



Colorado *FIRST* FIRST LEGO League Study



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Executive Summary

Colorado*FIRST* (www.coloradofirst.org) is a non-profit organization established in 2001 whose overall intent is to create and manage programs to encourage and motivate K-12 students to actively engage in STEM (Science, Technology, Engineering and Mathematics) through robotics competition, while also learning the principles of teamwork and eventually inspire students to pursue a STEM career in the future.

Colorado*FIRST* manages three programs (*FIRST* LEGO League Jr., *FIRST* LEGO League, and *FIRST* Robotics Competition) for students ranging from K-12. Our survey targeted the *FIRST* LEGO League (FLL) program, where 4th thru 8th grade students research a real-world problem. They are challenged to develop a solution, design, assemble and program a robot based on the LEGO Mindstorms® technology designed to meet the challenge theme of that year and be assessed by a panel of judges.

In 2017, a survey of 23 questions was created, issued and collected from parents and mentors of 4th to 8th grade students that participated in Colorado*FIRST* programs. In 2018, Colorado*FIRST* has received approval to survey the 4th to 8th grade students participating in FLL. The purpose of the study is to help analyze how a young individual is growing and learning from the FLL program, their intention in continuing on to future Colorado*FIRST* programs and their interest in pursuing a STEM career in the future.

During our interview with Rodger Stewart, Colorado*FIRST* Chief Growth Officer, we discovered that one growing concern was the decline of students “graduating” from the FLL program to the FRC (*FIRST* Robotics Competition) or FTC (*FIRST* Tech Challenge) program which targets students at High School level. Part of our questionnaire will address the FRC and FTC programs and hopefully obtain key information that will shed the light to the reasons behind this drastic decline in numbers.

Through Qualtrics online questionnaire, we collected responses from 4th to 8th grade students who participated in the 2018 FLL season to analyze whether Colorado*FIRST*'s core values are being met and to provide data that may assist the organization in improving their programs and meeting their goals.

To conduct this study, an online questionnaire of 25 questions were developed to cover the following constructs:

- Knowledge on STEM careers
- Interest toward pursuing STEM careers
- Impact on leadership after program participation

- Impact on personal skills development after program participation
- Desire to participate in other Colorado*FIRST* programs
- Attitude toward support received from Colorado*FIRST*
- Overall attitude toward FLL

During the November 10, 2018 FLL tournament located at University of Colorado Denver, a station with 3 laptops was set up to encourage the tournament participants to answer our questionnaire. After the event, the survey was distributed via email to all students of the FLL program. Within a two-week period, 143 survey responses were received, but out of the 143, only 107 were fully completed. The information gathered was analyzed using the Statistical Package for the Social Sciences (SPSS).

Introduction

Companies and people who are part of the STEM arena have played a pivotal role in creating the world we see today. We have certainly made tremendous strides in information technology, medicine, aviation, motor vehicles and the Space program, to name a few. According to Smithsonian Science Education Center, “Four billion people on the planet use a mobile phone, while 3.5 billion people use a toothbrush. In the past two years, 90% of all the world’s data has been generated. NASA plans to set foot on Mars in the next 20 years, and driverless cars are already being tested in Europe. The future is here, and it requires a citizenry fluent in science, technology, engineering and math (STEM)...By 2018, it is projected that 2.4 million STEM jobs will go unfilled.” The STEM shortage affects several industries. It is predicted that 3.5 million positions may be needed within the manufacturing industry alone but there is a strong possibility that 2 million of these positions may not get filled due to the lack of qualified individuals (Radu).

Unfortunately, we are not seeing enough students pursuing a STEM education and career to fill this gap and the need is growing. Therefore, the question becomes: How do we encourage and inspire our younger generation to pursue a STEM education and career? This is where Colorado*FIRST* comes into play, it is an organization on a mission to inspire young people to be science and technology leaders by engaging them in exciting mentor-based programs that build science, engineering, math, and technology skills. Their programs are designed to inspire innovation and foster well-rounded life capabilities including self-confidence, communication, and leadership.

Our goal while working with Colorado*FIRST* was to collect information from the students participating in the FLL program to determine and analyze if Colorado*FIRST* is meeting their intent and core values.

Background Information

According to the U.S. Bureau of Labor and Statistics, “Employment in occupations related to STEM - science, technology, engineering, and mathematics - is projected to grow to more than 9 million in between 2012 and 2022” (Vilorio). Specifically, employment in STEM occupations has grown 79% since 1990, from 9.7 million to 17.3 million, outpacing overall U.S. job growth (Graf). As stated by the TED (The Economics Daily), in 2016, there were about 8.8 million STEM occupations which represented about 6.3% of U.S. employment. According to the U.S. Department of Commerce, STEM occupations are growing at 17%, while other occupations are growing at only 9.8%. As mentioned in a research conducted by the National Science Foundation, scientific and technological innovations have become increasingly important in the 21st century. “To succeed in this new information-based and highly technological society, students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past” (Berg). Our advances in technology are moving at a rapid speed and without the people in STEM professions, these new products and innovations would never have been developed (Terrell).

However, one of the major problems that these industries are facing is a lack of qualified younger students who will fulfill the roles of current employees once they move on and retire. According to the U.S. Department of Education, only as little as 16% of college students graduated in a STEM industry field or subject whereas there will be estimated of 1.2 million job vacancies in these sections by 2018 (Berg). Nevertheless, from 2017 to 2018, Junior Achievement found a significant drop in teenage boys who want to a STEM career, down from 36% to 24%. In addition, the low level of interest among teenage girls remained unchanged at 11% year-over-year (Kim). Unfortunately, when students start to struggle with STEM lessons, they become less interested in the subject, which is why it is so important for organizations like Colorado*FIRST* to step in.

This study will be on one of the three programs that are managed by Colorado*FIRST*, *FIRST* LEGO League (FLL) and the data analyzed will be provided to Colorado*FIRST* to assist them in improving their FLL program management.

Hypothesis Development and Constructs

Based on the background information as well as our in-depth conversation with Rodger Stewart, we initially came up with the following hypotheses:

1. Overall attitude toward FLL program is most impacted by the support received from Colorado*FIRST*.

2. The number of years participating in the program has a significant influence in students' desire to continue joining other Colorado*FIRST* programs.
3. Older students (grade 7-8) are more likely to have a greater desire in participating in other Colorado*FIRST* programs than younger ones (grade 4-6).
4. Students who have the knowledge of STEM careers are more likely to be interested in pursuing STEM career fields in the future.
5. Male students generally have more positive attitude toward the FLL program than female students.
6. Overall attitude toward FLL program is the most important construct in contributing to the outcome.
7. Male students are more likely to stay longer in the programs than female students.

Our survey consists of seven constructs to determine whether Colorado*FIRST*'s FLL program was performing its core values to its expected potential by the students' standards. We measured the attitude toward these constructs to determine whether students feel that Colorado*FIRST* is supporting them and their teams, and is fulfilling its intended function as a robotics program. Based on the responses, we will give Colorado*FIRST* some recommendations on whether there are any adjustments that need to be made to the program to satisfy their core values. (Phillips, et al).

Construct	Description	Sample Question
Knowledge on STEM careers (STEM-KNOWLEDGE)	Measure attitude students might have on STEM careers	I know what types of careers fall under STEM. Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree
Interest toward pursuing STEM careers (STEM-INTEREST)	Measure interest students might have in pursuing STEM careers	I am interested in pursuing a STEM career. Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree
Impact on leadership after program participation (LEADERSHIP)	Measures the effect Colorado <i>FIRST</i> programs have on students' leadership	I frequently take on leadership roles after taking part in FLL. Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree
Impact on personal skills development after program participation (SKILL)	Measures the effect Colorado <i>FIRST</i> programs have on students' personal skills development	FLL has helped me improve my planning skills. Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

Desire to participate in other ColoradoFIRST programs (DESIRE)	Measures desire to continue with ColoradoFIRST and their programs	I have interest in pursuing FRC and/or FTC. Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree
Attitude toward support received from ColoradoFIRST (SUPPORT)	Measures attitude toward ColoradoFIRST as the tournament organizer	I feel that I have received adequate support from ColoradoFIRST. Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree
Overall attitude toward FLL (OVERALL)	Measures overall attitude towards the FIRST Lego League program	I really enjoyed my FLL experience. Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

These constructs were developed to measure the attitude of the students based on several factors. The constructs were measured on a Likert scale from 1-7, all with 1 being “Strongly Agree” and 7 being “Strongly Disagree.”

The reliability of each construct was also tested. After running the tests, we concluded that STEM-Interest and Support constructs were not reliable, yet all other constructs were reliable.

Construct	Alpha	Reliable?
Overall	0.835	Yes
Skill	0.840	Yes
Leadership	0.836	Yes
Support	0.659	No
Desire	0.734	Yes
STEM-Knowledge	0.738	Yes
STEM-Interest	0.594	No

Instrument Design

Our questionnaire consisted of 25 questions, directed towards the students participating in the FLL program and the majority of the questions were measured on a Likert scale. The questionnaire consisted of seven different constructs - all focused on measuring the impact FLL has had on the students who have participated in the program.

All seven constructs and 25 questions were randomly arranged, 23 out of 25 questions were using a Likert scale from 1 (Strongly Agree) through 7 (Strong Disagree), 2 other questions were categorical in order to retrieve their inputs in higher education interest and experience with the FLL program. In addition to the 25 questions, there were also three demographic questions at the end of the survey.

All questions were structured utilizing the Dillman method, using simple wording, avoiding repetition of words, increasing clarity, direct and short questions, and no complicated jargon. The number of questions were kept to a minimum, with three questions designated per construct (with the exception of two questions per the two STEM career related constructs) and three questions utilized for demographics.

Demographics questions included:

- Gender (Male, Female)
- Grade (4th, 5th, 6th, 7th, 8th)
- Number of years participating in FLL (1 year, 2-3 years, 4-5 years, 6-7 years, 8+ years)

Sampling

A URL for the survey was distributed via email along with a cover letter explaining the purpose and use of this study to all students participating in the Colorado *FIRST*'s FLL program. The survey was created in Qualtrics, which gave us the ability to monitor the response rate. In addition to the online distribution of the survey, we also volunteered in the Central Denver Regional FLL tournament at CU Denver with the purpose of collecting additional in-person responses. Two weeks after the survey distribution, with the help of Colorado *FIRST*'s Chief Growth Officer, Mr. Rodger Stewart, we were able to collect a total of 143 responses, in which 107 responses were fully completed. A reminder email was sent after the first week. Based on the responses we received, we had about a 57.2% response rate overall.

Methodology

The data was collected using Qualtrics that was in turn converted into Excel and SPSS data. Using SPSS, reliability tests were run to determine the validity of the collected data, T-test pairs were used to determine which construct contribute the most in the outcome of the survey, and multiple regression was ran to determine which construct has the most impact on the overall experience of the students. In addition, MANOVA analysis was run to determine how the construct responses differed among demographic variables. In fact, there were no significant results with gender and years in FLL.

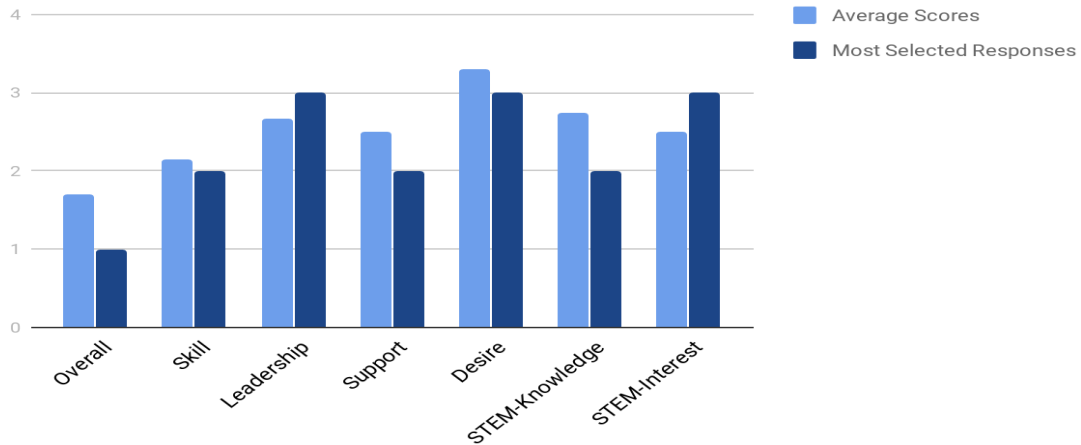
Results

When comparing the results of each individual construct, we observed that for every construct most students felt that they had positive experience after participating in the FLL program. The overall attitude toward the FLL program averaged 1.70 (on a scale of 1-7), with the highest attitude toward personal skills development after participating in the program (mean of 2.15) .

All constructs scored high in satisfaction, the lowest average score for construct being 3.30. When analyzing the responses most selected within each construct, most survey-takers selected a 1 to 2 out of 7 when considering encouraging STEM careers, knowledge in STEM careers, support received from Colorado *FIRST*, personal skills development after program participation and leadership behavior exhibition. The overall attitude toward the program was even more favored, as most selected 1 out of 7 when reflecting on the program overall.

Construct	Average Scores (1-7)	Most Selected Response
Overall	1.70	1
Skill	2.15	2
Leadership	2.66	3
Support	2.50	2
Desire	3.30	3
STEM-Knowledge	2.75	2
STEM-Interest	2.50	3

Overall Attitude per Construct



Within the constructs, we found that the overall average attitude toward the program is 1.70, which is very favorable. However, the desire to continue other programs with Colorado*FIRST* is only 3.30. Hence, even though the students are overall satisfied with the FLL program, they are still hesitant to join other programs by Colorado*FIRST* in the future.

Regarding our initial hypothesis, the results reflect the following (interpretation for each hypothesis can be found in Appendix):

1. Overall attitude toward FLL program is not significantly impacted by the support received from Colorado*FIRST*. In fact, the personal skills development after participation has the most impact on the students' overall attitude toward the FLL program.
2. We cannot conclude that students who stay longer in the program are more likely to have a greater desire in participating in other Colorado*FIRST*'s programs due to the insignificance of 0.192.
3. Older students (grade 7-8) are more likely to have a greater desire in participating in other Colorado*FIRST*'s programs than the younger ones (grade 4-6).
4. Students who have the knowledge on STEM careers are more likely to be interested in pursuing STEM career fields in the future.
5. We cannot conclude that male students generally have more positive attitude toward the FLL program than female students and vice versa due to insignificance of data.
6. Overall attitude toward FLL program is the most important construct in contributing to the outcome.
7. Gender is not associated with how long the students decide to stay in the programs.

Discussion

The impact of these results suggests that students are benefiting from the ColoradoFIRST FLL program. The students feel that their leadership and personal skills are significantly improved after participating in the program, and are overall satisfied with the program. The result also suggests that even though many students are interested in pursuing STEM careers in the future (mean of 2.50), they might need more information regarding the STEM careers (mean of 2.75). The overall goal of the FIRST programs is to encourage more students to potentially enter STEM career fields after graduating from high school. With the shortage of qualified people to fill STEM positions, it has become even more prevalent for organizations such as ColoradoFIRST to find innovative ways to inspire students in pursuing a STEM career. As a result, ColoradoFIRST needs to continue to have open channels of communication and find more innovative ways to encourage their current students in pursuing a STEM career.

When comparing to the 2017 study conducted with FLL mentors and parents, we do see some similarities. In the previous study, parents and mentors feel as if their children, students, and community members are benefiting from the ColoradoFIRST FLL program. They feel as if the core values of the program are being seen in the behavior and interests of the children involved, and are overall satisfied with their participation in the program. Similarly, our study also proves that students are having positive experience with the program and that their skills have significantly improved after participation.

During our conversation with Mr. Stewart, he expressed that there has been lack of retention in *FIRST* programs after students get older and can no longer participate in the FLL program. Based on the 2017 study, it was found that most students were not continuing past FLL because they simply were unaware that there were available subsequent programs. Our questionnaire revealed that most students were aware of subsequent programs and they do have interest in participating in those programs. This shows that ColoradoFIRST has obviously put more effort since last questionnaire in educating students about their *FIRST* programs. We had an opportunity to observe that at the FLL tournament competition they had live demonstrations and informational booths to educate and bring awareness of all ColoradoFIRST programs to mentors, parents and students.

Conclusions

In conclusion, we feel the *FIRST* Lego League program is performing well and meeting Colorado*FIRST*'s core values and standards. Most students surveyed showed increased interest in STEM and future Colorado*FIRST* programs and an increased improvement in social behavior and personal skills. It showed that the students felt their personal skills such as prioritization, planning, communication, self-confidence and teamwork have improved since participating in the program.

Two of Colorado*FIRST*'s major concerns was to see if students would continue on to participate in their future programs (FTC and FRC) and if students were interested in pursuing a STEM career in the future. The data shows that even though students are knowledgeable on STEM careers and have interest pursuing a STEM career in the future, they might need additional guidance and mentorship from Colorado*FIRST* in this regard. Our research confirms that Colorado*FIRST*'s efforts in educating students on STEM careers and opportunities is having an impact. Although we could not conclude that students who have participated in the program longer are more likely to join future programs, we feel that it is necessary to retain current participants and recruit potential students. We would suggest Colorado*FIRST* introduce a referral program where current students would receive a gift card if they successfully introduced another friend to join the program. Potential participants would be more likely to join if their friends, who are already in the program, shared about how positive the experience has been for them. In addition, current students might be willing to stay in the program if their friends are also a part of it. With this strategy, not only will they retain the current students, they will also be able to recruit new potential students through word-of-mouth marketing.

Another way to encourage students to continue in pursuing Colorado*FIRST* future programs and increase interest on pursuing a STEM career would be to assign a specific color to each field of study, for example (Science - Green, Technology - Yellow, Engineering - Blue, Math - Red). Provide students with a color-coded shirt or pin with a designated symbol and/or the field of study name (i.e. Science) and encourage them to wear during events. This would motivate students to choose a STEM career and also provides the student a way in identifying other students who share their same interest therefore fostering friendships, building camaraderie and lasting relationships and potentially the desire to continue to be part of Colorado*FIRST* other programs such as FTC and FRC.

If we were to conduct this research again, there are a few things we would have done differently. Specifically, we would have sent an email to parents and mentors a day prior to the tournament to inform them that there would a laptop table station set up for completing the survey on the day of the tournament and that there would be a chance to

win a \$30 raffle upon completion. Our table was set up beside the registration station, which was a huge distraction since they were all focused on checking in for the tournament. Plus, the coaches were the ones registering for the students which did not provide us the opportunity to engage with all the students upon check in. In addition, the parents and the coaches were responsible for keeping track of their students, which prevented us from approaching our target market. Once the official tournament started, coaches did not wish to lose sight of their students, hence it was difficult to collect any more responses after that. In addition to our laptop station, handing out physical copies of the survey might have been another option. This way, students would be able to find an opportunity during their break to complete the survey without having to leave the competition (which is required for completing the survey at our laptop station).

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Appendix

Hypothesis 1: Overall attitude toward FLL program is most impacted by the support received from Colorado *FIRST*.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.689 ^a	.475	.450	.73049

a. Predictors: (Constant), leadership, desire, skill, support

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.003	.238		.012	.990
	desire	.007	.054	.011	.129	.897
	support	.138	.117	.146	1.185	.239
	skill	.279	.110	.294	2.531	.013
	leadership	.272	.120	.321	2.271	.026

a. Dependent Variable: overall

A multiple regression analysis was conducted to examine the relationship between the overall attitude towards the program (Overall) and other measuring constructs (Skill, Leadership, Support, Desire).

The R square of the model is 0.475, which means that the model explains very well the variation in the response variable around its mean. In short, with an R Square of 0.475 (>0.4 is considered very good), the regression model fits well with the data. Comparing between R Square and Adjusted R Square, we can see that there is not a significant difference between the two (0.475 and 0.450), which means that the dataset is acceptable.

We can conclude that the independent variables (Skill, Leadership, Support, Desire) have a significant effect on the outcome of the dependent variable (Overall). When observing the B (slope), we can see that the values for all constructs are positive, which represent positive relationships between Overall and the constructs. With this data, we can conclude that students with higher desire to pursue further programs with

ColoradoFIRST are expected to have a more positive overall experience with the FLL program. Similarly, students who claimed they get sufficient support from ColoradoFIRST, thought they have gained personal skills and exhibited leadership behaviors after joining the program are expected to have a more positive overall experience with the program. However, among the constructs, only Skill has a significance that is lower than 0.05 at 0.015, indicating that this particular construct makes a significant contribution to the outcome of the model.

Hypothesis 2: The number of years participating in the program has a significant influence in students' desire to continue joining other ColoradoFIRST's programs.

Cell Means and Standard Deviations

Variable	FACTOR	CODE	Mean	Std. Dev.	N	95 percent	Conf. Interval
desire	years	1	3.762	1.620	42	3.257	4.267
	years	2	2.957	1.414	47	2.542	3.372
	For entire sample		3.337	1.559	89	3.009	3.665

Variable	FACTOR	CODE	Mean	Std. Dev.	N	95 percent	Conf. Interval
support	years	1	2.563	.989	42	2.255	2.872
	years	2	2.518	1.087	47	2.198	2.837
	For entire sample		2.539	1.037	89	2.321	2.758

Variable	FACTOR	CODE	Mean	Std. Dev.	N	95 percent	Conf. Interval
skill	years	1	2.262	.936	42	1.970	2.553
	years	2	2.106	1.127	47	1.775	2.437
	For entire sample		2.180	1.038	89	1.961	2.399

Variable	FACTOR	CODE	Mean	Std. Dev.	N	95 percent	Conf. Interval
leadership	years	1	2.786	1.135	42	2.432	3.139
	years	2	2.574	1.190	47	2.225	2.924
	For entire sample		2.674	1.163	89	2.429	2.919

Variable	FACTOR	CODE	Mean	Std. Dev.	N	95 percent	Conf. Interval
overall	years	1	1.722	.895	42	1.443	2.001
	years	2	1.702	1.068	47	1.388	2.016
	For entire sample		1.712	.985	89	1.504	1.919

***** Analysis of Variance -- Design 1 *****

EFFECT years

Multivariate Tests of Significance (S = 1, M = 1 1/2, N = 40 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Bilias	.08394	1.52115	5.00	83.00	.192
Hotellings	.09164	1.52115	5.00	83.00	.192
Wilks	.91606	1.52115	5.00	83.00	.192
Solte	.08394				
Note	F statistics are exact.				

EFFECT years (Cont.)

Univariate F-tests with (1,87) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
desire	14.35370	199.53394	14.35370	2.29349	6.25844	.014
support	.04645	94.51036	.04645	1.08633	.04276	.837
skill	.53646	94.36491	.53646	1.08465	.49459	.484
leadersh	.98977	117.93579	.98977	1.35558	.73014	.395
overall	.00896	85.36682	.00896	.98123	.00913	.924

A MANOVA test was also ran to determine the influence of number of years participating in the program on the constructs. Based on the responses that we have collected, we have regrouped the number of years into two categories in order to conveniently analyze the data: 1 being one year in the program, and 2 being more than two years in the program. According to the MANOVA output, the results are statistically insignificant with p equals to 0.192. We conclude that there is not a significant difference in the number of years participating in the program among the five different constructs. Hence, we cannot conclude that students who have participated in the program for more than a year are more likely to join other ColoradoFIRST's programs.

Hypothesis 3: Older students (grade 7-8) are more likely to have a greater desire in participating in other ColoradoFIRST's programs than the younger ones (grade 4-6).

Cell Means and Standard Deviations						
Variable .. desire						
FACTOR	CODE	Mean	Std. Dev.	N	95 percent Conf. Interval	
grade	1	3.923	1.786	39	3.344	4.502
grade	2	2.880	1.185	50	2.543	3.217
For entire sample		3.337	1.559	89	3.009	3.665

Variable .. support						
FACTOR	CODE	Mean	Std. Dev.	N	95 percent Conf. Interval	
grade	1	2.795	1.080	39	2.445	3.145
grade	2	2.340	.965	50	2.066	2.614
For entire sample		2.539	1.037	89	2.321	2.758

Variable .. skill						
FACTOR	CODE	Mean	Std. Dev.	N	95 percent Conf. Interval	
grade	1	2.350	.982	39	2.032	2.669
grade	2	2.047	1.071	50	1.742	2.351
For entire sample		2.180	1.038	89	1.961	2.399

Variable .. leadership						
FACTOR	CODE	Mean	Std. Dev.	N	95 percent Conf. Interval	
grade	1	2.878	1.239	39	2.476	3.280
grade	2	2.515	1.085	50	2.207	2.823
For entire sample		2.674	1.163	89	2.429	2.919

Variable .. overall						
FACTOR	CODE	Mean	Std. Dev.	N	95 percent Conf. Interval	
grade	1	1.940	1.087	39	1.588	2.292
grade	2	1.533	.868	50	1.287	1.780
For entire sample		1.712	.985	89	1.504	1.919


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***** Analysis of Variance -- Design 1 *****
EFFECT .. grade
Multivariate Tests of Significance (S = 1, M = 1 1/2, N = 40 1/2)

Test Name          Value          Exact F          Hypoth. DF          Error DF          Sig. of F
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Pillais             .13894            2.67856           5.00                83.00             .027
Hotellings          .16136            2.67856           5.00                83.00             .027
Wilks               .86106            2.67856           5.00                83.00             .027
Roys                .13894
Note.. F statistics are exact.

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EFFECT .. grade (Cont.)
Univariate F-tests with (1,87) D. F.

Variable          Hypoth. SS          Error SS          Hypoth. MS          Error MS          F          Sig. of F
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desire            23.83841            190.04923         23.83841            2.18447           10.91265    .001
support           4.53339             90.02342          4.53339             1.03475           4.38113    .039
skill             2.02166             92.87972          2.02166             1.06758           1.89368    .172
leadersh         2.89034             116.03522         2.89034             1.33374           2.16710    .145
overall          3.62649             81.74929          3.62649             .93965            3.85942    .053

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A MANOVA test was also ran to determine the influence of grades on the constructs. Based on the responses that we have collected, we have simplified the grades (5 categories: 4th, 5th, 6th, 7th, 8th) into two categories in order to conveniently analyze the data: 1 includes grade 4-6, and 2 includes grade 7 and 8. According to the MANOVA output, the results are statistically insignificant with p equals to 0.027. We conclude that there is a significant difference in the years of participation among the five different constructs. When looking into the significance of each construct, only Desire is significant at 0.001. In this case, we can conclude that there is indeed a significant relationship between grades and the desire to pursue further programs. When comparing the means between the two groups of grades regarding their desire to pursue other programs, we observe that grade 1 has significantly higher mean than grade 2 ($3.923 > 2.867$). Hence, we can conclude that students in grade 7-8 are more interested in joining other programs with Colorado *FIRST*. In contrast, the number of years in program do not influence the support students get from Colorado *FIRST*, skill and leadership improvement, or the overall experience with the program. We also ran a MANOVA test to determine the influence of gender on the constructs. However, there was no significant results.

Hypothesis 4: Students who have the knowledge on STEM careers are more likely to be interested in pursuing STEM career fields in the future.

Correlations

Correlations			
		steminterest	stemknowled ge
steminterest	Pearson Correlation	1	.329
	Sig. (2-tailed)		.001
	N	107	94
stemknowledge	Pearson Correlation	.329	1
	Sig. (2-tailed)	.001	
	N	94	95

We also wanted to know if there is any relationship between STEM-Knowledge and STEM-Interest. We were curious to see if there is a correlation between students knowing about STEM careers and their actual interests in pursuing STEM careers. Therefore, we have ran a Correlation test in order to determine the relationship between the two constructs. The correlation coefficient (Pearson Correlation) for STEM-Knowledge and STEM-Interest is 0.329, which means the two constructs are indeed correlated since we typically need a minimum of 0.2 to be considered correlated. The direction of the relationship is positive, which means that as STEM-Knowledge increases, STEM-Interest also increases. With a significance of 0.001, we can conclude that there is a significant correlation between the two variables, indicating that changes in STEM-Knowledge result in changes in STEM-Interest. Overall, we can conclude that students who have knowledge on STEM careers are more likely to have interest in pursuing STEM careers in the future.

Hypothesis 5: Male students generally have more positive attitude toward the FLL program than female students.

♦ **T-Test**

	Please select your gender:	N	Mean	Std. Deviation	Std. Error Mean
desire	Male	64	3.1406	1.59231	.19904
	Female	32	3.5625	1.54893	.27382
support	Male	65	2.4923	1.08351	.13439
	Female	31	2.4409	.88354	.15869
skill	Male	65	2.1231	1.03677	.12860
	Female	32	2.2083	.94186	.16650
leadership	Male	62	2.6774	1.15800	.14707
	Female	30	2.6583	1.12473	.20535
overall	Male	66	1.7071	.91617	.11277
	Female	32	1.7188	1.06461	.18820

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
desire	Equal variances assumed	.049	.825	-1.235	94	.220	-.42188	.34168	-1.10028	.25653
	Equal variances not assumed			-1.246	63.669	.217	-.42188	.33851	-1.09820	.25445
support	Equal variances assumed	.979	.325	.230	94	.818	.05145	.22350	-.39231	.49521
	Equal variances not assumed			.247	71.279	.805	.05145	.20795	-.36317	.46606
skill	Equal variances assumed	.006	.939	-.392	95	.696	-.08526	.21742	-.51688	.34637
	Equal variances not assumed			-.405	67.399	.687	-.08526	.21038	-.50513	.33461
leadership	Equal variances assumed	.064	.801	.075	90	.941	.01909	.25518	-.48787	.52604
	Equal variances not assumed			.076	59.000	.940	.01909	.25258	-.48632	.52449
overall	Equal variances assumed	1.585	.211	-.056	96	.955	-.01168	.20822	-.42498	.40163
	Equal variances not assumed			-.053	53.942	.958	-.01168	.21940	-.45156	.42820

We were curious about there being a major difference between genders against each construct (Desire, Support, Skill, Leadership, Overall). We decided to run a T-Test group analysis to obtain this information. To analyze this data in SPSS we identified

male students as number 1 and females students were identified as number 2. Results identified that male students have a more positive attitude towards Desire, Skill and Overall than female students. Female students showed a more positive attitude towards Support and Leadership than male students. But when looking at the Sig (2-tailed) for each independent variable (Desire, Support, Skill, Leadership, Overall) they are all above .05 (Desire .220, Support .818, Skill .696, Leadership .941, Overall .955), therefore, we cannot confidently say these results are accurate. Therefore, we cannot confidently say that gender plays a role on attitude towards the FLL program.

Hypothesis 6: Overall attitude toward FLL program is the most important construct in contributing to the outcome.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	desire	3.3000	95	1.58349	.16246
	support	2.4947	95	1.02552	.10522
Pair 2	desire	3.2577	97	1.55140	.15752
	skill	2.1581	97	1.00588	.10213
Pair 3	desire	3.3132	91	1.55036	.16252
	leadership	2.6676	91	1.15413	.12099
Pair 4	desire	3.2784	97	1.57449	.15986
	overall	1.7045	97	.96810	.09830
Pair 5	desire	3.3011	93	1.54663	.16038
	stemknowledge	2.7527	93	1.25461	.13010
Pair 6	desire	3.2865	96	1.58404	.16167
	steminterest	2.4792	96	1.19410	.12187
Pair 7	support	2.4861	96	1.02246	.10435
	skill	2.1458	96	1.01314	.10340
Pair 8	support	2.5275	91	1.02808	.10777
	leadership	2.6621	91	1.15252	.12082
Pair 9	support	2.4845	97	1.01724	.10328
	overall	1.6976	97	.95753	.09722
Pair 10	support	2.5090	93	1.02575	.10636
	stemknowledge	2.7366	93	1.25454	.13009
Pair 11	support	2.5018	95	1.01975	.10462
	steminterest	2.4947	95	1.19728	.12284
Pair 12	skill	2.1577	93	1.02221	.10600
	leadership	2.6559	93	1.14441	.11867

Paired Samples Test

		Paired Differences 95% Confidence Interval of the Difference				
		Upper	t	df	Sig. (2-tailed)	
Pair 1	desire - support	1.11792	5.114	94	.000	
Pair 2	desire - skill	1.42517	6.706	96	.000	
Pair 3	desire - leadership	.96992	3.955	90	.000	
Pair 4	desire - overall	1.90214	9.517	96	.000	
Pair 5	desire - <u>stemknowledge</u>	.88104	3.274	92	.001	
Pair 6	desire - <u>steminterest</u>	1.16233	4.514	95	.000	
Pair 7	support - skill	.51990	3.761	95	.000	
Pair 8	support - leadership	.02630	-1.662	90	.100	
Pair 9	support - overall	.97123	8.476	96	.000	
Pair 10	support - <u>stemknowledge</u>	-.03677	-2.369	92	.020	
Pair 11	support - <u>steminterest</u>	.25915	.055	94	.956	
Pair 12	skill - leadership	-.33116	-5.923	92	.000	
Pair 13	skill - overall	.61591	5.051	97	.000	
Pair 14	skill - <u>stemknowledge</u>	-.37856	-5.610	94	.000	
Pair 15	skill - <u>steminterest</u>	-.09571	-2.790	96	.006	
Pair 16	leadership - overall	1.12590	9.983	92	.000	
Pair 17	leadership - <u>stemknowledge</u>	.00480	-1.892	92	.062	
Pair 18	leadership - <u>steminterest</u>	.39134	1.157	91	.250	
Pair 19	overall - <u>stemknowledge</u>	-.82680	-9.867	94	.000	
Pair 20	overall - <u>steminterest</u>	-.51902	-6.151	96	.000	
Pair 21	<u>stemknowledge</u> - <u>steminterest</u>	.53917	1.717	93	.089	

We wanted to identify which construct (Desire, Support, Skill, Leadership, Overall) was the most important in contributing to the outcome. We ran multiple T-Test pairs analysis and discovered that the most important construct was Overall. The Paired Sample Test table shows most pairing comparisons are below .05, except for pair 8, pair 11, pair 17, pair 18, and pair 21. Therefore, we can conclude that all other pairs are statistically significant. When comparing the means for the significant pairs, we observe the Overall has the lowest mean, which in this case means the highest contribution toward the outcome. For example, when comparing the means of pair 13 (with significance of 0.000), between Skill and Overall, Overall has a lower mean of 1.6973 (< 2.1395). In conclusion, there is evidence to suggest that participants statistically consider overall attitude toward the FLL program (Overall) as the main contribution to the outcome.

Hypothesis 7: Male students are more likely to stay longer in the programs than female students.

Case Processing Summary

	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
	Please select your gender: * How many years have you participated in FIRST programs?	102	68.9%	46	31.1%	148

Please select your gender: * How many years have you participated in FIRST programs? Crosstabulation

Count

How many years have you participated in FIRST programs?

		How many years have you participated in <u>FIRST</u> programs?				
		1 year	2-3 years	4-5 years	6-7 years	8+ years
Please select your gender:	Male	29	22	10	3	3
	Female	19	11	4	0	1
Total		48	33	14	3	4

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.531 ^a	4	.639
Likelihood Ratio	3.488	4	.480
Linear-by-Linear Association	1.732	1	.188
N of Valid Cases	102		

Initially, we thought that there would be a significant difference between gender and the number of years participating in the program so we decided to run a Cross-Tabulation test to determine whether or not there is a difference. The output suggests that male students stay longer in the program compared to female students. However, the Asymptotic Significance is 0.639, which is associated with a 63.9% risk of being wrong in rejecting the null hypothesis. 0.639 exceeds the typical 0.05 standard of being significant, hence we can conclude that there is no significant association between gender and the number of years participating in the program. In other words, gender is not associated with how long the students decide to stay in the programs.