely (12)	4.86 ± .93 (pre), 6.79 ± 1.07 (post)	t (11)=-2.55, p <0.03
27	confidence: ability to teach & engage students in scientific inquiry activities	12 cm, 5 anchor: not at all (0) to completely (12)	4.37 ± .71 (pre), 6.58 ± 1.01 (post)	t (11)=-3.68, p =0.004
28	understanding and application of data organization & presentation techniques	Total = 10 points	1.33 ± .50 (pre), 3.42 ± .55 (post)	t (11)=-3.61, p =0.004
29	understanding calculations and when to use the measures of central tendency	Total = 15 points	2.04 ± 1.35 (pre), 12.17 ± 1.17 (post)	t (11)=-6.54, p =0.001
30	central tendency concept score	5 point: none (1) to complete (5)	2.39 ± .38 (pre), 4.50 ± .22 (post)	t (11)=-6.47, p =0.001
31	impact of RIP professional development on understanding scientific inquiry	12 cm, 5 anchor: none (0) to completely (12)	9.12 ± .86; 8.8	
	Teacher RIP Impact Questionnaire (2004)			
32	stimulates student interest to learn science	5 point: not at all (1) to extremely-great (5)	N=5: 4.60 ± .24; 1	
33	enables understanding & responding to student interests, strengths, experiences & needs	5 point: not at all (1) to extremely-great (5)	N=5: 4.80 ± .20; 1	
34	provide opportunities for student scientific discussion & debate	5 point: not at all (1) to extremely-great (5)	N=5: 4.60 ± .24; 1	
35	positively influence students' development of effective communication skills	5 point: not at all (1) to exceptionally-large (5)	N=5: 4.60 ± .24; 1	
36	positive change in student attitudes toward science	5 point: not at all (1) to extremely-great (5)	N=5: 4.60 ± .24; 1	
37	RIP impact on student ability to make good decisions	5 point: not at all (1) to exceptionally-high (5)	N=5: 4.40 ± .24; 1	
38	RIP impact on student ability to critically evaluate data	5 point: not at all (1) to extremely-great (5)	N=5: 4.60 ± .20; 1	
39	RIP impact on development of students' critical thinking ability	5 point: not at all (1) to extremely-great (5)	N=5: 4.40 ± .20; 1	
	Hoi'ke Assessment of Student Products 2002 versus 2003			
40	subject matter mastery and conceptual understanding	4 point: needs improvement (1) to excellent (4)	3.06 ± .12 (2002), 3.63 ± .18 (2003)	t (30)=-2.33, p <0.03
41	student creativity in scientific thought & process	4 point: needs improvement (1) to excellent (4)	2.93 ± .16 (2002), 3.50 ± .16 (2003)	t (25)=-2.48, p =0.02
42	student team work & collaborative effort	4 point: needs improvement (1) to excellent (4)	3.04 ± .26 (2002), 3.63 ± .12 (2003)	t (21)=-2.09, p <0.05

(Table 2 continued)

Open and closed format items from the *Teacher and Student Pre- and Post-Assessments*, administered before and after week-long RIP teacher professional development and student/teacher RIP training sessions, respectively, were compared (Items 23-31 and 10-19, respectively). These items consisted of content knowledge, perceptions, attitudes, and opinions related to science and learning about science. The Post-Assessment contained three additional items that students could not respond to until becoming familiar with the RIP (Items 20-22). Closed response formats included three-item multiple choice, four- or five-point/anchor Likert Scales, or placement of a vertical line to indicate response on a horizontal scale (0-9 or 12 cm) with four or five equally spaced anchors. A brief open and closed format *Student Post-RIP Questionnaire* to assess the attitudes and opinions of students about learning science through the RIP was designed and administered to peers by HLCS high school students mid-year, 2003 (n=30 students; closed format: four point/anchor Likert Scale; Items 1-3). *Parent Questionnaires* were administered to twenty-four parents at the end of 2003 to assess their opinions and perceptions of student learning at HLCS during the previous year at HLCS (before the RIP was introduced to the school) compared to the present time (one-year after the RIP was introduced to the school) [closed format: seven point/anchor Likert Scale, Items 4-9]. An open and closed format *Teacher RIP Impact Questionnaire* assessed observations and opinions of positive impact of the RIP on their students and themselves (n=5 teachers; closed format: five point/anchor Likert Scale; Items 32-39). Authentic evaluations of student work for subject matter mastery and understanding of underlying concepts, creativity and organization, and teamwork and effort conducted at the Fall 2002 and the Spring 2003 Hoi'ke were compared (*Hoi'ke Assessment of Student Products*, closed format: four point/anchor Likert Scale; Items 40-42).

Student and teacher research paper publications and science and science education talks, and awards and recognitions contribute further evidence of the impact of the RIP Program on student success in learning science (Tables 3 and 4, respectively). Student products consisted of contributions to scientific knowledge through published and "in-press" papers, invited and other student research investigation presentations and science education talks (Table 3, Items 1-7, 10). The results of science fair and science symposium participation serves as further evidence of quality of products (Table 4). Teacher products consisted of contributions to the field of science education through science education talks (Table 3, Items 8-10).

Table 3. HLCS Student and Teacher RIP Products

Item #	Type	Authors	Title	Source	Date
	Student Publications				
1	On-line journal (Full paper)	Allbrett, C. & McNeil, T.	*The effects of ka ha o ke ola (the Breath of Life) on heart rate*	Sci-Journal.org	2004*
2	On-line journal (Full paper)	Kamai, J. & Allbrett, V.	*Kava decreases the heart rate of daphnia*	Sci-Journal.org	2003
					*Submitted
	Student Talks				
3	Science-invited	Gora, C., Silva, K., & Marcellino, A.	*Do students use nutritional knowledge to choose their food?*	A.N.S.C.C.-AZ	2003
4	Science education-invited	Allbrett, V. & Jennings, K.	*How Halau Lokahi uses the RIP: an evaluation*	A.N.S.C.C.-AZ	2003
5	Science-invited	Allbrett, V.	*Probability-based decision-making in high school science*	A.S.A.-HI	2003
6	Science-invited	McNeil, T., Allbrett, C. & Se'e, T.	*Two-way ANOVA: Interaction Effects*	A.S.A.-HI	2003
7	Science-invited	Kamai, J., McNeil, T, Allbrett, C., Allbrett, V., Jennings, K. & Se'e, T.	*The effects of breathing on heart rate*	A.N.S.C.C.-HI	2002
	Teacher Talks				
8	Cultural-science education	Menon, U., Kojima, D. &. Wong, H.	*Learning about culture through the RIP*	A.I.E.C.-HI	2002
9	Science education	Menon, U, Kojima, D., Albrett, L., Wong, H., Nagasawa, J. & Landsman, R.	*He Ui a He Ninau: Embracing traditional Hawaiian culture and spirituality through authentic inquiry-based, thematic learning: a student/teacher/scientist collaboration*	A.N.S.C.C.-HI	2002
	Joint Teacher-Student Talk				
10	Science education	Menon, U. (T), Kojima, D. (T), Nagasawa, J. (T), Allbrett, C. (S), & McNeil, T (S).	*Using the RIP as a tool to understand culturally-relevant science*	N.H.E.A.C.-HI	2003

A.I.E.C.: Annual Indigenous Education Conference (HI-Honolulu); A.N.S.C.C.: Annual Native Science Connections Conference (AZ-Winslow, HI-Honolulu); A.S.A.: American Statistical Association (HI-Honolulu); N.H.E.A.C.: Native Hawaiian Education Association Conference (HI-Honolulu); (T)=Teacher, (S)=Student

Table 4. HLCS RIP-Based Student Science Fair and Contest Participation, Awards, and Citations*

Item #	*Event, Location & Date*	*Authors*	*Title*	*Awards/Recognitions*
1	HI State Science & Engineering Fair, Honolulu, HI, 2003	Jennings, K. (9) & Allbrett, V. (9)	*Kava decreases the heart rate of daphnia*	Honorable Mention, U.S. Army; Finalist, American Statistical Association
2	HI State Science Fair, Honolulu, HI, 2003	Allbrett, C. (10), McNeil, T. (11) & Se'e, T. (10)	*The effects of Hawaiian breathing on pulse rates*	Finalist, American Statistical Association
3	HI Pacific Science Symposium, Honolulu, HI, 2003	Kamai, J. (9)	*Kava decreases the heart rate of daphnia*	First Place, Plenary Session
4	Island Movie Contest, Honolulu, HI, 2003	Jennings, K. (9)	*Searching for its heart: RIP-ing at Halau Lokahi*	Honorable Mention

* Grade level shown in parentheses

Impact on HLCS Students and Teachers

Interest and attitudes in learning about science and learning in general

The majority of students appeared to enjoy using the RIP and felt that it helped them to learn science (**Table 2, Items 1 & 22, Table 5**). Approximately four-fifths of the students claimed that they enjoyed learning through the RIP, with 35% saying they experienced much to very much enjoyment using this process, while two-thirds of the students said they enjoyed learning *about science* through the RIP. Student interest in learning through RIP-based scientific inquiry was exemplified by their continuing their research investigations well into the evenings on many occasions and during holidays and vacations. Student comments reflected a positive attitude regarding the use of the RIP (Table 5). Teachers felt that the RIP greatly helped them understand and respond to individual students' interests, strengths, experiences, and needs (Table 2, Item 33). All teachers agreed that student engagement in the RIP stimulated student interest to learn science to a great or extremely-great extent and were engrossed in and took ownership of their learning (Table 2, Item 32; Table 5). Teachers felt that engaging students in inquiry-based learning using the RIP had a very strong positive impact on changing students' attitudes towards learning science and learning in general (Table 2, Item 36; Table 5). Parents claimed that students have shown more interest in attending school and more interest towards academics at school since the RIP Program was implemented (Table 2, Items 5 & 7).

Table 5. HLCS student and teacher comments regarding the influence of the RIP on student interest to learn science

Student Comments
"The RIP Process is an excellent way to learn."
"It makes learning science easier and less confusing."
"The RIP is a much better way of learning compared to how we learned before."
Teacher Comments
"Students started taking interest in studying and also began answering questions more frequently. When learning about science, students were so engrossed in what they were doing that they did not look at the wall clock anymore and would exclaim at the end of the day that they could not believe it was time to go home already. The average grade level of the entire class was raised in one semester and students were more interested in learning than ever before."
"Instruction through the RIP gave students more ownership over their own learning experience."

"The material covered had greater relevance and was more interesting to the students than that from traditional coverage of curriculum or simple hands-on approaches."

The RIP also impacted teacher attitudes towards learning science with their students. For example, one exemplar teacher stated, "It was very exciting and intellectually more satisfying learning science through the RIP with my students than by memorizing textbooks and doing labs that already have a known outcome."

Opportunities for scientific discussion and debate among students

HLCS teachers reported that the RIP greatly enhanced their ability to provide students with opportunities to discuss and debate scientific information and issues (Table 2, Item 34; Table 6).

Table 6. HLCS teacher comments regarding the RIP providing opportunities for scientific discussion and debate among students

Teacher Comments
"The structure of the entire day changed so that there were large blocks of time available for extended discussion on topics of interest, without the feeling that we will not have time to cover all the material. Daily seminars were held for student's to present background material relevant to their research investigations to each other."
"High school students presented their research investigations to their peers, middle school students, teachers, parents, community members and professional scientists."
"Most of the topics that were discussed in the class were always started from a relatively simple concept about everyday life. The discussion was guided by the teacher and/or the students toward a more complex topic without the student's overt recognition that this was happening. This helped students remove the mental block against learning 'difficult' scientific information. I could feel their happiness and sense of achievement."

Communication skills

Both HLCS teachers and parents felt that the RIP and RIP Program promoted development of skills and confidence to enable students to communicate effectively through speaking and writing (Table 2, Items 4 and 35). These perceptions were corroborated by external sources. Following a HLCS student research talk at a Hawaii Department of Education Inquiry Professional Development Workshop, one teacher participant commented that the student presenters did an excellent job conveying complex scientific concepts and information to a "scientifically-unsophisticated" audience of teachers. Moderator and Executive Director of

Native Science Connections Dr. Mark Sorenson, after hearing two HLCS student research talks at the 2002 Conference, exclaimed to the audience, "I don't believe that I was exposed to a scientific talk of this caliber until graduate school!"

PHOTOGRAPH: STUDENTS PRESENTING THEIR WORK AT A SCIENCE EDUCATION CONFERENCE

Critical thinking and decision-making ability

Teachers reported that they felt that the RIP substantially impacted student ability to make good decisions and had a strong impact on the development of their students' critical thinking ability (Table 2, Items 37 & 39, respectively). They also claimed that the RIP had a great positive impact on student abilities to critically evaluate data and so-called "facts" (Table 2, Item 39).

Facilitation of teacher learning and instruction about science through inquiry

Teacher knowledge and understanding of the scientific inquiry process including data organization, analysis, and application of mathematics and probability theory to decision making in science significantly increased by the end of the RIP training and conducting of a teacher research investigation (Table 2, Items 23, 28 & 29). Teacher respondents claimed that the RIP professional development sessions and actually engaging in a RIP inquiry facilitated their learning of science through inquiry (Table 2, Item 31; Table 7).

Table 7. HLCS teachers' comments, following training and conducting a RIP-based study, on facilitation of their learning and instruction about science through inquiry

"For me, the RIP removes the intimidation of learning science, particularly the types of science with which I have the most difficulty (physical science and chemistry). It breaks scientific inquiry down into understandable steps."
"It showed me that it was very exciting and intellectually more satisfying learning science through the RIP than by memorizing textbooks and doing labs that already have a known outcome."

Cooperation, shared responsibility, and respect for supporting a classroom community

According to HLCS teachers, successful learning of science through the RIP necessitated and fostered cooperation and shared responsibility, including accountability for learning, and respect for the classroom community (Table 8).

Table 8. HLCS teacher comments regarding cooperation, shared responsibility, and respect for supporting a classroom community

"With the RIP approach, students often work in groups and assume responsibilities usually chosen based on their strengths. Doing what they are best at helped them acquire more confidence, but also made them assume more responsibility and accountability to the welfare of their group because they were working from their strengths. It also helped to create a community because they could learn the information relating to other aspects of the investigation from other members of their research team."
"Because the RIP has an ethics component, students learn to respect their similarities and differences. They begin to share knowledge more and work as a team so that they all may gain from the experience. They also learn the ramifications of misbehavior, including cheating in science and the impacts that unethical behavior has on the individual and on society as a whole."
"The RIP encourages cooperation and shared responsibility, especially in a group project because all members of the group are needed to develop, implement, analyze, and make conclusions based on the study. The group pools ideas, discusses how to solve problems that arise, and is often needed when the study is being run. Many studies require multiple students carrying out tasks simultaneously. Each student must be responsible for their assigned task and must work cooperatively with the others to accomplish the study. Student investigators from one study would help other groups of researchers to meet deadlines or by training them in something that the former had already learned."

Parents reported that students showed more to much more improvement in their sense of responsibility towards finishing assignments compared to before the RIP program was implemented at HLCS (Table 2, Item 6). Overall, Parents also felt that since the RIP Program was implemented into HLCS, their children showed improvement in handling responsibilities at home (Table 2, Item 8). Team evaluators rated HLCS student Hoi'ke presenters significantly higher in demonstrated shared responsibility related to uniform effort and contribution across individual team members and in team communication ability following six months of learning through the RIP compared with immediately prior to formally introducing the RIP into the school (Table 2, Item 42).

PHOTOGRAPH: STUDENTS WORKING TOGETHER IN THE RIP

Impact of the RIP on student learning of science content, including scientific inquiry

HLCS students substantially increased their knowledge and understanding of the scientific inquiry process, including the different components and how they are connected since the RIP was implemented (Table 2, Item 10). This was accompanied by significant increases in self-reported understanding of inquiry-based concepts and increased confidence levels related to understanding of and proficiency in using scientific inquiry to learn science after learning the RIP (Table 2, Items 11-14). Student understanding and ability to apply mathematical concepts to their decision-making almost doubled by the end of their training in and implementation of a RIP (Table 2, Items 15 & 16). These increases in demonstrated knowledge and ability were accompanied by significant increases in student' self-reported familiarity and understanding of concepts related to data presentation, analysis, and the use of statistics in making decisions in science (Table 2, Items 17 &18). Students exhibited a significant increase in confidence in their ability to learn science following RIP training, with three-fourths of the students reporting that they learned more science through the RIP-based inquiry than they had learned previously through traditional lab investigations (Table 2, Items 19 & 20, respectively). The majority of students predicted that the RIP would help them as a general learning tool to learn more in school (Table 2, Item 21). Students reported that they learned more in the one year period since implementation of the RIP Program compared with the prior year at HLCS and that the RIP was helping them to learn in general (Table 2, Items 2 & 3). Parents of HLCS students stated that they felt that their children were learning more academically compared to the year and one-half at HLCS prior to implementation of the RIP program (Table 2, Item 9). Hoi`ke team evaluators rated HLCS students significantly higher in demonstrated proficiency in understanding and being able to explain to others scientific content, including scientific concepts and the inquiry process

they used to investigate the concepts, following six months of learning through the RIP compared with immediately prior to the RIP being formally introduced into the school (Table 2, Item 40).

Evidence of Creativity

The RIP Program at HLCS serves as an ideal medium for fostering student creativity consistent with the school's vision of merging Hawaiian culture with Western-standards-based science education. The student products presented in the next section exemplify the students' creative use of the RIP to successfully meet this goal. Hoi`ke team evaluators rated HLCS students significantly higher in demonstrated creativity in their use of inquiry to learn scientific concepts following six months of learning through the RIP compared with immediately prior to formally introducing the RIP into the school (Table 2, Item 41). The RIP stimulates students to be creative in their presentation of their research investigations as well as in the designing of the RIP study. One student, for example, developed an i-movie of her entire RIP-based inquiry on a CD for presentation at a science education conference. This product was subsequently honored in a movie contest (Table 4, Item 4).

Student and teacher products contributing to science and science education

Many of the more measurable RIP products were in the form of student publications, teacher and joint teacher-student research talks, and poster presentations. One student paper was published in and a second submitted to a secondary/college refereed on-line scientific journal (Table 3, Items 1 & 2). The former comprised the first controlled scientific study to demonstrate direct effects of kava on heart rate and the latter was the first study to scientifically investigate a

physiological impact of the Hawaiian *Breath of Life* on humans and compare its relaxation effects with those resulting from diaphragmatic breathing. Five *invited* student research talks were delivered (Table 3, Items 3-7). For example, as a result of successful student research presentations by HLCS students at a Native Science Connections Conference in science education in Honolulu, three students were invited to present their RIP products to teachers and students at schools in Winslow, AZ. Two teacher science education talks centering on the implementation of the RIP Program were delivered (Table 3, Items 8 & 9). Students and their teachers also worked as partners towards adding original knowledge to the scientific data-base and to science education (Table 3, Item 10). In its second year, this school was able to enter and successfully compete at the state science fair and junior science symposium levels with students receiving a number of accolades for their products (Table 4, Items 1-3).

AAST-Nature of the Evidence

The RIP Program impact on students and teachers was measured using a variety of assessment and evaluation tools, and indicators collected from 1994 to the present. Tables 9 and 10 present data from student, teacher, and parent questionnaire items and RIP student college and university applications and acceptances, respectively.

Table 9. AAST Questionnaire Summary and Analyses

Item #	Type	Scale	Descriptive Statistics (mean ± SEM; range)	Statistical Test Results
	RIP Student Questionnaire			
1	Positive impact on student's ability to succeed in college	5 point: none (1) to extremely-strong (5)	N=40: 4.00 ± .15; 3	
2	Positive impact on student's ability to succeed in college level science courses	5 point: none (1) to extremely-strong (5)	N=40: 3.95 ± .17; 4	
3	Enabled student to compete academically in college	5 point: no help (1) to extremely-helpful (5)	N=40: 3.78 ± .17; 3	
4	Degree to which student's participation in RIP program influenced future career objectives at time of high school graduation	5 point: none (1) to very strong influence (5)	N=40: 3.73 ± .20; 4	
5	Extent to which student's participation in RIP program positively impacted ability to achieve career objectives	5 point: none (1) to exceptionally-large (5)	N=40: 4.10 ± .16; 3	
6	Participation in RIP Program enhanced student's high school experience	1=yes, 2=no	N=40: 1=100%	
7	Influence of scientific inquiry through the RIP on creativity	1=yes, 2=no	N=40: 1=62.5%, 2=37.5%	
8	Positive impact of learning & using the RIP on ability to use logic & reasoning in making decisions and choices in life as a high school student	5 point: none (1) to very strong (5)	N=40: 3.60 ± .19; 4	
9	Positive impact of learning & using the RIP on ability to use logic & reasoning in making decisions and choices in life *as a college student*	5 point: none (1) to very strong (5)	N=40: 3.70 ± .21; 4	
10	Positive impact of learning & using the RIP on ability to use logic & reasoning in making decisions and choices in life in the student's *career*	5 point: none (1) to very strong (5)	N=40: 3.40 ± .21; 4	
11	Positive impact of learning & using the RIP on ability to use logic & reasoning in making decisions and choices in the student's personal life	5 point: none (1) to very strong (5)	N=40: 3.03 ± .22; 4	

Table 9 (continued). AAST Questionnaire Summary and Analyses

Item #	Type	Scale	Descriptive Statistics (mean ± SEM; range)	Statistical Test Results
	RIP Versus Non-RIP Student Comparisons			
12	College acceptances out of total applications (proportion)		.82 ± .03 (RIP), .60 ± .06 (non-RIP)	$t(56)=3.41$, $p=0.001$
13	Proportion of acceptances to top four college choices		.75 ± .04 (RIP), .46 ± .09 (non-RIP)	$t(56)=3.39$, $p=0.001$
14	Academic or research merit/merit aid scholarships per college acceptance		.73 ± .13 (RIP), .36 ± .13 (non-RIP) median=.50 (RIP), .00 (non-RIP)	$T=409.5$, $p=0.04$ (Mann-Whitney Rank Sum)
15	Proportion of college acceptances offering at least one merit/research scholarship		.51 ± .06 (RIP), .21 ± .10 (non-RIP)	$t(56)=2.57$, $p=0.01$
16	Number of students who pursued science as a career anytime since high school graduation	frequencies: 1=yes, 2=no	RIP: 1=27, 2=13; non-RIP: 1=5, 2=13	$\chi^2(1)=6.40$, $p=0.01$
17	Science major as undergraduate	frequencies: 1=yes, 2=no	RIP: 1=21, 2=19; non-RIP: 1=1, 2=17	$\chi^2(1)=9.71$, $p=0.002$
18	Number of former students in science careers and/or science graduate school programs	frequencies: 1=yes, 2=no	RIP: 1=17, 2=15; non-RIP: 1=1, 2=14	$\chi^2(1)=7.47$, $p=0.006$
19	Number of college graduates attending or graduated from post-graduate education institutions	frequencies: 1=yes, 2=no	RIP: 1=25, 2=7; non-RIP: 1=4, 2=10	$\chi^2(1)=8.25$, $p=0.004$
	Teacher RIP Impact Questionnaire			
20	Extent enables understanding & responding to student interests, strengths, experiences & needs	5 point: not at all (1) to extremely-great (5)	N=4: 4.75 ± .25; 1	
21	Extent provides opportunities for student scientific discussion & debate	5 point: not at all (1) to extremely-great (5)	N=4: 5.00 ± .00; 0	
22	Positive influence on students' development of effective communication skills	5 point: none (1) to exceptionally-large (5)	N=4: 4.75 ± .25; 1	
23	Positive change in student attitudes toward science	5 point: none (1) to extremely-great (5)	N=4: 4.75 ± .25; 1	
24	Impact on student ability to make good decisions	5 point: none (1) to exceptionally-high (5)	N=4: 4.50 ± .29; 1	
25	Impact on student ability to critically evaluate data	5 point: none (1) to extremely-great (5)	N=4: 4.50 ± .29; 1	
26	Impact on development of students' critical thinking ability	5 point: none (1) to extremely-great (5)	N=4: 4.50 ± .29; 1	

Table 9 (continued). AAST Questionnaire Summary and Analyses

Item #	Type	Scale	Descriptive Statistics (mean ± SEM; range)	Statistical Test Results
	Parent RIP Impact Questionnaire			
27	Positive impact on student's ability to succeed in high school	5 point: none (1) to extremely-strong (5)	N=16: 4.50 ± .13; 1	
28	Contribution to student's academic success in college and/or beyond	5 point: none (1) to extremely-strong (5)	N=16: 4.44 ± .20; 2	
29	Positive impact on student's ability to achieve his/her career objectives	5 point: none (1) to extremely-strong (5)	N=16: 4.31 ± .27; 3	
30	Participation in the RIP Program enhanced student's high school experience	yes (1), no (2)	N=16: 1=100%	
31	Provided parent with opportunity to become a partner in ways could not have if student had not participated in RIP Program	yes (1), no (2)	N=16: 1=69%, 2=31%	
32	Extent to which experiences in RIP Program helped student to develop critical thinking skills	5 point: none (1) to extremely-helpful (5)	N=16: 4.56 ± .16; 2	
33	Extent to which student's experiences in the RIP Program positively influenced ability to think critically and not just accept everything at face value	5 point: none (1) to exceptionally-strong (5)	N=16: 4.38 ± .22; 3	
34	Extent to which experiences in RIP Program helped students to develop decision-making abilities	5 point: none (1) to extremely-helpful (5)	N=16: 4.38 ± .15; 2	
35	Positive affect on student's attitudes towards learning about science	5 point: none (1) to exceptionally-strong (5)	N=16: 4.38 ± .20; 2	
36	Positive effect on student's attitudes towards learning in-general	5 point: none (1) to exceptionally-strong (5)	N=16: 4.25 ± .31; 4	
37	Extent to which RIP Program enhanced student's college applications to gain admission into schools of choice	5 point: none (1) to exceptionally-strong (5)	N=16: 4.38 ± .29; 4	

(Table 9 continued)

The students included in this evaluation of the RIP Program were 24 males and 16 females from the 1996-2000 graduating classes. Forty-five of the 75 students that were involved in the RIP Program during 1993-1999 were randomly selected and attempted contact was made via E-mail or phone with a request to respond to an on-line questionnaire to measure their perceptions related to the impact of the RIP Program on their high school, college and post-graduate education, careers, and other aspects of their lives (*RIP Student Questionnaire)*. Each student was given a unique validity code and the participants were assured that their identity and responses would remain anonymous to the evaluator. The codes were randomly matched to names by a third party so that the students' identities remained anonymous to the evaluator. Of the 43 students who responded to the initial contact, 40, or approximately 93%, actually submitted completed questionnaires with appropriate ID Codes. Eighteen (or 50%) of thirty-six contacted randomly selected non-RIP students from those who were in the chemistry or physics research programs at AAST responded to an abbreviated on-line version of the RIP Student Questionnaire containing some of the same questions. Responses from this sample were statistically compared with those from the RIP Program students, controlling for general participation in high school research as a variable determining college, university, and career impact (*RIP Versus Non-RIP Student Comparisons*). Parents of the RIP students selected for evaluation were e-mailed requests to participate by completing an anonymous parent questionnaire asking for perceptions and opinions of impact of the RIP Program on their son's/daughter's schooling, careers, and lives (*Parent RIP Impact Questionnaire*). A single questionnaire was completed for each student by one or both parents together. Forty-percent, or 16, of the 40 parents of the RIP students contacted responded with a completed parent questionnaire. An on-line teacher questionnaire was also completed by the two exemplary and two other teachers who were involved with the RIP Program and its students (*Teacher RIP Impact Questionnaire*).

Table 10. AAST Undergraduate Institution Applications (#Appl.) and Acceptances (#Accept.) from Sampled RIP Program Students*

Institution	# Appl.	# Accept.	Institution	# Appl.	# Accept.	Institution	# Appl.	# Accept.
Amherst College	1	1	Georgetown U.	1	1	Stanford U.	10	8
Beloit College	1	1	Harvard U.	11	2	Stevens Institute of Technology	2	2
Boston College	4	2	Harvey Mudd College	1	1	Swarthmore College	1	0
Boston U.	2	2	Haverford College	4	4	The Catholic U. of America	1	1
Brown U.	11	9	James Madison U.	1	1	The College of NJ	2	2
Bryn Mawr College	2	2	Johns Hopkins U.	2	2	The George Washington U.	1	1
Bucknell U.	1	1	Laffayette College	1	1	Trinity College	2	2
Caltech	2	2	Lehigh U.	1	1	Tufts U.	7	6
Carnegie Mellon U.	1	0	MIT	10	9	The U. of Chicago	1	1
College of Mt. St. Vincent	1	1	NJIT	2	2	U. of Illinois	1	1
Columbia U.	12	11	Northwestern U.	2	2	UMDNJ	1	1
Connecticut College	1	1	NYU	7	7	U. of Pennsylvania	8	5
Cooper Union	1	1	Occidental College	2	2	U. of Richmond	2	2
Cornell U.	5	3	Penn State U.	1	1	U. of Rochester	1	1
Dartmouth College	3	2	Princeton U.	11	9	Union College	1	1
Deep Springs College	1	1	Rutgers U.	7	7	Villanova U.	1	0
Drew U.	1	1	RPI	3	1	Wellesley College	3	3
Duke U.	6	6	School of Visual Arts (NYC)	1	1	Williams College	1	1
Emory U.	1	1	Seton Hall U.	3	3	Yale U.	16	10
Fairfield U.	1	1	Smith College	4	4			

Special Programs	# Appl.	# Accept.	Special Programs	# Appl.	# Accept.	Special Programs	# Appl.	# Accept.
Boston U.-Medical Program (7 Year)	4	4	N.Y.U.-BA/MD Program (8 Year)	1	1	U. of Michigan-INTEFLEX Combined Medical Program (7 Year)	4	4
Brown U.-Program in Liberal Medical Education (8 Year)	4	2	Northwestern U.-Honors Program in Medical Education (7 Year)	6	6			
City U. of NY-BA/MA Program in Economics	1	1	Rice U.-Medical Scholars Program (8 Year)	2	1	U. of Penn.-Wharton Elite Business/Engineering Dual Degree Program	1	1
Muhlenberg College-MCP Hahnemann Medical Program (8 Year)	1	1	Rutgers U./Rutgers College-Honors Programs	13	13	U. of Rochester-Early Medical Scholars Program (8 Year)	3	3
			The George Washington U.-BA/MD Program (7 Year)	1	1	Union College- Leadership in Medicine/Health Management Program (8 Year)	1	1

Total # Applications: 237
Total # Acceptances: 197

* Only one application and acceptance is included for each of the seven students who received early acceptance.

Student and teacher products; state science fair, science symposium, and other awards and accolades; and international and national media recognition of the RIP Program constitute authentic assessment- and evaluation-based evidence and demonstrate the program's impact on contributions to science and science education (Tables 11 & 12).

Table 11. AAST Student and Teacher RIP Products

Item #	Type	Authors	Title	Source	Date
	Student Publications				
1	Electronic media (Full Paper)	Abraham, E., Lolis, M. & Viswanathan, S.	Comparison of UV and electrochemical detection of melatonin in aqueous solution stored at various temperatures using HPLC	*Making Connections* , Lockheed Martin Research Symposium Brooklandville, MD	2000
2	Electronic media (Full Paper)	Chang, E. & KyungMouk, L.	UV treatment of *Aeromonas* -infested water: supporting a partnership in science education and koi health research	*Making Connections* , Lockheed Martin Research Symposium Brooklandville, MD	2000
3	Trade journal (Full Paper)	Park, K.H.	Are sedated koi healthy koi?	*Koi USA* : *24* (3), 70-79	1999
4	Science journal (Full Paper)	Robson, A.	Gonadal hormones have no effect on strong EODs	*NCSSSMST*[1] *Journal* : *4* (1), 19-23	1998
5	Sci.-Med. journal (Full Paper)	Ellerbee, A.	Temperature and the koi immune system	*Koi Health Quarterly* : *15* , 5-8	1997
6	Trade journal (Full Paper)	Gajria, D.	The modern wonder drug: an initial study of the effects of melatonin on the immune system in fish	*Mid-Atlantic Koi* : *11* (1), 5-13	1997
7	Science journal (Abstract)	Han, A. & Gupta, P.	Influence of melatonin on electric organ discharge behavior in the weakly discharging electric fish, *Brienomyrus brachyistius*	*Society for Neuroscience Abstracts: 23* , Part 2, 2388	1997
8	Intl. trade journal (Full paper)	Majithia, A.	Tranquilization and koi health: preliminary findings on the effects of anesthetics on T-cell proliferation	*Nishikigoi International* : Spring, 68-69	1997
9	Science journal (Abstract)	Miao, M. & Gupta, S.	Epinephrine induces rapid changes in centrally and peripherally-mediated electric organ discharge characteristics in a weakly electric fish	*Society for Neuroscience Abstracts* : *23* , Part 2, 1323	1997

[1] NCSSSMST= National Consortium for Specialized Secondary Schools of Mathematics, Science and Technology

Table 11 (continued). AAST Student and Teacher RIP Products

Item #	Type	Authors	Title	Source	Date
	Student Publications				
10	Science journal (Abstract)	Parikh, A. & Schwenkler, J.	Hexavalent and trivalent chromium affect specific phases but not rate of the electric organ discharge in a mormyrid	*Society for Neuroscience Abstracts*: *23*, Part 1, 249	1997
11	Science journal (Abstract)	Lin, C. & Gupta, S.	Norepinephrine alters the centrally controlled rate and peripherally controlled waveform of the electric signal in a weakly discharging electric fish	*Society for Neuroscience Abstracts*: *22*, Part 2, 1337	1996
12	Science journal (Full Paper)	Sayres, R.	Effects of testosterone on the electric organ discharge waveform in electric catfish, *Malapterurus electricus*	*NCSSSMST Journal*: *2* (1), 24-27	1996
13	Science journal (Full Paper)	Prabhakar, A.	Lead alters the waveform and frequency of the electric organ discharge in the electric fish, *Gnathonemus petersii* 1	*NCSSSMST Journal*: (1), 28-30	1995
14	Science journal (Abstract)	Prabhakar, A.	Lead alters the waveform and frequency of the electric organ discharge in *Gnathonemus petersii* (Mormyriformes, Teleostei)	*Society for Neuroscience Abstracts*: *20*, Part 1, 372	1994
	Student Talks				
15	Science-invited	Lin, C.	*Catecholaminergic control of the centrally- and peripherally-controlled electric organ discharges in weakly electric fish*	Hackensack University Hospital, Hackensack, NJ	1998
16	Science-invited	Ellerbee, A.	*The heat is on—an examination of koi fever*	16th Annual AKCA[2] Seminar, Denver, CO	1997
17	Science-invited	Gajria, D.	*From koi to man: unraveling the melatonin-health mystery*	16th Annual AKCA Seminar, Denver, CO	1997
18	Science (Poster)	Isecke, B. & Puthiamadathil, J.	*Effects of melatonin on courtship behavior in Poecilia latipinna (sailfin molly)*	Society for Neuroscience New Orleans, LA	1997
19	Science (Poster)	Lee, J.	*Social isolation and sexual behavior in Poecilia reticulata: a reexamination*	Society for Neuroscience New Orleans, LA	1997

[2]AKCA= Associated Koi Clubs of America

Table 11 (continued). AAST Student and Teacher RIP Products

Item #	Type	Authors	Title	Source	Date
20	Science	Miao, M. & Gupta, S.	*Epinephrine induces rapid changes in centrally and peripherally mediated electric organ discharge characteristics in a weakly electric fish*	Society for Neuroscience New Orleans, LA	1997
21	Science	Parikh, A. & Schwenkler, J.	*Hexavalent and trivalent chromium affect specific phases but not rate of the electric organ discharge in a mormyrid*	Society for Neuroscience New Orleans, LA	1997
22	Science-invited	Park, K.	*Are sedated koi healthy koi?*	16th Annual AKCA Seminar, Denver, CO	1997
23	Science (Poster)	Silverglate, S. & Bello, D.	*Food deprivation affects courtship behavior and coloration in Poecilia reticulate*	Society for Neuroscience	1997
24	Science-invited	Ellerbee, A.	*The effects of temperature on the immune system of fish*	Longwood Gardens Lecture Series, Kennett Square, PA	1996
25	Science	Lin, C. & Gupta, S.	*Norepinephrine alters the centrally controlled rate and peripherally controlled waveform of the electric signal in a weakly discharging electric fish*	Society for Neuroscience Washington, DC	1996
26	Science-invited	Majithia, A.	*Tranquilization may enhance the immune system*	Longwood Gardens Lecture Series, Kennett Square, PA	1996
27	Science	Prabhakar, A.	*Lead alters the waveform and frequency of the electric organ discharge in Gnathonemus petersii (Mormyriformes, Teleostei)*	Society for Neuroscience Miami Beach, FL	1994
28	Science-invited	Nagahawatte, T. & Nemr, A.	*Social isolation and hormones as influences on sex: A proposal*	Conference, Pittsburgh, PA	1993
29	Science-invited	Prabhakar, A.	*Using fish as bio-monitors for water pollutants-Lead*	Annual NCSSSMST Conference, Pittsburgh, PA	1993
	Teacher Publications				
30	Science journal (Abstract)	Landsman, R. & Perrotti, L.	Development of an inexpensive, time and space efficient neuroscience research program for high school and undergraduate students	*Society for Neuroscience Abstracts*: 23, Part 1, 279	1997

Table 11 (continued). AAST Student and Teacher RIP Products

Item #	Type	Authors	Title	Source	Date
	Teacher Publications				
31	Science jounal (Abstract)	Landsman, R., Perrotti, L., Niedosik, D. & DeWitt, D.	Integration of science disciplines in a high school science program through neuroscience research	*Society for Neuroscience Abstracts* : 22, Part 1, 252	1996
	Teacher Talks				
32	Science education-invited	Landsman, R.	*Koi research at AAST: answering the call for science education reform*	16th Annual AKCA Seminar, Denver, CO	1997
33	Science education-invited	Landsman, R.	*Science Education in the US: implementing changes in educational curriculum and practice*	Longwood Gardens Lecture Series, Kennett Square, PA	1997
34	Science education	Landsman, R. & Perrotti, L.	*Development of an inexpensive, time and space efficient neuro-science research program for high school and college students*	Society for Neuroscience New Orleans, LA	1997
35	Science education-Invited	Perrotti, L.	*Koi immunology at the Academy-teaching science by doing science*	16th Annual AKCA Seminar, Denver, CO	1997
36	Science, science education-invited	Landsman, R	*Stress and immunology in Koi* : science education and fish	Longwood Gardens Lecture Series, Kennett Square, PA	1996
37	Science-science Education-invited	Landsman, R.	*Neuroendocrinological-behavioral mechanisms and stress in fish - high school scientists' contributions to knowledge*	Biochemistry Seminar Series, Stevens Institute of Technology,	1996
38	Science, science education-invited	Landsman, R. & Perrotti, L.	*High school studies on stress in fish and immunology in Koi*	Hofstra University Fish Health Seminar, New York, NY	1996
39	Science education	Landsman, R., Perrotti, L., Niedosik, D. & DeWitt, D.	*Integration of science disciplines in a high school science program through neuroscience research*	Society for Neuroscience Washington, DC Hoboken, NJ	1996

Table 11 (continued). AAST Student and Teacher RIP Products

Item #	Type	Authors	Title	Source	Date
	Joint Student-Teacher Publications				
40	Electronic media (Full Paper)	Abraham, E. (S), Adhvaryu, A. (S), Gupta, P. (S), Han, A. (S), Lolis, M. (S), Parikh, N. (S), Perotti, L. (TA), Viswanathan, S. (S) & Landsman, R. (T)	Comparison of UV and electrochemical detection of melatonin in aqueous solution stored at various temperatures using HPLC	*Making Connections*, *Lockheed Martin Research Symposium* Brooklandville, MD	2000
41	Electronic media (Full Paper)	Chen, D. (S) & Landsman, R.	Promotion of science literacy among high school and undergraduate students through affordable, time and space efficient research	*Making Connections*, *Lockheed Martin Research Symposium* Brooklandville, MD	2000
42	Electronic media (Full Paper)	Perkins, T. (S) & Landsman, R.	Accentuating the importance and nature of interdisciplinary science study through neuroscience research in a secondary educational environment: pros and cons	*Making Connections*, *Lockheed Martin Research Symposium* Brooklandville, MD	2000
43	Trade journal (Full Paper)	Ellerbee, A. (S), Perrotti, L. & Landsman, R.	Temperature and fish immunology: assumptions, truths, and new data	*Mid-Atlantic Koi*: *10* (11), 5-8	1997

(S)=student, (T) =teacher, (TA)=graduate student teacher assistant

Table 12. AAST RIP Program Student Science Fair and Junior Science Symposium Awards and Recognition and Internlional Research Awards 1994-1998*

Event, Location: NJ State Science & Engineering Fair, Somerset, NJ

Year	***Award/Recognition***
1998	Category Awards: Behavioral Science-Second Place
	Zoology-Second Place
	Life Science Award, Sr. Division Winner
	Statistics Award-First Place
1997	Category Awards: Behavioral Science-Second Place
	Zoology-Second Place
	Statistics Awards-First Place, Second Place
1996	Category Award: Medicine and Health-First Place
	Statistics Awards-First Place, Second Place
	Univ. of Medicine and Dentistry of NJ Award
1995	ISEF Finalist, Sr. Division
	Category Awards: Water Pollution-First Place
	Behavioral Science-First Place
	American Chemical Society Award-Second Place
	Chemical Technology Award
	Navy/Marine Corps Distinguished Achievement Award-First Place
	Statistics Awards-First Place, Second Place
	Statistics Award-First Place

Event, Location : Junior Science Symposium, New Brunswick, NJ

Year	***Award/Recognition***
1998	Paper Finalist- Second Place
1997	Paper Finalist- Honorable Mention
1995	Paper Finalist- Honorable Mention
	Poster Competition-First, Second & Third Place
1994	Paper Finalist, Honorable Mention

Event, Location: International Platinum Kohaku Award
(for the most significant medical contribution
to the understanding of fish health)
Jack Chang Gold Factory &
The Associated Koi Clubs of America

Year	***Award/Recognition***
1998	International Winner
1997	International Winner
1996	International Winner

*RIP Program students only participated during these five years. Every student who participated in the State Science Fair or Junior Science Symposium received at least one award.

Impact on AAST Students and Teachers

Student interest in and attitudes toward learning and pursuing careers in science

Overall, AAST students felt that their participation in the RIP Program had a strong influence on their future career objectives at the time of high school graduation and a large positive impact on their ability to achieve these objectives (Table 9, Items 4 and 5, respectively). Compared to non-RIP students (28%), significantly more of the RIP students (68%) pursued science as a career at some point after graduating high school (Table 9, Item 16). Significantly more RIP students also chose science as an undergraduate major (53%) and are currently in science careers and/or science graduate school programs (53%) compared to non-RIP students (5.9% and 7.1%, respectively) [Table 9, Items 17 & 18]. Students attributed much of their interest and enjoyment in learning science and learning in-general, in high school and later while pursuing careers related to science, to their participation in the RIP Program (Table 13).

Table 13. AAST student, teacher, and parent comments regarding the effects of the RIP/RIP Program on student attitudes

Student Comments
"It [the RIP Program]changed my attitude about learning at the AAST, where before the program I did not [have] the motivation to succeed that I did after the program. The program completely changed my attitude and changed me from an average student to a passionate one that was able to take on a leadership role in college. Not only did I become involved in research when I started Connecticut College, but I was able to help other students in statistics and during their research work."
"The RIP Program at the Academy fostered a love of learning, not just for science but all academic disciplines. Through the program I learned to be a self-starter, to search for the answers to my questions. Again this is a skill that I have taken with me and applied even now as a medical student. My last evaluation for a rotation mentioned my enthusiasm for learning and quest for knowledge. These are two attributes I contribute to my invovlement [*sic*] in the RIP Program."
"It made what I was learning directly relevant for my interests. I was very interested in computer technology and I was able to apply this interest directly to my research on color changes in fish. My techniques interested real scientists and this made me feel very important and made science much more attractive to me as a career. Also, I learned to enjoy chemistry and physics more because I know [*sic*] could understand that they were relevant to my work that I was interested in."
"I love to learn about science. When I was encouraged to do my own scientific research in high school, for the first time I felt that outsiders were really interested in what I was doing. I was amazed that outside organizations wiuld [*sic*]actually pay to have me fly to places and present my findings because they were scientifically important! This all somehow made me feel respected and important and led me to really wanting to learn about science."
"I would not only say that it enhanced my high school experience, but it was the most influential part of the Academy for me personally. …as I started taking the pre-research class, my whole attitude changed. It brought out a passion for the scientific process that I didnt know I possessed. Specifically, my interest in statistics and performing original research was born in this program, and it has growth and persisted since."
"The experience solidified my interest in pursuing a career in a scientific field, which happened to be medicine."

Teacher Comments
"The flexibility of the process as well as the program as a whole provided the opportunity to differentiate my science curriculum and instructional practices. In other words, the RIP allowed for the students to develop their own research question that led to a study of a topic based on their own interest and experiences. Because the RIP incorporates team work and collaborative efforts amongst students, it allows for flexible grouping by abilities. Each student's strength is tapped as he/she has an opportunity to take the role of a 'resident expert,' taking the lead to perform specific tasks. At the same time, as students build confidence in their strengths, I then was able to challenge them in their weaker areas."
Parent Comments
"He went in wondering what he would like to do as an adult and graduated with a clear purpose to become a scientist."
"While my daughter was already science focused, the RIP Program gave her depth and challenges not available at and way beyond any secondary experience I have ever heard of. Her investigations fed her interest in science and opened a whole new field of career opportunities to my child."
"It made our daughter realize that she must dig beneath the surface in every discipline in order to truly understand it."

AAST teachers reported that the RIP had an extremely-positive influence on change in student attitudes toward science (Table 9, Item 23). They felt that the RIP enabled them to, an extremely-great extent, respond to student interests, strengths, experiences, and needs (Table 9, Item 20; Table 13). Parents of RIP Program students claimed that it had a strong positive affect on student attitudes towards learning science and towards learning in-general (Table 9, Items 35 & 36; Table 13).

Learning science became intrinsically rewarding as evidenced by student devotion for collecting data for testing their hypotheses or improving their studies, rather than for going to science fairs or publishing papers. Students were self-motivated and frequently used their summers and vacations at AAST conducting their RIP studies or preparing talks or manuscripts to be submitted for publication. According to one student, "We were fueled by our desires to learn the answers to our questions not those assigned to us by our instructors, this made all the difference."

PHOTOGRAPH: GIRLS CVONDUCTING THEIR RIPS IN THE IMMUNOLOGY LABORATORY

Impact on high school experience, and subsequent academic and career opportunities and successes

Both students and their parents unanimously felt that participation in the RIP Program enhanced the high school experience (Table 9, Items 6 & 30; Table 14). Parents also felt that the RIP Program had a strong to extremely-strong positive impact on the students' success in high school, many referring to the impact of the RIP Program on students' ability to multi-task in high school and beyond (Table 9, Item 27; Table 14).

Table 14. AAST student and their parent's comments regarding RIP/RIP Program enhancement of their high school experience and later academic and career opportunities and successes

High School Experience
Student Comments
"It expanded my world-view by taking the theoretical and making it practical, by making myself, as well as my fellow students, active within a realm where we thought it was impossible for us to even participate."
"Participating in the… [RIP] research program at AAST gave me the opportunity for … learning in subjects which I might otherwise have never studied in class -- or given much attention to if I had. The excitement and intense work required by the RIP program drew together many of my skills, and gave me the opportunity to engage areas of academic study to which I might not otherwise have paid much attention."
"The RIP program provided a lot of structure… . I learned a lot of discipline while working on my project and my work ethic improved dramatically."
Parent Comments
"He always came home from school very excited about his study and what he was finding. I really believe that his engagement in scientific research was the pinnacle of his high school experience and encouraged his academic and personal growth."
"It taught him the process of learning. He actively took the responsibility to become a learner."
"The principles and methods she learned in research were useful in evaluating statement and theories in other subjects and life in general."
Subsequent Academic and Career Opportunities and Successes
Student Comments
"The process/workflow of research that I learned at AAST helps adopt a methodical approach to my work and studies to this day."
Learned to think about how to design research to isolate the effects of variables. …the idea of scientific inquiry led me to social science research in college. I have co-authored 1 book chapter and 1 paper in a peer reviewed journal, several newspaper opeds [*sic*] in major publications, and a senior thesis based on my interest in research that began at the Academy.
"The statistics that I learned … was something that has been invaluable in my undergraduate finance work and especially in my graduate business studies."
"I learned ways in which to creatively use my time so that I could accomplish a number of things at once. For example, in college I was able to design a scientific research investigation that could fulfill the requirements of two different classes: Speech and Biological Research. The Academy RIP program taught me how to lump things together in my life so that I could gain the most advantage out of doing one thing well instead of many things adequately."
Parent Comments
"His experiences in high school scientific inquiry laid the path for his future success as a scientist. He is in the final year of his PhD in neuroscience and we completely attribute his goal and drive toward this goal as a direct consequence of the impact from the high school research program."
"Because of this challenging experience, he realized that that he could set his aims high and meet his personal goals. Specifically, this confidence led him to successfully complete a difficult double major in completely disparate fields at Williams College while being involved a wide myriad of extracurricular activities."
"The experience of participating in the research program, which was demanding in terms of time and effort, not only allowed our daughter to realize her abilities and potential in the field of science, but forced her to be disciplined in her time management, so as to pursue her other interests."

Regular and special undergraduate program application and acceptance data for the 40 RIP student respondents are shown in Table 10. There were a total of 237 college applications, or six applications per student. Among these, were 42 special program applications, or one per student. Five of six, or 83% of all applications and 93% of the special program applications led to student acceptances.

RIP Program students appeared to enjoy advantages over non-RIP students in post-high school academic and career opportunities. RIP students received significantly more college acceptances per application, a higher proportion of acceptances to their top four college choices, more academic or research/merit aid scholarships per college acceptance, and more college acceptances offering at least one scholarship (Table 9, Items 12-15). Also, significantly more RIP students that non-RIP students with college degrees graduated from or are currently attending post-graduate education institutions (Table 9, Item 19).

RIP students claimed that their participation in the RIP Program had a strong positive impact on their ability to succeed in college and in college level science courses, was very-helpful in enabling them to compete academically in college, and had a large positive impact on their ability to achieve their career objectives (Table 9, Items 1-3 & 5, respectively; Table 14). Parents of RIP students concurred that RIP Program participation contributed strongly to post-high school success, strongly enhancing applications for colleges of choice and helping students to achieve their career objectives (Table 9, Items 28-29 & 37).

Opportunities for scientific discussion and debate among students

Teachers unanimously agreed that the RIP Program successfully provided opportunities for student scientific discussion and debate (Table 9, Item 21; Table 15). Some students provided

unprompted mention of opportunities and the impact of discussion and debate on their learning of content that stemmed from the RIP Program in their responses to the questionnaire items (Table 15).

Table 15. AAST student and teacher comments regarding opportunities for student scientific discussion and debate

Student Comments
"Teachers seldom told us what to do. We were usually on our own to make decisions and then present them to the teacher and/or our classmates. Our research team would debate and discuss each aspect of our RIP study. On many occasions discussion would be carried from the laboratory into the classroom so that it would involve the entire classes input and the teacher. We would search the Web, download relevant articles from libraries, and even e-mail scientists when we needed to find information relevant to the discussion. Because the content of the "RIP was closely supported by the course science content that we were studying, we were actually discussing the material we needed to know and so these discussions and debates became part of our background material for the RIP in addition to being the content of the science course. This was a far more exciting way, and for me much better, than getting our information from the teacher and by reading a textbook."
"It was the students' responsibility in each RIP team to teach other members of the class about the content from their RIPs. It seemed that we were always preparing something based on our research investigation or other class material to present to each other for discussion."
"One of the most important things I developed from the RIP program was the ability to stand on my own in discussing and debating scientific information. The experience allowed me to have the confidence and ability to question what I am reading and to find evidence to build a successful argument for or against it."
Teacher Comments
"We had in-house science conferences and fairs. Both scientists and students would present their scientific investigations to the audience at our semi-annual science symposium. Also we held student-led weekly seminar courses in which students were assigned articles, in many cases contradictory, to read and present that focused on the content areas surrounding students' research investigations. Scientists from major universities and companies were invited guests and would participate in discussion and debate following the student presentations."
"When papers were prepared for publication or posters for presentation, it always involved a group effort and many hours of discussion and debate as to how to interpret and discuss findings, how to express content, and how to design the presentation."
"Students presented and then defended their RIP story-board proposals in front me, fellow students, and university and company scientists before their studies were actually started. This process allowed all of the students to discuss and contribute their ideas to their colleagues investigations and well as to assist in assessment of the validity of all parts of their investigations.

The frequency of research investigation presentations and number of students presenting their work at in-house conferences and seminars, and professional science and science education sessions exemplify the varied opportunities and experiences afforded by the RIP Program (Table 11, Items 15-29.

Development of communication skills

RIP students attributed their successful abilities to communicate through writing and speaking in college, graduate school, and/or in careers to the practice they experienced through giving research talks and preparing manuscripts of their work for publication in high school (Table 16).

Teachers felt that participation in the RIP program had an exceptionally-large positive influence on student ability to communicate effectively (Table 9, Item 22).

One teacher wrote,

> I will never forget when Audrey, Devika, and Keun Hee were presenting their research talks at Long Wood Gardens and Dr. Kate Mc Gill, an internationally-respected Clinical Biochemist, approached them afterwards and asked them at which graduate school they were conducting their research!

Dr. Mc Gill later recognized the quality of the student's presentations, constituting authentic evaluation, by statements published in an international trade magazine (Mc Gill, 1997):

> …one of the most interesting presentations I have ever heard from a professional laboratory scientist's standpoint…" and, "As well as the sheer interest value of the talks, I was particularly impressed by the quality of presentation by high school students. The work presented that Sunday morning would hold it's own with that of most universities in the UK (p. 51).

Table 16. AAST student comments regarding impact of the RIP/RIP Program on their communication skills

Student Comments
"I believe firmly that my participation and work in the program not only gave me an education in the subject matter I was investigating, but also in the areas of organizational and communication skills, and aided the development of my writing and speaking abilities."
"Many aspects of my job involve reading and commenting on the wording of financial reports. I believe that my experience in publishing a paper through the program gave me insight into how to concisely word thoughts on paper."

"For part of my [college] degree requirements I elected to conduct research and write a senior thesis. I also finished my research and was able to write up an honor thesis and contribute to a paper. I had worked on presentations and papers in the Academy's RIP Program and those experiences served as my foundation in scientific writing."

Parents voiced agreement with students and teachers and suggested that their communication abilities benefited the students in aspects of their lives beyond high school. For example, one parent stated, "The presentation skills she [my daughter] developed through the RIP Program have been wonderful in real life situations."

Confidence in abilities to learn science and in other aspects of life

Students, teachers and parents agreed that students developed confidence in their abilities through their participation with the RIP (Table 17). During their presentations at professional science and science education conferences and meetings, RIP students spoke and interacted with their materials and scientists with such confidence in and command of their content knowledge and communication skills that they appeared to be and were treated as "seasoned" scientists. For example, Dr. David Crews, a distinguished neuroscientist from the University of Texas, followed up his attendance at an AAST *Junior student's* talk at the annual Society for Neuroscience meetings with a written invitation for the latter to join his laboratory and attend the *graduate program* in Zoology at the University of Texas!

Table 17. AAST student, teacher, and parent comments regarding impact of the RIP/RIP Program on student confidence in abilities

Student Comments
"I learned to have more confidence in my own creative abilities."
"After coming to college, I realized that I was more prepared to work in a laboratory setting than many other student because of my previous research experience. I was able to adjust and learn more quickly than others in my lab and definitely had a head start. Having such an advantage helped me feel more confident and motivated in my research endeavor."
"I learned how to learn and this propelled me into my current success as a graduate student in science."
"I realized that I can accomplish any challenge. The hours and mental effort are possible; I've kept that in mind when it comes to any project."

Teacher Comments
"I watched many of my students grow from curious, but less than confident, learners to confident learners of science and other academic areas during their involvement in the RIP Program. I attribute this confidence to the myriad of opportunities for continuous on-going feedback from myself, other students, and members of the science and other professional communities afforded through their experiences while conducting their RIP-based inquiries and throughout their exposure to the RIP Program."
"One of the largest easily observable changes in students involved in our RIP Program was a dramatic, and well justified, increase in confidence in their speaking and writing abilities. My students became so adept at speaking and communicating their RIP studies to the outside scientific and other professional communities, including their scientific findings and the underlying scientific concepts, that they were commonly confused by professionals as being graduate students that looked 'so young.'"
"The RIP Academy students clearly developed confidence in their knowledge of content and understanding of the process of science, and how the two complemented each other, and thus in their ability to critically analyze the scientific information they heard and read."
Parent Comments
"I feel that the research program gave my son the confidence that he could complete difficult tasks if he remained dedicated to them. Because of this challenging experience, he realized that that he could set his aims high and meet his personal goals."
"It not only helped him get into a fine college, it gave him real responsibility, an understanding of how dedication and hard work are needed for success, and a sense of pride and confidence in his accomplishments."
"She certainly exhibits confidence in herself and her decision making abilities. These attributes were certainly enhanced by her experience in the high school research program."
"Gave her self-confidence and made her an independent thinker."

Critical thinking and decision-making ability

Based on student, teacher, and parent questionnaire responses and comments, the RIP had profound affects on student thinking and decision-making skills. Overall, students reported that learning through and using the RIP resulted in a strong positive impact on their ability to use logic and reasoning in making decisions and choices in life as high school and college students and a moderate to strong impact in their careers and personal life (Table 9, Items 8-11, respectively). Students' comments cited ways that learning to think like a scientist contributed to their being critical consumers of information relevant to their daily lives, and how they use logic and reasoning in their decision-making (Table 18). AAST teachers rated the impact of the RIP as between high and exceptionally high for student ability to make good decisions, to critically evaluate data, and on the development of students' critical thinking ability (Table 9, Items 24-26, respectively; Table 18).

Table 18. AAST student, teacher, and parent comments regarding impact of the RIP/RIP Program on student thinking and decision-making

Student Comments
"The RIP is a process or model for conducting scientific research. But is [*sic*] is also a valuable model for how to think about things. Conducting science research at the Academy taught me how to think and this has been useful in all aspects of my life. I feel like I always make careful decisions after weighing the alternatives."
"I learned how to apply probability and logical reasoning to my decision-making ability. I have learned to list, analyze and weigh all of the alternatives in both an objective and subjective sense prior to making a decision. Thus, I now am able in mant [*sic*] situations to take my "best guess" at making the decision that will most likely lead me to the best outcome. As an adult, my life's decisions have also been greatly impacted by my ability to critically analyze information. Thus, when making medical or other decisions, I look much deeper than just at the advertising. I am able to read und understand the "important" information and to make an "educated" decision.
"My involvement in the program taught me to be a critical thinker and to reason through problems as they arose. …I have taken these experiences and the knowledge that I have gained and apply them currently as a medical student. Often I must reason through why a patient has a certain abnormal lab finding and how to correct it. Although some students prefer to learn laundry lists of etiologies for certain conditions and the multitude of ways to approach them, I prefer to rely on my reasoning skills and my core knowledge base. I feel from these I am able to reason through why a lab value may be abnormal and develop a strategy to approach it appropriately."
Teacher Comment
"The RIP process is a model for thinking that promotes learning. My students bought into and adopted this model as their way of thinking and approaching problems to solve. The RIP literally taught them how to learn, and did so very effectively. I would be surprised if they were not using it in all aspects of their everyday life."
Parent Comments
"I think the RIP Program taught my child to look at statements and theories more deeply and to test them out. Obviously this influenced her decision making by forcing my child to be a better consumer of information, not take things at face value."
"Through the RIP Program, my son realized that careful analysis of data does not always reveal what a person hypothesized. He does not make assumptions that everything he 'learns' is accurate or reliable and often seeks corroborating information about topics he is curious about. He asks many questions and critically analyzes what he hears and reads."
"He is always questioning, and his questions always lead him to action. We see him being guided from questions that arise from his critical evaluation and assessment of events he encounters. This has been extremely instrumental in his ability to achieve as much as he has in college and graduate school science."

Parents felt that the RIP was helpful to extremely helpful in the development of critical thinking skills and decision-making ability, and had a strong positive influence on the ability of students to think critically and not just accept everything at face value (Table 9, Items 32-34; Table 18).

Impact of the RIP on student learning of science content

SAT scores for non-RIP and RIP students were not available for comparison. Because AAST students in general were considered high achieving, comparisons of grades or standardized test scores of RIP with non-RIP students would not be expected to reflect any significant differences. In alignment with the NSES, the philosophy of the RIP Program is designed with the belief that students best learn science by doing the same activities that scientists do to learn about the world. Thus evaluations conducted by scientists and other professionals in the field become the most

valid indicator of student knowledge about and understanding of science. The primary source of direct evidence of student's learning of science content then comes from the student products in the form of published papers and research talks and their accolades, such as professional and science fair honors, awards, and recognitions (sample RIP student publications, research talks, and awards are presented in Tables 11 and 12).

INSERT PHOTOGRAPH: STUDENTS PRESENTING THEIR RESEARCH INVESTIGATIONS AT THE SOCIETY FOR NEUROSCIENCE

The research investigations of RIP students were frequently featured in regional and state newspaper articles (e.g., Longo, 1994; McGrath, 1994; and Saks, 1995) which contained evaluation of the quality of the scientific work by scientists active in the field of the student's inquiry. For example, McGrath (1994), in an article in *The Bergen Record* featuring the research findings of RIP students, wrote the following:

> "Here you have a high school student putting to shame some of what you see at a graduate level," said Peter Moller, a professor of biopsychology at Hunter College in New York City and research associate at the American Museum of Natural History. (p. D1, D3)

Student products were also recognized by internationally well-known scientists. For example, after attending research investigation presentations by two RIP students and reading their published studies, Mc Gill (1997) wrote in an international publication:

> Their research has demonstrated conclusively just how easily the immune response to disease and injury can be damaged in koi, making them especially vulnerable and slow to respond to treatment. They have also discovered that some anaesthetics, used in very low concentrations as tranquillizers, can actually boost the immune system, a very important finding with possible impact on future fish handling and treatment procedures. (p.51)

Three students were also internationally recognized in 3 successive years for their scientific contributions to the understanding of fish health. The work of these students, evaluated by an international panel of scientists and fish hobbyists, received the Annual International Platinum Kohaku Award for the most significant scientific contribution to the understanding of fish health (Table 12).

INSERT PHOTOGRAPH: PLATINUM KOHAKU AWARD RECIPIENTS RECEIVING RECOGNITION

Using the RIP, students were able to contribute new and exciting scientific findings to the scientific literature. The work of students significantly contributed to the development of a fish model for the understanding of the effects of neurotransmitters (chemicals found in the nervous system associated with neural messages) on behavior simultaneously controlled by the central and peripheral nervous systems (Table 11, Items 15, 20, & 25). Findings from other student work documenting that the electric signaling of electric fish could be used as biomonitors for water toxins was highlighted in a professional level science book written for scientists (Moller,

1995). RIP Program students worked closely with their teachers to successfully develop an assay for measuring the response of the immune system in fish so that they could study the effects of a variety of factors on fish health and disease (Shah, Gajria, Perrotti, & Landsman, 1997). Students developed technologically-based state-of-the-art methods that have challenged scientists for years. For example, students successfully developed a method for quantifying coloration using computer programs and 35 mm photographs to study its evolutionary significance in animals Table 11, Item 23). Some students were even successful at evaluating the published work of professional scientists and locating errors in methodology or data analysis, resulting in the development of their own research investigations (Table 11, Items 6 & 17). Students also used their knowledge of science as critical consumers of science products. On one occasion, they discovered an error in one of the formulas used by a statistical program manufactured by the former Jandel Corporation. The students took the next step in the RIP by contacting the company and demonstrating the error to company technicians. This resulted in the error being fixed and a partnership between the company and AAST's RIP Program in which Jandel donated all of their software on-site licenses. Companies were so impressed with the quality of the students research investigations that they solicited partnerships with the RIP Program, featuring student outcomes that used their products. For example, results from student-led RIPs are featured internationally on SPSS Corporation websites to advertise successful applications of their products and as part of the corporation's White Papers (http://www.spss.com/sigmastat/prod_sigmastat_uses.htm).

Students claimed that the RIP increased academic performance in science (Table 19). According to RIP Program teacher and developer Robert Landsman,

> By the time most students were seniors, the caliber of the research that they pursued was at a graduate school level, demonstrating both their ability to use inquiry in their learning and their understanding of the underlying scientific concepts involved in all aspects of their RIP studies.

One teacher said, "Many of the projects involved interdisciplinary techniques, and the entire RIP is interdisciplinary/transdisciplinary because it involves content and development of skills in language arts, mathematics, science, art, etc."

In describing how the RIP Program experience enhanced their child's high school experience, one parent stated, "It also gave her a solid background that facilitated her college science experience."

Table 19. AAST student and teacher comments regarding impact of the RIP/RIP Program on student learning of science content

Student Comments
"I found myself learning more science content in all of my science classes because there were so many connections to my research investigation. Before I had just memorized things, now I really needed and wanted to understand these things." You might say that the research 'drove' my learning of content in science."
"I learned to approach my academic endeavors in a more disciplined way. Doing research was fun and motivated me to want to learn more chemistry and physics so that I could better understand my research topic-cellular immunology. The research program experience gave me ownership over my own learning progress."
"The positive influence of participation in the AAST RIP Program was twofold: … My knowledge base obviously expanded, especially through the study of the scientific method and statistical analysis."
"It … provided a practical grounding to … the theoretical concepts we were studying in science classes (cheifly on undertanding physics (electricity, electrical recordings, signal/noise concepts), biophysics(electric signaling in water), chemistry (conductivity, pH), biochemistry (chemical structures and properties) and biology (animal behavior and physiology)."
"The classes were taught with application of the knowledge in mind and this made the transition of applying these skills to one's individual research much easier."

Evidence of creativity fostered by the RIP

The majority of students indicated that their experience with RIP-based scientific inquiry influenced their creative ability (Table 9, Item 7). The most frequent student responses to

questionnaire items related to creativity were that the RIP Program provided them with opportunities to develop "new ways" and/or "many ways" to solve a problem and that the RIP promoted the development of their ability to "think outside the box." Students often, and one teacher, cited examples of creative thinking and creative applications to their research investigations (Table 20).

Table 20. AAST student and teacher comments regarding influence of the RIP/RIP Program on students' creativity

Student Comments
"I learned how to think creatively through participating in research because I had to solve problems as they arose in the course of our study. At one point, I thought that our results were uninformative because I didn't see the expected outcome. My teacher seized the opportunity to teach the importance of data analysis and discussions of sources of error in the methods section. It was revolutionary for me to consider that we could present data in a way that was both self-critical and informative. It required that we think creatively about the findings and learn how to frame them so that it would be of value scientifically as a constructive building block toward answering a larger question."
"I learned to have more confidence in my own creative abilities. Sometimes I will use a technique used by other scientists, but will try some part of it slightly differently and it will have a very positive consequence in improving the entire method. I actually learned to be creative like this in the Academy research program when I designed a better way to make the silastic implants [containing hormones] so that they could be easily put into the fish."
"I learned how to approach problems from a multitude of directions at the same time. This takes alot of creativity so that you can use aspects of rach [*sic*]approach to make your own solution to the problem even better. This dimension of problem-solving has enabled me to excel in both my research and academic endeavors. I was able to incorporate some of this creativity into the method I used to quantify color change in my RIP. I studied how motivational states influenced color change in the guppy. No scientists were able to figure a way to quantify the color changes accurately. I used the pixel counts and other characteristics of Photoshop to quantify the color xhanges [*sic*] that had been recorded in 35 mm pictures. The methods I used attracted famous scientists to the presentation of my work at the Society for Neuroscience."
"Every one of our [students'] investigations had to be directly connected to some part of the course curriculum. Either the teacher or we had to align the research topic of our investigations with what we were expected to learn in the course. Sometimes this was easy and sometimes was quite a challenge and forced us to use creativity in our thinking to link the RIP background section with what we were expected to cover and learn in a particular unit. When we had problems keeping water factors such as pH and conductivity constant in the aquaria, we used our chemistry class to learn about pH and buffers and relationships between temperature and these factors. When we needed to spin fish blood samples in a centrifuge to separate white blood cells, we used physics classes to explore centrifugal force."
"I am able to think outside of the box more. I think my gain in creativity is my ability to solve problems in different ways. Even when you cannot initially solve a probelm [*sic*] in business, it helps that you can fal [*sic*] back on the methods that you learned from my background in the RIP research program."
Teacher Comment
One evening two students and their two student research assistants were beginning their investigations on the immune system of fish after spending an entire day obtaining trout cells from a hatchery. The school immunology laboratory had been pre-set at great time and supply expense to conduct the investigation. Something went wrong in the transporting of the cells from the field to the school lab and the cells had all died. To save their investigation, the students decided to revise their study by substituting African electric fish immune cells in place of trout cells. This creative decision led to a very exciting evening with the students and their parents being the first to ever observe and record the very unique immune cells in these fish.

Application of RIP to life

Students were able to and still are applying components of the RIP and the entire process in science and non-science application to help make their everyday lives successful. Their questionnaire responses and comments frequently mentioned that their RIP experiences helped them to make career choices and decisions, fulfill job responsibilities, and/or select college and/or graduate school majors (Table 21).

Table 21. AAST student comments regarding application of the skills and processes learned from the RIP to life

"In my work at a Memory Disorders Clinic, I conduct informed consent sessions with people with dementia and their caregivers. I observed the interactions between patients and their family members and started asking questions about how their interactions related to decision making abilities of patients. I identified an event where I could collect data. I worked with my mentor to design and carry out a study. The process of scientific inquiry I learned in high school was instrumental in how I was reading the interaction between patients and caregivers as a source of data. The skills I learned from RIP, namely how to be an astute observer, how to ask questions and how to answer those questions, have stuck with me."
"I have taught a number of undergraduate courses during my MD program and have introduced the RIP in ecery [*sic*] course!"
"I am currently applying to MD/PhD programs and plan a career as a physician-scientist. I plan a career in academic medicine, with my time divided between clinical care, basic research, and teaching responsibilities. I will likely spend the majority of my time in the laboratory, investigating the basic processes underlying human diseases. Thus, the RIP training at the Academy helped to cement my career decision and laid a good foundation for my undergraduate research training."
"I provide advice to those who are running or starting small companies, especially in information technology. My approach to a new project is identical to the RIP in many ways: I gather comprehensive information via Internet, journals, case studies, financial data, etc., then form a proposal and/or hypothesis, run tests or create models, then apply the results of my investigations to my clients. This approach reduces the error of my advice, and increases the efficiency of my work."
"My research experience has served as an invaluable tool both academically and profesionally. As an economics and international relations major at Stanford University, I often found myself writing research and policy papers on various economic and political topics where I had to formulate my own hypothesis. These papers required a fair amount of research and due diligence to be able to gain support for my hypothesis, skills that I was able to acquire through the RIP at the Academy. I also use these skills as an investment bankers when analyzing differnet [*sic*] markets."
"Due to the reserach [*sic*] at the Academy, I was able to delve myself deeper in the scientific experience at college than most other students. While I had a notion that I would like to go to medical school, the RIP program actually steered me towards pursuing an MD/PhD program and pursue the academic medicine and research route."
"At the London School of Economics, I applied RIP when writing my Masters thesis on credit markets in developing countries."
"The way I approach my work in dementia research has been greatly influenced by my experience in high school research. I value the integrity of the data I gather over all other aspects that could influence my handling of the data. I feel that my reverence for science and the scientific process was solidified in high school and is enacted every day in my work."
"…in my career in medicine, I need to use evidence-based medicine everyday and read journals and really try to understand what are the best treatment plans for my patients. My exposure to research has allowed me to thoughtfully read these papers and make decisions on which studies were done well and which were not to make ultimate choices as to the proper treatment of my patients."
"In my personal life, I am able to use my reasoning skills when making all of my decisions. My decision to go to graduate school was difficult in itself, but choosing between programs and schools was also difficult. In the end, I was able to lay out all of my options and analyze the impact of each of my decisions. The experience of performing research first hand made this experience a lot smoother."

RIP facilitation of teachers learning of science

Whether newly trained in RIP-based instruction or experienced partners in using the RIP process in learning with their students, teachers indicated that this inquiry approach to science education helped them to better learn and understand more scientific concepts or underlying scientific concepts that were previously challenging to them (Table 22).

Table 22. AAST teacher comments regarding RIP facilitation of their learning

"The RIP profesasional [*sic*] development training taught me the same processes that I would be guiding my students through, and I was able to begin learning aspects of areas of science that I had never before thoroughly understood. To be able to practice science, you really need to understand the concepts underlying the principles."
"I began to see how scientists really learn about things and was able to apply components of the RIP to actually add to my own learning of science concepts. Because the teacher in a RIP program is a partner in learning with the student, the teacher learns as much as the student about the content of the topic under investigation."

Teacher as a source and facilitator of change in science education

Teachers involved in the AAST RIP Program frequently gave informal and formal talks and published papers explaining the RIP Program and the products that resulted from its implementation (Table 11, Items 30-31, 32-39, 41-42; Table 23). Teachers also partnered with students in the production of new science knowledge (Table 11, Items 40 & 43, Table 23). Three RIP teachers were awarded the 1994-1995 New Jersey State Department of Education's Best Practice Award in Sciences and Mathematics.

The uniqueness of the RIP approach to inquiry-based science education at AAST was highlighted in the *New York Times* (Roane, 1996), and trade publications such as *Mid-Atlantic Koi Magazine* (Burton & Burton, 1996) applauded it as a solution in science education reform.

Table 23. AAST teacher comments regarding teacher as source and facilitator of change in science education

Teacher Comments
"My training and participation in guiding students in the RIP, made me realize that I could be the producer of positive change. It motivated me because it was an exciting approach to science education, quite different from the old textbook-lecture approach. I was able to learn and produce new science right alongside my students. This motivated me to extend outward and share this program with other teachers and schools. It also stimulated me to support my students in taking high school science to a new level with in-house research that could actually produce refereed publishable papers and invited science education and science talks. So, not only was I able to be a part in shaping and learning from this approach to instruction through inquiry, but I was also able to share it with others to help facilitate change in science education."
"I successfully presented papers at the Society for NS and other professional science and science education conferences. The successes of the students who went through the Rip Program were clearly due to the characteristics of the program. Thus, the student products and recognition of their value by professionals in the field indicate that the instructional techniques in the RIP really do work successfully."
"The entire process is inquiry, while each component of the process is an essential element of inquiry in science. The steps and accompanying activities that Dr. Landsman has developed to introduce the RIP components to teachers, and teachers their own students, and to inplement the process in the classroom or school, makes it very user friendly and easy to bring inquiry into the high school education arena. The entire program is based on the students taking responsibility for their own learning...learning how to learn and constructing their own path through education. The teacher facilitates and guides, when necessary, the process."
"Everything that was done was student led. Eventually, most students even initiated their own RIPs. Socratic questioning was used as opposed to teacher-delivered information as a tool to stimulate learning. The student became both the source and consumer of information. The teacher served as guide and co-consummer of information produced by the student."

De-emphasis of textbook and lecture in lieu of real experiences

Student responses frequently referred to a variety of advantages and positive outcomes resulting from the RIP and RIP Program not relying heavily on textbooks and lectures, but rather emphasizing original sources of information and active engagement in the learning process through research (Table 24).

Table 24. Student comments regarding the RIP Program's less emphasis on textbook and lecture and more emphasis on active learning

"It gave me real-life experience of scientific research methods, and an understanding of scientific methodology that far exceeded anything I could have gained from textbooks and in-class lectures."
'It made science less of a dry subject confined to poorly-written introductory textbooks, and more of a living option. …I've been able to return to it now with a vigor which I probably would not otherwise have had. I have a much deeper understanding of the 'scientific process', and an increased appreciation for what science manages to show us about ourselves and the world in which we live."
"…learning through scientific inquiry turned me on to science. What turned me off to science…was my freshman year science classes at Stanford which were all lecture based and full of pre-meds. I was "spoiled" from the interesting, interactive RIP experience where the 'textbook' was the classroom. My experience from the RIP program stuck with me as I always found myself sticking my head in and learning about other students' scientific research and through conducting my own social scientific research."
"Immediately got me engaged and excited about science. Brought science out of the textbook. Also showed me that I could be not just a student of science, but also an author - that aspect was and is still fascinating to me. After thousands of years of scientific research, there is still room for me to make a contribution."
"More than anything, engating in the RIP helped to show me that learning is not something that goes on merely in the classroom or in books…we learn about the world in a wide variety of ways, very few of which come close to the importance of being "face-to-face" … with our objects of study, able to guide our research and test our results by way of other great practitioners in the field."

Cooperation, shared responsibility, and respect for supporting a classroom community

Students, teachers, and parents cited important aspects of the RIP Program that supported the classroom community. Students frequently mentioned development of respect for differences in their abilities and personalities, the collegiality arising from group collaborations, students unselfishly supporting each other in their scientific inquiry endeavors and even in unrelated class-work, sharing the responsibility with the teacher in designing and executing the curriculum and the safety responsibilities they shared as a whole (Table 25). Teachers frequently mentioned collaboration among their peers, ethics components of the RIP such as the responsibility of students to each other for safety in the laboratory, and parent support of student endeavors. The majority of parents felt that the RIP Program clearly provided them with unique opportunities to become participants in the student's education experience (Table 9, Item 31; Table 25).

Table 25. AAST student, teacher, and parent comments regarding impact of the RIP/RIP Program on the classroom community

Student Comments
"It helped me in the following aspects: …working on a difficult and intellectually stimulating project in a group with sometimes differing interests…."
"I was given freedom to not only choose my what I was going to research, but how I was going to do it, what I was going to hypothesize and how I was going to present it."
"One student responsibility was that 'senior,' more experienced, RIP students became the teacher for and mentor students just entering the program. That meant that new students learned initially as assistant research scientists and then eventually began their own inquiry as the head scientist."
"The program had a strong ethics component. Safety was always a big issue and student's responsibility to ensure the safety of fellow students was always stressed and enforced."
"We learned by experience that we had to hold up our end of the work commitment for our investigations to even have a chance to turn out okay. We were responsible to our colleagues, ourselves, and our teachers"
Teacher Comments
"A strong ethics component is part of the RIP. Students learn formost [*sic*] to respect each other for individuality and variance in knowledge and abilities. Inquiry can involve the use of high-risk materials and procedures and so safety through respect and concern for others was also introduced as part of the RIP curriculum. Everyone was expected to support each other. When a key student was absent on a certain day, other students not involved in that study were expected to fill in and assist so that the study was not ruined."
"One of the initial and primary foci of the RIP is on ethics, including general ethics and scientific ethics. Students are exposed to the concepts of the rights of the animal and human subject in research as well as the treatment of each other as colleagues and scientists. One student group RIP project on the effects of growth hormone on regeneration in planaria ended up being a study in ethics. The students observed that their worms looked different and varied in numbers in a very strange way over the course of their investigation. They set up infared cameras and caught a second group of students visiting the research lab after hours and exchanging the planaria that they had not cared well for with the healthy specimens of the victimized student scientists! Their study then focussed on ethics and cheating in science."

"The pogram [*sic*] involved a constant interaction with teachers specializing in many areas, including the sciences, but not limited to them. For example, many of the RIPs involved using research tools and techniques found in electrical engineering and chemistry necessitating the involvement of teachers specializing in those fields to become co-mentors on a number student investigations. When research presentations were being prepared, the art and language arts teachers used these opportunities to share in the guidance of students."
"In many instances, parents of the students became as committed to the RIP Program as the students. Charlie was studying a neural control of electric signaling in a nocturnal electric fish and had to collect his data in the evenings. Charlie's father would come to pick him up in the evenings and would patiently wait, sometimes for hours, for his son to complete his data collection. On one occasion, Charlie was collecting data and his results were so exciting that his father stayed until the wee hours of the morning allowing his son the opportunity to complete his entire study! On numerous other occasions, parents came to school to support their student's efforts in different ways."
Parent Comments
"I believe the program brought a greater sense of responsibility and sticktoitiveness in reference to completing various tasks. It gave us the opportunity to be involved in the life of our child to a greater degree and thereby focusing on the fact that what one does in life is no single effort to achieve the highest potential success."
"We were in the school to help in completing the presentation that my daughter was supposed to be giving and I being a scientist, felt kind of jealous since I was not given that kind of opportunity in the early school years."
"Although the scope of her research project was beyond our understanding, we became partners in terms of providing transportation as well as snacks and the service of washing lab coats. We also shared in the pride of her accomplishments."