Museum Visitor Studies, Evaluation & Audience Research

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Evaluation:
Flight Planning Program

Prepared for the
Hiller Aviation Museum
San Carlos, CA

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SUMMARY AND DISCUSSION

This report presents findings of a program evaluation conducted by Randi Korn & Associates, Inc. (RK&A), for the Hiller Aviation Museum in San Carlos, California. The evaluation examined learning outcomes and experiences of 6th to 8th grade Boy Scouts attending the Hiller Aviation Museum's Flight Planning Program to earn an Aviation Scout Merit Badge. The full-day program was offered one Saturday a month in October, November, and December 2010. A total of 65 Scouts completed pre-program and post-program questionnaires about their understanding of the importance of math in aviation, ability to compute basic mathematical formulas for flight planning, experiences in the program, and math background.

The findings presented here are among the most salient. Please read the body of the report for a more comprehensive presentation of findings.

BACKGROUND CHARACTERISTICS

- 51 percent of the boys were ages 10 to 11 and 49 percent were ages 12 to 14.
- 66 percent of the boys were in 6th grade, 17 percent in 7th grade, and 16 percent in 8th grade.
- Most of the boys were currently taking 6th- grade math (49 percent) or pre-algebra (26 percent).
- The top two reasons for attending the program were "to complete as many badges as possible" (51 percent) and because "the activities for completing the aviation badge sounded interesting" (22 percent).
- 63 percent of the boys had visited the Hiller Aviation Museum in the past.

PRE-PROGRAM AND POST-PROGRAM ATTITUDES ABOUT THE IMPORTANCE OF MATH IN AVIATION

After attending the Flight Planning Program, Boy Scouts expressed a more positive attitude about math and its importance in aviation.

Of five statements about the importance of math, the boys' responses to three statements did not change significantly from pre-program to post-program; however, it is important to note that the pre-program mean scores were quite favorable to begin with. The boys' responses to two statements changed significantly[1] from pre-program to post-program:

- On the scale 1 "Strongly disagree" to 5 "Strongly agree," the mean score for the statement "Math is an important subject for pilots to know" improved significantly from pre-program (mean = 4.2) to post-program (mean = 4.6).

[1] A "significant change" statistically significant at the $p \leq 0.05$ level.

- On the scale 1 "Strongly agree" to 5 "Strongly disagree" (reverse coded), the mean score for the statement "Pilots don't need to know math because the airplane computer does all the calculations" improved significantly from pre-program (mean = 4.1) to post-program (mean = 4.4).

A total score representing the boys' overall attitude about math and its importance in aviation was computed by adding together the scores of the five statements (with a possible range of 5 to 25 points).

- The boys' overall attitude about math and its importance in aviation improved significantly from pre-program (mean = 21.21) to post-program (mean = 22.26).

RUBRIC-SCORED LEARNING OUTCOMES

RK&A developed three rubrics to measure and classify the boys' accomplishment of two learning outcomes. Each rubric identified specific criteria for classifying each boy's accomplishment of the learning outcome into one of four categories on a scale of: 1) Below Beginning, 2) Beginning, 3) Developing, or 4) Accomplished.

OBJECTIVE ONE: LEARN TO USE MATH IN FLIGHT PLANNING

After attending the Flight Planning Program, Boy Scouts showed greater facility in using math to solve an aviation problem.

Objective One: Improve student facility using simple, linear equations such as those used for flight planning (e.g. distance = speed × time; fuel consumed = fuel flow rate × time). Pre-program math problems would demonstrate a certain level of computation mastery. Post-program math problems should demonstrate improvement in computation mastery.

An open-ended question on the pre-program and post-program questionnaires asked "If the fuel gauge on your airplane was broken, how would you find out if you have enough fuel to complete your flight?" RK&A evaluated and scored each boy's written responses to the question according to the following rubric:

Score	Criteria
Below Beginning (1)	Participant does not provide a response, provides an irrelevant response, or a response that does not include any solution.
Beginning (2)	Participant does not reference math skills but provides a relevant response.
Developing (3)	Participant references math skills in a general way in his response, uses incorrect variables or equations that do not answer or only partly answers the question.
Accomplished (4)	Participant uses math equations to answer the question. The answer may or may not be correct.

- The post-program mean rubric score (2.09 on the 4-point rubric scale) shows a significant improvement over the pre-program mean rubric score (1.86 on the 4-point rubric scale).

OBJECTIVE TWO: UNDERSTAND THAT MATH IS ESSENTIAL FOR SAFE FLIGHT

After attending the Flight Planning Activity, Boy Scouts did not acknowledge learning anything about math and its importance in planning a flight. After attending the Flight Simulator Activity, Boy Scouts did not acknowledge learning anything about math and its importance in flying an airplane.

Objective Two: Students understand that the application of math to flight is essential for successful, safe flight. After the program, students should conclude that without math, the airplane cannot be flown safely.

FLIGHT PLANNING ACTIVITY

A question on the post-program questionnaire asked "What, if anything, did you learn during the Flight Planning Activity?" RK&A evaluated and scored each boy's written response according to the following rubric:

Score	Criteria
Below Beginning (1)	Participant states that he did not learn anything (e.g., writes "I don't know") or provides an opinion ("I learned flying is cool").
Beginning (2)	Participant states that he learned aviation facts or concepts but does not mention math (e.g., "I learned to plan a flight").
Developing (3)	Participant states he learned general math concepts and facts, or general importance of math to activity.
Accomplished (4)	Participant discusses in detail the importance, utility or applications of math to flight planning.

- Most of the boys scored at the Below Beginning or Beginning levels (77 percent), meaning they did *not* mention anything about math when they described what they had learned in the Flight Planning Activity.

FLIGHT SIMULATION ACTIVITY

A question on the post-program questionnaire asked "What, if anything, did you learn during the Flight Simulation Activity?" RK&A evaluated and scored each boy's written response according to the following rubric:

Score	Criteria
Below Beginning (1)	Participant states that he did not learn anything (e.g., writes "I don't know") or provides an opinion ("I learned flying is cool").
Beginning (2)	Participant states he learned aviation facts or concepts but does not mention math (e.g., "I learned to fly a plane").
Developing (3)	Participant states he learned general math concepts and facts, or general importance of math to activity.
Accomplished (4)	Participant discusses in detail the importance, utility or applications of math to flight simulation.

- Nearly all of the boys scored at the Below Beginning or Beginning levels (92 percent), meaning they did *not* mention anything about math when they described what they had learned in the Flight Simulator Activity.

PROGRAM EXPERIENCES

OPINION OF THE FLIGHT PLANNING ACTIVITY

Boy Scouts' responses to the Flight Planning Activity were fairly positive but ratings also indicate that the computations and the map activity were confusing to some boys.

On the post-program questionnaire, the boys evaluated four statements about the Flight Planning Activity using the scale Always – Sometimes – Never.

- 86 percent of the boys were "always" familiar with the calculations they were asked to complete.
- 69 percent of the boys "always" understood the instructor's directions.
- 48 percent of the boys "always" ended up with the same answers as the instructor, and 49 percent "sometimes" ended up with the same answers as the instructor.
- 57 percent of the boys were "sometimes" confused when reading the map.

CONCLUSIONS

Evaluating the effects of a one-time experience, such as the Flight Planning Program, is challenging. Studies in both informal and formal education have long shown that repeat exposures have a much greater effect on students' attitudes and skills than a one-time program. As such, it is noteworthy that this evaluation of the Flight Planning Program found any differences in the pre- and post-measures. The fact that the Scouts' overall attitudes towards math and its importance in aviation improved and Scouts' ability to use math to solve a problem was also enhanced speaks to the overall success of the Program.

That said, the findings also demonstrate some aspects of the Flight Planning Program that could be enhanced. The Scouts seem somewhat unclear about the Program's main message, "Without math, an airplane cannot be flown safely." Their confusion is demonstrated in their similar pre- and post-program ratings of the statement "Without math, pilots would not be able to safely fly to their destination." Furthermore, this statement also had the lowest mean ratings of all the statements. Scouts' ambiguity about the Program's message is also shown in the rubric-scored, post-program questions that asked Scouts to describe what they learned in the Flight Planning and Flight Simulator Activities—the vast majority of Scouts did not discuss math in their responses. Museum staff may want to be more explicit about this message during the Program, including overtly connecting the Flight Planning with Flight Simulator Activities. In fact, Scouts' responses to the Flight Simulator Activity indicate that the connection to math was particularly tenuous for this aspect of the Program. The Scouts' post-program responses also show that instructors could spend additional time reviewing computations and explaining the map. This would ensure that the majority of boys would be able to complete these two aspects of the Program.

INTRODUCTION

This report presents findings of a program evaluation conducted by Randi Korn & Associates, Inc. (RK&A), for the Hiller Aviation Museum in San Carlos, California. The evaluation examined learning outcomes and experiences of 6th to 8th grade Boy Scouts attending the Hiller Aviation Museum's Flight Planning Program to earn an Aviation Scout Merit Badge. The full-day program was offered one Saturday a month in October, November, and December 2010. A total of 65 Scouts completed pre-program and post-program questionnaires about their understanding of the importance of math in aviation, ability to compute basic mathematical formulas for flight planning, experiences in the program, and math background.

Specifically, the evaluation objectives were to examine Boy Scouts':

- Perceptions of the usefulness of math;
- Understanding and appreciation of the practical applications of math skills necessary to planning a successful flight;
- Ability to make basic computations necessary to planning a successful flight;
- Reasons for pursing the aviation Scout Merit Badge;
- Program experiences.

METHODOLOGY

Standardized questionnaires were used for the evaluation because the resulting data can be analyzed using a variety of statistical procedures. RK&A consulted with Hiller Aviation Museum staff to develop pre-program and post-program questionnaires with a variety of question formats (see questionnaires, Appendix A). Most of the items on the pre-program and post-program questionnaires were identical, allowing RK&A to look at changes after participation in the program without the confounding variables of prior math education and experience. To reduce the possibility of priming by the pre-program questionnaire, one item on both questionnaires asked about a task, calculating how much fuel a plane holds, that was not explicitly covered in the program. The post-program questionnaire included additional items asking the Scouts to evaluate specific activities in the program.

Prior to the day of the program, the boys' parents received a parental consent form giving permission for the child to participate in the evaluation. Only boys who returned parental consent forms were surveyed. On each program day, RK&A verbally administered the pre-program questionnaire to the entire group of Boy Scouts (with parental consent) before they began the program and then verbally administered the post-program questionnaire to the entire group (with parental consent) after they completed the program. To ensure the responses were confidential, the questionnaires were identified by a number instead of a name.

DATA ANALYSIS

Data were analyzed using SPSS 12.0.1 for Windows, a statistical package for personal computers. Analyses included both descriptive and inferential methods. For all statistical tests, a 0.05 level of

significance was used to preclude findings of little practical significance.[2] Only statistically significant findings are presented in the body of the report. See Appendix B for a listing of all statistical analyses that were run.

Frequency distributions were calculated for all variables. Summary statistics, including the mean (average) and standard deviation (spread of scores: "±" in tables), were calculated for interval level variables such as rating scales and rubric scores.

To test for changes in mean scores from pre-program to post-program, a paired-comparison (dependent) t-test was performed and the t-statistic was used to test the significance of the difference in pre-program and post-program means. For example, Scouts' pre-program and post-program ratings of the statement "Math is an important subject for pilots to know" were compared to determine if ratings of the statement changed from pre-program to post-program.

Responses to open-ended questions (e.g. "If the fuel gauge on your airplane was broken, how would you find out if you have enough fuel to complete your flight?") were scored quantitatively according to rubrics that describe, on a continuum, accomplishment of certain learning outcomes. For each outcome, the rubric includes a continuum of achievement on a scale from 1 to 4, with 1 being "Below Beginning" to 4 being "Accomplished." To develop the rubric, RK&A used the program's stated goals and objectives and the boys' written responses.

The remainder of this report presents findings of the program evaluation. Tables and graphs are used to present the information. Percentages within tables do not always equal 100 owing to rounding. Findings are organized around the following five sections:

SECTIONS OF THE REPORT:

1. Introduction
2. Background Characteristics
3. Pre-program and Post-program Attitudes About Math and its Importance in Aviation
4. Rubric-Scored Learning Outcomes
5. Program Experiences

[2] When the level of significance is set to $p = 0.05$, any finding that exists at a probability (p-value) ≤ 0.05 is "significant." When a finding (such as a difference in pre-program and post-program rating scores) has a p-value of 0.05, there is a 95 percent probability that the finding exists; that is, in 95 out of 100 cases, the finding is correct. Conversely, there is a 5 percent probability that the finding would not exist; in other words, in 5 out of 100 cases, the finding appears by chance.

PRINCIPAL FINDINGS

This report examines learning outcomes and experiences of 6th to 8th grade Boy Scouts attending the Hiller Aviation Museum's Flight Planning Program. A total of 65 Scouts completed pre-program and post-program questionnaires. A few high school-aged Scouts also attended the program and were surveyed; however, their responses were removed from the sample owing to the disparity between their and the middle school-aged boys' math background.

DATA COLLECTION DAYS

Table 1 presents the number of Scouts participating in the program evaluation according to program date. The majority of data was collected in December, as this program was the most well attended and had the highest parental consent form return rate.

TABLE 1

DATA COLLECTION DAYS

DATE	*n*	%
October 9	10	15
November 13	14	22
December 11	41	63

BACKGROUND CHARACTERISTICS

This section describes the Scouts' age, grade in school, current math class, reason for participating in the program, and history of visiting the Hiller Aviation Museum.

AGE AND GRADE

Table 2 shows the Scouts' age and grade in school. One-half were 10 to 11 years (51 percent), and one-half were 12 to 14 years (49 percent), with a mean age of about 12 years. Two-thirds of the Scouts were in 6th grade (66 percent), and the rest were in 7th grade (17 percent), 8th grade (16 percent), or 5th grade (1 percent).

TABLE 2

AGE AND GRADE

AGE [1] (*n* =65)	%
10	3
11	48
12	29
13	19
14	1
GRADE (*n* = 65)	**%**
5th	1
6th	66
7th	17
8th	16

[1]Median age = 11 years; Mean age = 11.7 years (± 0.87)

CURRENT MATH CLASS

Table 3 shows the Scouts' current math class. Nearly one-half were taking 6th-grade math (49 percent), and just over one-quarter were taking pre-algebra (26 percent). The others were taking Algebra (12 percent), 7th-grade math (5 percent), 8th-grade math (5 percent), geometry (1 percent), or none (1 percent).

TABLE 3

CURRENT MATH CLASS

MATH CLASS (*n* = 65)	%
6th-grade math	49
Pre-algebra	26
Algebra	12
7th-grade math	5
8th-grade math	5
Geometry	1
None	1

REASON FOR ATTENDING THE PROGRAM

One-half of the Scouts attended the program because they were "trying to complete as many badges as possible" (51 percent), and one-fifth attended because "the activities for completing the aviation badge sounded interesting" (22 percent) (see Table 4). The remaining boys attended because of an interest in airplanes and flying (11 percent), to pursue an aviation hobby (9 percent), because of an interest in becoming a pilot (6 percent), or because their parents enrolled them (5 percent).

TABLE 4

MAIN REASON FOR PURSUING THE AVIATION SCOUT MERIT BADGE

REASON (*n* = 65)	%[1]
I'm trying to complete as many badges as possible.	51
The activities for completing the aviation badge sounded interesting.	22
I have a general interest in airplanes and flying.	11
Learning about airplanes and flying is a hobby of mine.	9
I would like to be a pilot when I grow up.	6
My parents enrolled me.	5

[1]Total percent exceeds 100 because some of the boys reported more than one reason for attending the program.

FIRST OR REPEAT VISIT TO HILLER AVIATION MUSEUM

The majority of Scouts had previously visited the Hiller Aviation Museum (63 percent) (see Table 5).

TABLE 5

FIRST OR REPEAT VISIT TO HILLER AVIATION MUSEUM

VISIT (*n* = 65)	%
Repeat	63
First	28
Not sure / No response	9

PRE-PROGRAM AND POST-PROGRAM ATTITUDES ABOUT THE IMPORTANCE OF MATH IN AVIATION

EXPLANATION OF SCORING

This section presents information about changes in the boys' attitudes about math and aviation after attending the program. On the pre-program and post-program questionnaires, the boys responded to five statements about math and aviation on the scale "Strongly disagree − Disagree – Not Sure – Agree – Strongly agree." Depending on the statement, the most favorable response was either "Strongly disagree" or "Strongly agree." Each statement was scored from 1 to 5 points with 1 point given to the least favorable response and 5 points given to the most favorable response.

The scores of the five statements were added together to create a total score representing overall attitude about math and its importance in aviation (with a possible range of 5 to 25 points). To identify changes in attitude from pre-program to post-program, the boys' pre-program and post-program scores were compared for each statement, as well as the total score representing students' overall attitude about math and its importance in aviation.

FINDINGS

Table 6 presents the pre-program and post-program mean scores for the five statements (see Appendix C for a full breakdown of boys' pre- and post-program responses to each statement). According to the scoring plan of 1 = least favorable response to 5 = most favorable response, note that the *pre*-program mean scores ranged from 3.9 to 4.5, indicating that the boys had very good attitudes about math and aviation even before they even started the program.

TABLE 6

PRE- AND POST-PROGRAM ATTITUDES ABOUT MATH AND AVIATION

5 - POINT SCALE: STRONGLY DISAGREE (1) / STRONGLY AGREE (5)	*n*	PRE-PROGRAM MEAN	POST-PROGRAM MEAN
Math is an important subject for pilots to know.[1]	65	4.2	4.6
Math is useful and necessary for a variety of endeavors.	63	4.4	4.5
Without math, pilots would not be able to safely fly to their destination.	63	3.9	4.0
5 - POINT SCALE: STRONGLY AGREE (1) / STRONGLY DISAGREE (5)	***n***	**PRE-PROGRAM MEAN**	**POST-PROGRAM MEAN**
I have to take math in school, but it doesn't really help me in the real world.	65	4.5	4.6
Pilots don't need to know math because the airplane computer does all the calculations.[2]	65	4.1	4.4

[1] $t = 3.739$; $df = 64$; $p = .000$
[2] $t = 2.421$; $df = 64$; $p = .018$

Of the five statements, two show a statistically significant change in the boys' attitudes from pre-program to post-program:

- On the scale 1 "Strongly disagree" to 5 "Strongly agree," the mean score for the statement "Math is an important subject for pilots to know" improved significantly from pre-program (mean = 4.2) to post-program (mean = 4.6).
- On the scale 1 "Strongly agree" to 5 "Strongly disagree" (reverse coded), the mean score for the statement "Pilots don't need to know math because the airplane computer does all the calculations" improved significantly from pre-program (mean = 4.1) to post-program (mean = 4.4).

Table 7 shows the pre-program and post-program mean scores representing the boys' overall attitude about math and its importance in aviation. To create the total score representing overall attitude, scores of the five statements were added together (with a possible range of 5 to 25 points).

- The boys' overall attitude about math and its importance in aviation improved significantly from pre-program (mean = 21.21) to post-program (mean = 22.26).

TABLE 7

PRE- AND POST-PROGRAM OVERALL ATTITUDE ABOUT MATH AND AVIATION

TOTAL SCORE (POSSIBLE RANGE: 5 – 25)	*n*	RANGE	MEAN	±
Pre-program total score	62	15 - 25	21.21	2.159
Post-program total score	62	16 - 25	22.26	2.180

[1]t = 3.523; *df* = 61; *p* = .001

RUBRIC-SCORED LEARNING OUTCOMES

This section presents the boys' rubric scores for two program objectives. Each boy's written responses to three open-ended questions on the pre-program and/or post-program questionnaires were scored using rubrics designed to measure and classify his accomplishment of each objective into one of four categories: 1) Below Beginning, 2) Beginning, 3) Developing, or 4) Accomplished. For both objectives, verbatim responses exemplifying each level of accomplishment are provided in Appendix D.

OBJECTIVE ONE: LEARN TO USE MATH IN FLIGHT PLANNING

Objective One: Improve student facility using simple, linear equations such as those used for flight planning (e.g. distance = speed × time; fuel consumed = fuel flow rate × time). Pre-program math problems would demonstrate a certain level of computation mastery. Post-program math problems should demonstrate improvement in computation mastery.

EXPLANATION OF SCORING

To assess the boys' achievement of this objective, the pre-program and post-program questionnaires asked the question "If the fuel gauge on your airplane was broken, how would you find out if you have enough fuel to complete your flight?" RK&A evaluated and scored each boy's pre-program and post-program responses to the math problem according to the following rubric:

Score	Criteria
Below Beginning (1)	Participant does not provide a response, provides an irrelevant response, or a response that does not include any solution (e.g., "I don't know" or "fly until you crash").
Beginning (2)	Participant does not reference math skills but provides a relevant response. Example: "Use emergency gauge or make emergency landing."
Developing (3)	Participant references math skills in a general way in his response, uses incorrect variables or equations that do not answer or only partly answers the question. Example: "By finding out how much fuel you were going to burn and making sure you had at least an hour of extra fuel."
Accomplished (4)	Participant uses math equations to answer the question. The answer may or may not be correct.

FINDINGS

Prior to the program, most boys scored at the Below Beginning (37 percent) or Beginning (42 percent) levels. Twenty percent of the boys had a rating of Developing, and 1 percent had a rating of Accomplished (see Figure 1). The boys' pre-program mean score was 1.86 on the 4-point rubric scale (see Table 8).

After the program, the percentage of boys who scored at the Below Beginning or Beginning levels dropped (28 percent and 38 percent, respectively), while the percentage of boys scoring at the Developing or Accomplished levels increased (31 percent and 3 percent respectively) (see Figure 1). The boys' post-program mean score was 2.09 on the 4-point rubric scale, a significant improvement over the pre-program mean score (see Table 8).

TABLE 8

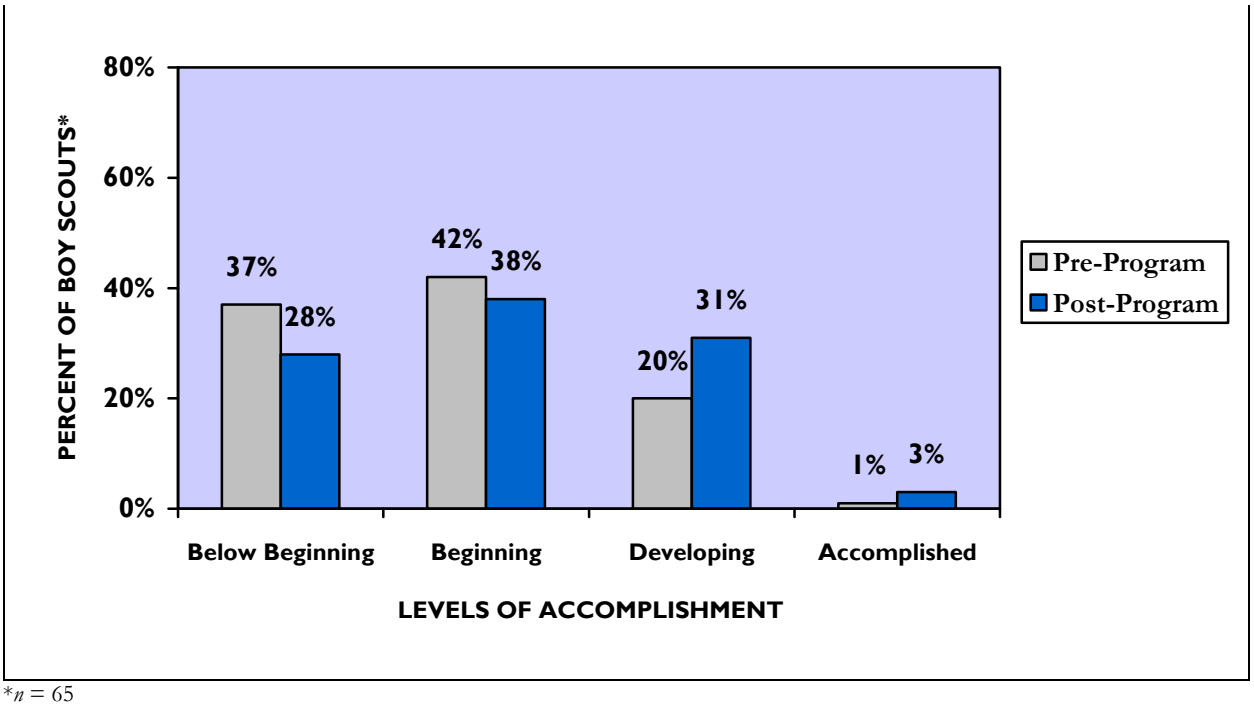
OBJECTIVE ONE SCORE – MATH PROBLEM SOLVING: PRE-PROGRAM AND POST-PROGRAM MEANS

		PRE-PROGRAM	POST-PROGRAM
	n	MEAN	MEAN
Score (highest score = 4.0)	65	1.86	2.09

$t = 2.367$; $df = 64$; $p = .021$

FIGURE 1

OBJECTIVE ONE SCORE – MATH PROBLEM SOLVING: PRE-PROGRAM AND POST-PROGRAM PERCENTS



*$n = 65$

Objective Two: Students understand that the application of math to flight is essential for successful, safe flight. After the program, students should conclude that without math, the airplane cannot be flown safely.

EXPLANATION OF SCORING: FLIGHT PLANNING ACTIVITY

To assess the boys' achievement of this objective, the post-program questionnaire asked the boys to describe, in writing, "What, if anything, did you learn during the Flight Planning Activity?"

RK&A evaluated and scored each boy's post-program written responses about the Flight Planning Activity according to the following rubric:

Score	Criteria
Below Beginning (1)	Participant states that he did not learn anything (e.g., writes "I don't know") or provides an opinion ("I learned flying is cool").
Beginning (2)	Participant states that he learned aviation facts or concepts but does not mention math (e.g., "I learned to plan a flight").
Developing (3)	Participant states he learned general math concepts and facts, or general importance of math to activity.
Accomplished (4)	Participant discusses in detail the importance, utility or applications of math to flight planning.

FINDINGS: FLIGHT PLANNING ACTIVITY

After the program, most of the boys scored at the Beginning (62 percent) or Below Beginning levels (15 percent), meaning they did *not* mention anything about math in their responses (see Figure 2). Only 23 percent of the boys scored at the Developing level, meaning they mentioned math in a general way. None of the boys scored at the Accomplished level. Overall, the boys' mean score = 2.08 on the 4-point rubric scale (see Table 9).

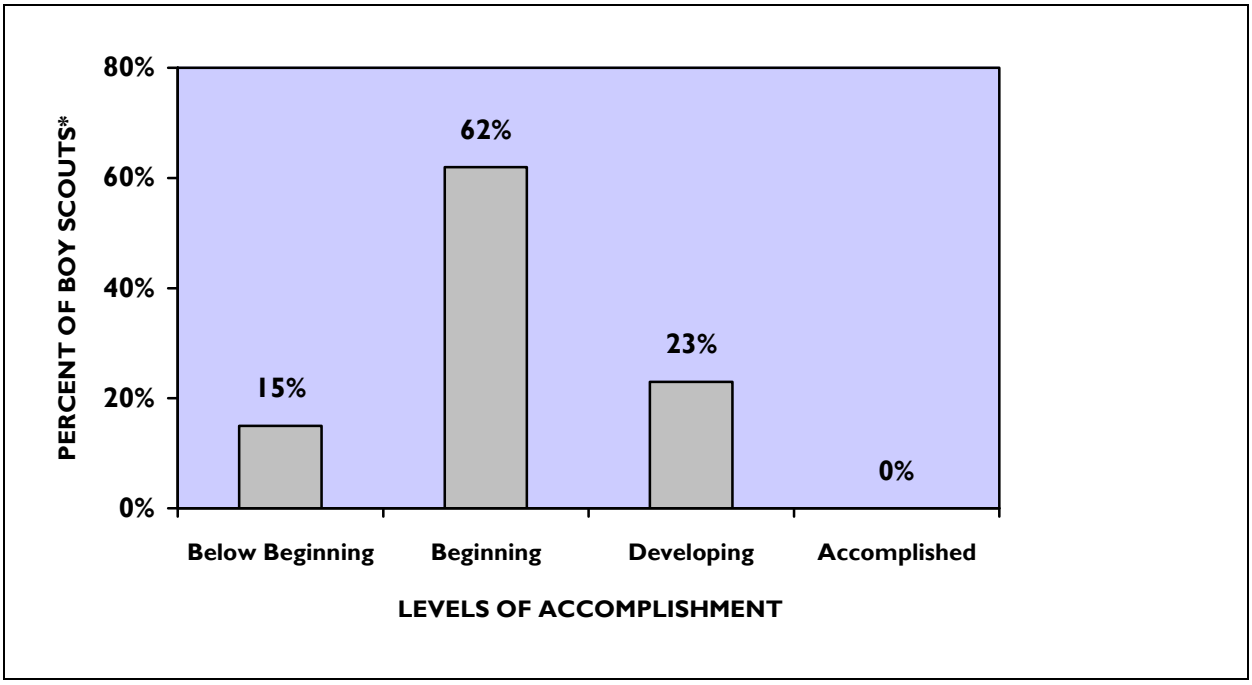
TABLE 9

OBJECTIVE TWO SCORE – FLIGHT PLANNING ACTIVITY: POST-PROGRAM MEAN

	n	POST-PROGRAM MEAN
Score (highest score = 4.0)	65	2.08

FIGURE 2

OBJECTIVE TWO SCORE – FLIGHT PLANNING ACTIVITY: POST-PROGRAM PERCENTS



*n=65

EXPLANATION OF SCORING: FLIGHT PLANNING ACTIVITY

RK&A evaluated and scored each boy's post-program written responses to the question, "What, if anything, did you learn during the Flight Simulator Activity?" according to the following rubric:

Score	Criteria
Below Beginning (1)	Participant states that he did not learn anything (e.g., writes "I don't know") or provides an opinion ("I learned flying is cool").
Beginning (2)	Participant states he learned aviation facts or concepts but does not mention math (e.g., "I learned to fly a plane").
Developing (3)	Participant states he learned general math concepts and facts, or general importance of math to activity.
Accomplished (4)	Participant discusses in detail the importance, utility or applications of math to flight simulation.

FINDINGS: FLIGHT SIMULATOR ACTIVITY

After the program, most of the boys scored at the Beginning (58 percent) or Below Beginning levels (34 percent), meaning they did *not* mention anything about math in their responses (see Figure 3). Eight percent of the boys scored at the Developing level, meaning they mentioned math in a general way. None of the boys scored at the Accomplished level. Overall, the boys' mean score = 1.74 on the 4-point rubric scale (see Table 10).

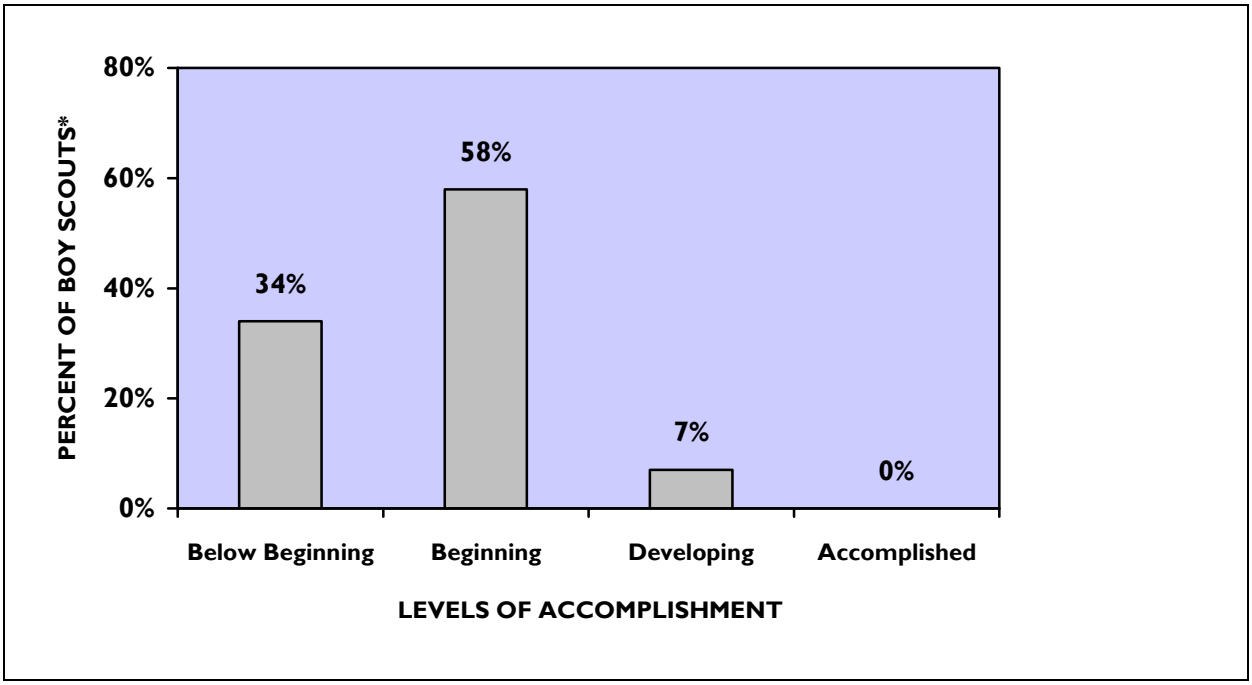
TABLE 10

OBJECTIVE TWO SCORE – FLIGHT SIMULATOR ACTIVITY: POST-PROGRAM MEAN

	n	POST-PROGRAM MEAN
Score (highest score = 4.0)	65	1.74

FIGURE 3

OBJECTIVE TWO SCORE – FLIGHT SIMULATOR ACTIVITY: POST-PROGRAM PERCENTS



*n=65

PROGRAM EXPERIENCES

OPINION OF THE FLIGHT PLANNING ACTIVITY

On the post-program questionnaire, the boys evaluated four statements about the Flight Planning Activity using the scale Always – Sometimes – Never. Depending on the statement, the most favorable response was either "Always" or "Never." Table 11 presents the results.

The boys indicated favorable responses to two aspects of the flight planning activity. Most of the boys were "always" familiar with the calculations they were asked to complete (86 percent) and the majority of the boys "always" understood the instructor's directions (69 percent).

The boys had mixed responses to two aspects of the flight planning activity. First, 48 percent of the boys "always" ended up with the same answers as the instructor, however, 49 percent "sometimes" ended up with the same answers as the instructor, and 3 percent "never" ended up with the same answers as the instructor (3 percent). Second, 42 percent of the boys were "never" confused by reading the map, however, 57 percent of the boys were "sometimes" confused, and 1 percent were "always" confused.

TABLE 11

OPINION OF THE FLIGHT PLANNING ACTIVITY

STATEMENT	*n*	ALWAYS %	SOMETIMES %	NEVER %
I was familiar with the calculations (addition, subtraction, multiplication, division) that I was asked to complete.	65	86	14	0
I understood the instructor's directions.	65	69	31	0
I ended up with the same answers as the instructor.	65	48	49	3
I found reading the map confusing.	65	1	57	42

APPENDIX A: PRE-PROGRAM AND POST-PROGRAM QUESTIONNAIRES

REMOVED FOR PROPRIETARY PURPOSES

APPENDIX B: STATISTICS

DESCRIPTIVE STATISTICS

CATEGORICAL VARIABLES: FREQUENCIES

Pre-program and Post-program Questionnaires:
Program date
Q1 First or repeat visit to Hiller Aviation Museum
Q2 Main reason for pursuing the aviation Scout Merit Badge
Age
Grade
Current Math Class
Post-program Questionnaire:
Q6 Opinion of four aspects of the Flight Planning Activity

DESCRIPTIVE STATISTICS

INTERVAL-RATIO VARIABLES: PERCENTS AND SUMMARY STATISTICS (MEAN ± STANDARD DEVIATION)

Pre-program and Post-program Questionnaires:
Q3 Five statements about the importance of math in aviation (5-point scale: Strongly disagree to Strongly Agree)

Overall attitude about the importance of math in aviation (sum of the scores of the Q3 statements about the importance of math in aviation (possible 5 – 25 point range))

DESCRIPTIVE STATISTICS

RUBRIC-SCORED VARIABLES: PERCENTS AND SUMMARY STATISTICS (MEAN ± STANDARD DEVIATION)

Rubric scores: 1 = Below Beginning, 2 = Beginning, 3 = Developing, 4 = Accomplished

Pre-program and Post-program Questionnaires:
Q4 If the fuel gauge on you airplane was broken, how would you find out if you have enough fuel to complete your flight?
Post-program Questionnaire:
Q5 What, if anything, did you learn during the Flight Planning Activity?
Q7 What if anything, did you learn during the Flight Simulator Activity?

INFERENTIAL STATISTICS

PAIRED-SAMPLE (DEPENDENT) T-TEST ON PRE-PROGRAM AND POST-PROGRAM MEANS

Q3 Five statements about the importance of math in aviation (5-point scale: Strongly disagree to Strongly Agree)

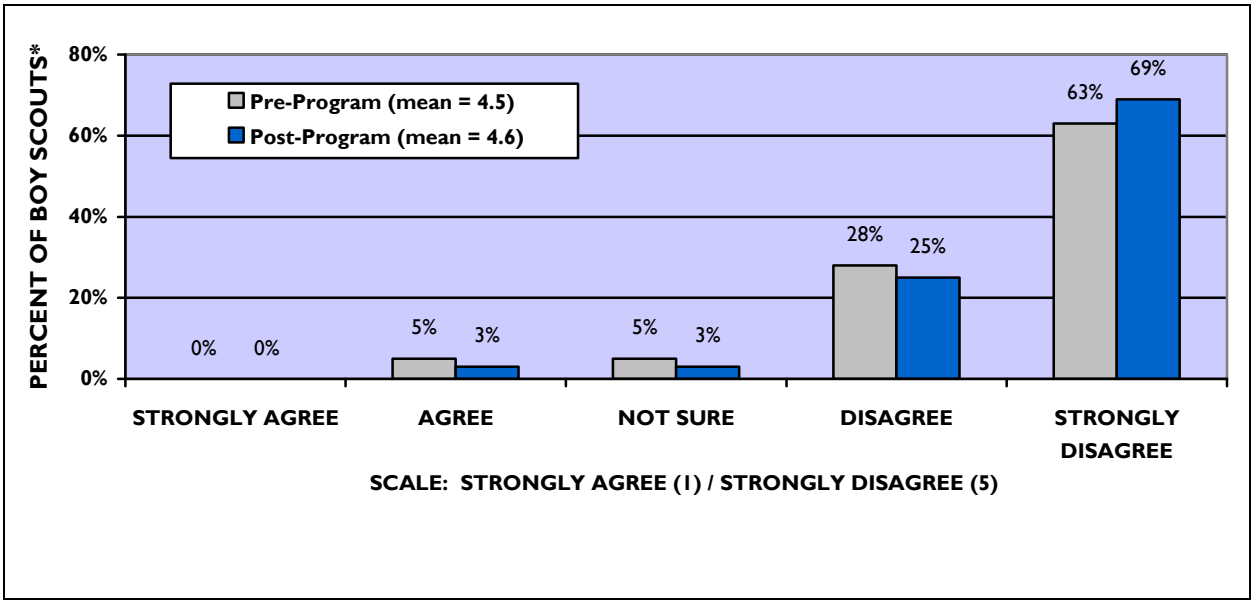
Overall attitude about the importance of math in aviation (sum of the scores of the Q3 statements about the importance of math in aviation (possible 5 – 25 point range))

Q4 Rubric score: If the fuel gauge on you airplane was broken, how would you find out if you have enough fuel to complete your flight? 1 = Below Beginning, 2 = Beginning, 3 = Developing, 4 = Accomplished

APPENDIX C: ATTITUDES ABOUT THE IMPORTANCE OF MATH IN AVIATION: PRE-PROGRAM AND POST-PROGRAM PERCENTS

FIGURE 4

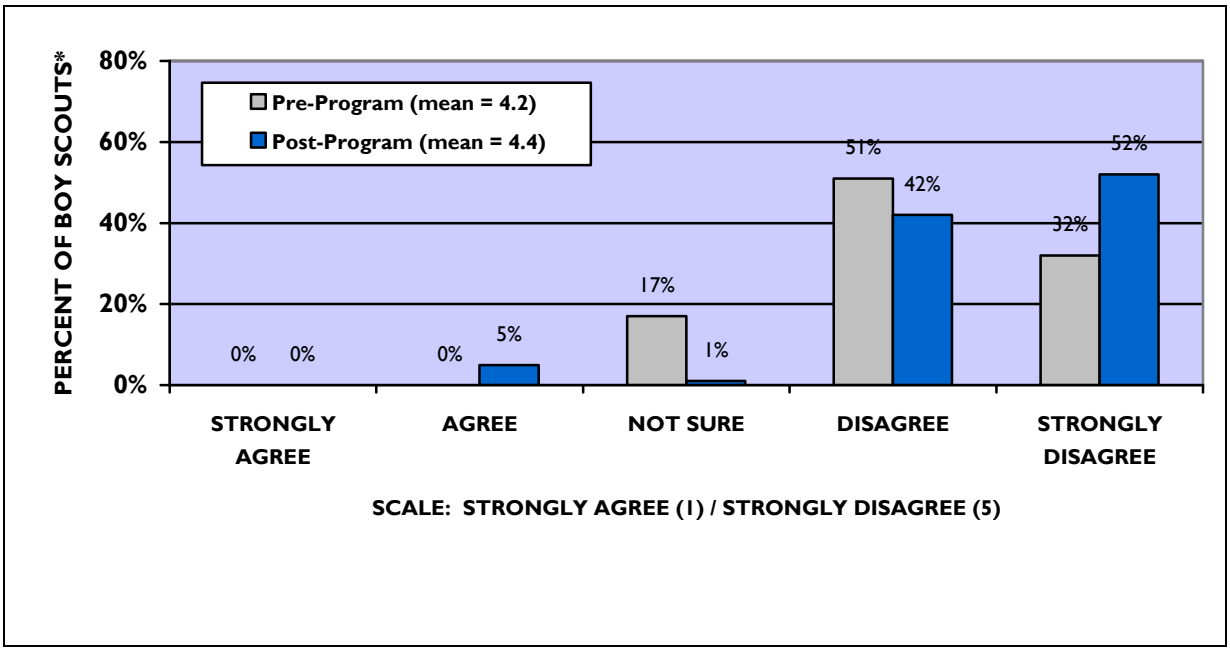
I HAVE TO TAKE MATH IN SCHOOL BUT IT DOESN'T REALLY HELP ME IN THE REAL WORLD: PRE-PROGRAM AND POST-PROGRAM PERCENTS



*n=65

FIGURE 5

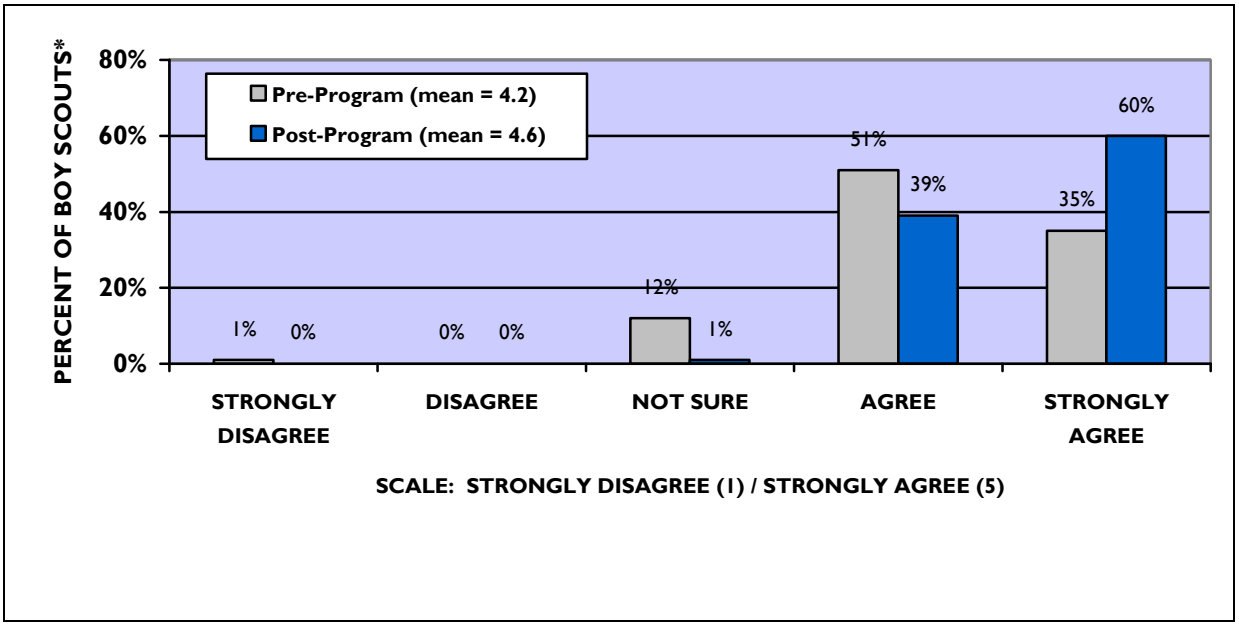
PILOTS DON'T NEED TO KNOW MATH BECAUSE THE AIRPLANE COMPUTER DOES ALL THE CALCULATIONS: PRE-PROGRAM AND POST-PROGRAM PERCENTS



*n=65

FIGURE 6

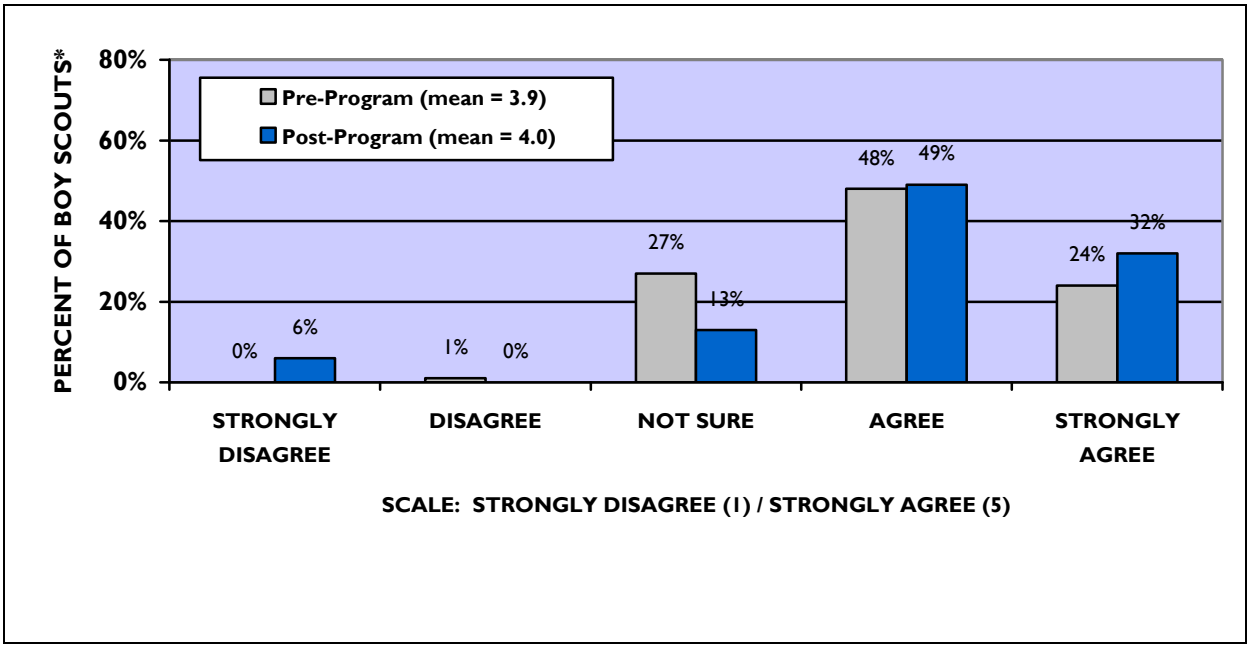
MATH IS AN IMPORTANT SUBJECT FOR PILOTS TO KNOW: PRE-PROGRAM AND POST-PROGRAM PERCENTS



*n=65

FIGURE 7

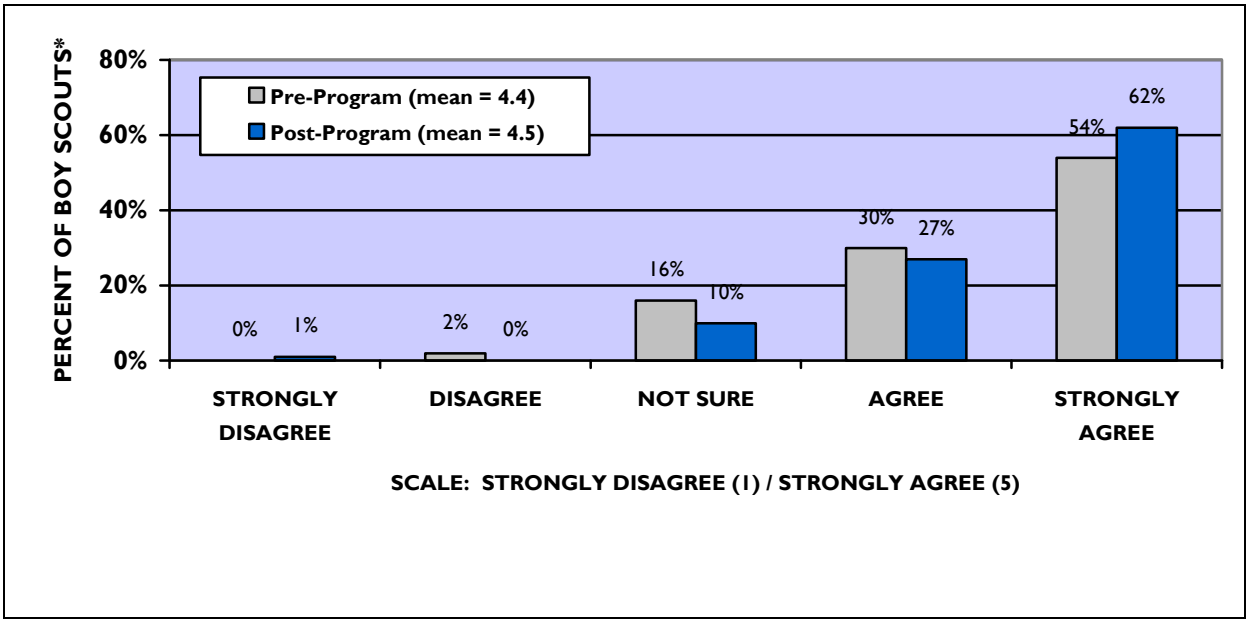
WITHOUT MATH, PILOTS WOULD NOT BE ABLE TO SAFELY FLY TO THEIR DESTINATION: PRE-PROGRAM AND POST-PROGRAM PERCENTS



*n=63

FIGURE 8

MATH IS USEFUL AND NECESSARY FOR A VARIETY OF ENDEAVORS: PRE-PROGRAM AND POST-PROGRAM PERCENTS



*n=63

APPENDIX D: VERBATIM RESPONSES OF RUBRIC LEVELS

Objective #1: Improve student facility using simple, linear equations such as those used for flight planning (i.e. distance = speed x time; fuel consumed = fuel flow rate x time). Pre-program math problems would demonstrate a certain level of computation mastery. Post-program math problems should demonstrate improvement in computation mastery.

Pre-/Post-Program Question 4

If the flight gauge on your airplane was broken, how would you find out if you have enough fuel to complete your flight?	
Score	Criteria
Below Beginning (1)	Participant does not provide a response, provides an irrelevant response, or a response that does not include any solution. **Example 1 from respondent questionnaire: "I don't know."** **Example 2 from respondent questionnaire: "You wouldn't crash and die."**
Beginning (2)	Participant does not reference math skills but provides a relevant response. **Example 1 from respondent questionnaire: "It would be hard to tell but by the sound of the engine and remembering when it was last filled [with gas] you would [be able to] tell."** **Example 2 from respondent questionnaire: "Land immediately and check."**
Developing (3)	Participant references math skills in a general way in his response, uses incorrect variables or equations that do not answer or only partly answers the question. **Example 1 from respondent questionnaire: "I would have written down how much fuel I had at the beginning, know the formula for my plane—how much gas it uses—and then subtract the amount of fuel I stared with [from] how much I have used.** **Example 2 from respondent questionnaire: "Amount of fuel at beginning of flight, amount used when gauge broke, nm/gal, min/nm, distance to destination."**
Accomplished (4)	Participant uses math equations to answer the question. The answer may or may not be correct. **Example from respondent questionnaire:** **"Number of hours flying = h; Gallons of fuel burned per hour = g; gallons of fuel carried = c; c- (h X g) = fuel left"**

Objective #2: Students understand that the application of math to flight is essential for successful *safe* flight. When queried before the program, students may conclude that math is not necessary to fly the airplane safely. When queried after the program, students should conclude that without math, the airplane cannot be flown safely, at least in this scenario. Generalized outcome: math is useful and necessary in a variety of endeavors (i.e. it's not just "useless school work").

Post-Program Questions 5

What, if anything, did you learn during the Flight Planning Activity?	
Score	Criteria
Below Beginning (1)	Participant states that he did not learn anything or provides an opinion. **Example 1 from respondent questionnaire: "I have no clue."** **Example 2 from respondent questionnaire: "I understood after explained. [*sic*]"**
Beginning (2)	Participant states that he learned aviation facts or concepts but does not mention math. **Example 1 from respondent questionnaire: "About the history of airplanes and flying."** **Example 2 from respondent questionnaire: "How to plan a flight and know if the flight is safe before even taking off."**
Developing (3)	Participant states he learned general math concepts and facts, or general importance of math to activity. **Example 1 from respondent questionnaire: "That math is important for pilots to know."** **Example 2 from respondent questionnaire: "I learned about calculating stuff for flying."**
Accomplished (4)	Participant discusses in detail the importance, utility or applications of math to flight planning. **No example available. None of the respondents scored at the accomplished level for this question.**

Post-Program Questions 7

What, if anything, did you learn during the Flight Simulator Activity?	
Score	Criteria
Below Beginning (1)	Participant states that he did not learn anything or provides an opinion. **Example 1 from respondent questionnaire: "Nothing—know it all."** **Example 2 from respondent questionnaire: "It is hard to land a plane."**
Beginning (2)	Participant states he learned aviation facts or concepts but does not mention math. **Example 1 from respondent questionnaire: "I learned how to control a plane."** **Example 2 from respondent questionnaire: "A plane is sensitive to the slightest touch."**
Developing (3)	Participant states he learned general math concepts and facts, or general importance of math to activity. **Example 1 from respondent questionnaire: "I learned that landing speed is 60 knots.** **Example 2 from respondent questionnaire: "1. Put your left hand on the steering wheel and your right hand on the throttle. 2. To land go at a speed of 60, go head first then slowly lift up your plane so you land on your back wheels then kill the throttle."**
Accomplished (4)	Participant discusses in detail the importance, utility or applications of math to flight simulation. **No example available. None of the respondents scored at the accomplished level for this question.**