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# Using Hands-on Experiences including Various Forms of ARTS to Increase Ninth-Grade Female Students' Interest in STEM -Final Results

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## Abstract

Due to the ever-growing number of employment opportunities in the science, technology, engineering, and math fields, increasing emphasis is placed on STEM education at all levels. This paper reports on research focused on increasing STEM interest and awareness in ninth-grade minority female students, primarily from a low socioeconomic background. Thirty-seven female students participated in this research study. They attended fifteen hour-long sessions of STEM-infused hands-on workshops presented by university professors in the College of Education and the College of Arts and Sciences. The workshops took place during school hours, adding to their regular curriculum. The school does not currently have an arts program, although the founder of the school is a music artist. Therefore, the workshops incorporated the arts as the central theme, while the lessons were delivered in biology, chemistry, engineering, and mathematics. The study is motivated by the need to close the achievement gap and improve the representation of women and minorities in STEM fields. Data were collected through surveys, assessments, and interviews and analyzed using quantitative and qualitative methods. The significance of the study lies in the potential to inspire underserved females to enter the STEM fields.

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**Index terms**— high school STEM education, female students, integrating the ARTS, STEM interest, and awareness.

## 1 INTRODUCTION

The researchers, as well as the workshop presenters, are faculty members at a private university located in the state of Florida. The study aimed to include 9th-grade female students from all racial and ethnic backgrounds and expose them to hands-on workshops related to STEM. Further, it is the view of the researchers involved in this study that this population of minority, underserved students will benefit from the infusion of the arts in this project. According to ??rouillette (p.58), "Now there is growing recognition that, in STEAM projects, the arts not only play their traditional content area role but also scaffold the teaching of science concepts that students could not otherwise envision." One challenge educators face introducing new, often unfamiliar STEM concepts is building a personal connection that will have meaning. Through creative, arts-based approaches, this challenge is more likely to impact the imagination and interest of the student. This effort to connect is carefully crafted by the educator, with the emphasis being placed on STEM disciplines. The arts are a paved learning pathway that allows students to invent, problem-solve, create, and make what they are learning tangible. The research location is a public charter school that receives funding from the state. The principal and his leadership team provided the physical space and staffing necessary to support the STEAM workshops. STEAM professionals recruited from Nova Southeastern University delivered art-focused presentations at the weekly meetings.

The ninth-grade female students were asked to participate in this research study provided by faculty members from the researchers' University because they are currently enrolled in an intervention High School. The parents

43 of these underaged children must grant permission to allow their child to participate. These students were chosen  
44 based on students having similar academic performance. One group of 25 female students was identified from  
45 the school's advanced science class (biology), with the remaining 12 students participating on a volunteer basis.  
46 The biology class has a Florida-certified teacher and two aides.

## 47 2 II.

### 48 3 Method and Materials

49 The school helped identify all 37 students to participate in this study. These students participated in weekly  
50 STEM (STEAM) workshops with a pre-planned ob and career opportunities in STEM experienced tremendous  
51 growth each year. Because of this, industry professionals, politicians, and educators strongly encourage and  
52 support students matriculating into degree programs in the STEM field. While the growth in the number of  
53 graduates needed to fill the increasing number of opportunities is promising, female and minority students are  
54 underrepresented in the STEM fields (National Science & Technology Council, 2018). Many educators believe a  
55 lack of interest in the STEM professions begins at an early age. Disenfranchised students need the opportunities  
56 afforded to students in more affluent areas of a school district, city, or state (Anderhag et al., 2016). Research  
57 shows a lack of minority female students going into the STEM fields. This is partly due to the need for more  
58 awareness of the STEM field. This STEM knowledge and understanding measured at the beginning and end of  
59 the research study will be shared after the final analysis. J STEM (STEAM) curriculum that the presenters and  
60 the researchers created. In addition, the students took a pre-survey using the S-Stem questionnaire regarding  
61 their perceptions of the STEM (STEAM) program before the start of the project. Following the 15 STEM  
62 (STEAM) workshop sessions, the participating students will take a post-survey using the S-STEM questionnaire.  
63 The research team will compare the pre-and postquestionnaire results at the end of the intervention period.

64 All participants have the right not to participate and leave the study anytime. If they decide not to participate  
65 or go, they will still receive the regular science program at the school but will not be part of the research study.  
66 However, if a student chooses to stop being in the study before it is over, any information collected (such as the  
67 pre-survey) will be kept in the research records for 36 months from the end of the study and may be used as a  
68 part of the research.

69 There is no guarantee or promise that participants will receive any benefit from this study. The possible use  
70 of being in this research study is to know how their perception of the STEM (STEAM) field has changed and  
71 science knowledge has improved at the end of the study. The researchers intend that information learned from  
72 the survey will benefit people in similar settings.

73 All information about the participants in this research study will be handled confidentially, within the limits  
74 of the law, and will be limited to people who need to review this information. The lead researcher stored the  
75 participant information on a university computer. The researchers will use the data for granting agencies and  
76 publications to share knowledge with other researchers and educators.

77 Many K-12 students, predominantly minority female students in the United States, lack the knowledge and  
78 skills to continue their STEM education and ultimately enter the workforce.

79 There is an estimated 13% growth rate of STEM careers between 2017 and 2027, compared to 9% in other  
80 career fields (Education Commission of the States, 2020). To meet this need for STEM professionals, educational  
81 leaders in the United States are adamant in stating, "to hold a competitive edge in a rapidly changing global  
82 workforce, bolstering the nation's science, technology, engineering, and math (STEM) workforce is essential"  
83 (National Education Association, 2016).

84 Although in their earliest years, children are natural scientists, engineers, and problem-solvers (Murphy, 2001),  
85 by the time these same students reach the 8 th grade, over 50% have lost interest in focusing on higher education  
86 or a career in one of the STEM disciplines. Other researchers strongly believe that students are interested in  
87 STEM disciplines; a strong interest never develops ??McCreedy & Kierking, 2013). Regardless of the reason, the  
88 fact remains that our STEM pipeline is significantly reduced by the time students reach middle school, secondary  
89 school, and college. Females, students from lower socioeconomic backgrounds, and students from ethnic or racial  
90 minority groups are most affected (Figure 1).

## 91 4 Example 1

92 Strongly Disagree Disagree Neither Agree nor Disagree Agree Strongly Agree O O O O O

93 Of these, equal gender representation is the most significant concern for educators. Studies have shown that,  
94 while gender disparity is lessening, more can be done to recruit females into STEM-related higher education  
95 and careers (Hawkins, 2015). Efforts to rectify this problem have shown that early exposure to informal STEM  
96 experiences can positively affect learning and participation (Langdon et al., 2011). This research project involved  
97 developing and delivering weekly STEAM hands-on workshops to high-school females and evaluating their effect  
98 on STEM interest, awareness, and knowledge. The study was conducted in an urban, predominantly Hispanic,  
99 lower socioeconomic Title 1 school in West Palm Beach, Florida. An over-arching research question guided the  
100 work: "Can participation in weekly STEAM workshops increase young females' STEM interest and awareness?"

101 In the most recent census, West Palm Beach, Florida, had approximately 110,000 residents, with a racial  
102 breakdown of 37% non-Hispanic white, 34% African American, and 25% Hispanic, earning a median income of

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roughly \$54,000 (United States Census Bureau, 2019). The School District of Palm Beach County (SDPBC) consists of 160 K-12 schools enrolling approximately 170,000 students yearly. The district offers over 300 Choice programs that allow students to focus on various personal interests (e.g., the International Baccalaureate program, programs dedicated to music and the fine arts, information technology, and foreign languages). In addition, three schools host Choice STEM programs at the high school level (Palm Beach County Schools, 2020).

The high school hosting the research project is a Title 1 institution with a population of approximately 200 students. In the most recent school year, the population was about 70% Hispanic, 14% Black, and 12% non-Hispanic white; the remaining 4% represented other racial and ethnic groups. The population is 44% female and 56% male, and 88% of students are eligible for free or reduced lunch. In addition, the school has ten research aimed to develop and deliver a STEM-focused weekly program at the high school. This study focused on all aspects of STEM integrating the arts. The participants included female, predominantly Hispanic, 9th-grade students. Administrators at the school provided teachers, staff, and the physical space necessary to support the program. In addition, STEM professionals from the researchers' private university were recruited and delivered focused presentations at the weekly meetings, including anatomy, elementary physics, food science, botany, 2-D painting/drawing, sound, engineering, Tai Chi, and physiology.

The Student Attitudes Toward STEM Survey (S-STEM) measures students' interest and awareness of STEM content and careers (Friday Institute for Educational Innovation, 2012) and has shown acceptable levels of reliability and construct validity (Faber et al., 2013; ??nfried et al., 2015). The S-STEM consists of four sections to measure one make within the STEM domain (i.e., science, technology, engineering, and math). For this study, the researchers used a modified version of the science section comprised of nine statements with answers ranging from "Strongly Disagree" to Agree Strongly." The answers will represent numeric values ranging from 1 to 5; an overall average will be computed.

Based on the Central Limit Theorem (CLT), the sample size of 37 is sufficient for statistical significance. The Central Limit Theorem is used so that the sampling distribution will always be generally distributed if the sample size is large enough, in our case, 37 students.

The pre-survey on Science, Technology, Engineering, and Mathematics was given in October 2022 before the workshops (Figure 2).

## 5 III.

## 6 RESULTS AND DISCUSSION

Statistical methods for analyzing data are critical as they provide necessary insight to researchers. For individuals conducting research problems, it is essential to understand how to develop a research problem, along with a plan for gathering data, followed by ways to interpret the collected data. Next, researchers gather raw data and transform them into graphs to further dissect the results. Finally, researchers can conclude a population using analysis methods such as descriptive statistics, inferential statistics, and correlation analysis. This study will investigate 9th-grade female students' attitudes and abilities toward four areas of STEM following a survey obtained from a population sample.

### 7 a) Development of Raw Data into Graphs

The central limit theorem is the principle that the distribution from sample means makes assumptions as a population grows. Using the preliminary pre-survey data of 9th-grade female students, we can make assumptions about the people of all 9th-grade female. For this study, the students were asked preliminary questions regarding their feelings and abilities in four areas of STEM: math, science, engineering, and technology. The questions required the students to respond with one of the provided answer choices, strongly disagree, disagree, neither agree nor disagree, coordinate, and strongly agree. Established answer choices allow for easy understanding and better comparison between the students and the post-survey data. In addition, the preliminary survey results were developed into a graph to provide a visual of the data.

### 8 Figure 2: Preliminary Survey Data

A bar graph is determined to suit the data best to show all responses on the same plane. This graph easily distinguishes the frequency of each response to the questions. From this, we can gather some general assumptions regarding 9th-grade female students. For example, the question "Math has been my worst subject" produced a substantial number of "disagree," while the other responses were somewhat equal. This tells us that most students do not think math is their worst subject.

### 9 b) Descriptive Statistics Analysis

To better understand the results of the survey, it is advisable to make use of descriptive statistics. Measures of central tendency and variability are often used first to analyze data. The main direction is determined by uncovering the mean, median, and mode. Variability considers the responses' dispersion using tools such as range and interquartile range.

## 10 D) CORRELATION ANALYSIS

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159 Due to the nature of the survey, the data would be considered ordinal. The research questions are formatted  
160 in a way that generates responses on a scale known as a Likert scale (Sullivan & Artino, 2013). Likert data  
161 requires respondents to rank their agreeableness to each statement. Reactions in the data set are among five  
162 choices ranging from strongly disagree to agree strongly. The differences between each option are not necessarily  
163 equal, which allows us to consider this ordinal data (Sullivan & Artino, 2013).

164 Ordinal data is best analyzed using median, mode, range, and interquartile range. Inputting the survey data  
165 into the SPSS software computes this information for further analysis. Each question is labeled as the subject  
166 abbreviation followed by the question number (e.g., M1 = "I like math"). The responses are converted into  
167 quantitative data for ease of interpretation. Therefore, 1= strongly disagrees, 2= disagree, 3= neither agree nor  
168 disagree, 4= agree, and 5= strongly agree.

169 The data in the tables allows for a more straightforward interpretation of the survey results. The mode is  
170 valuable because it tells the researcher which response was the most common and indicates how most participants  
171 felt toward the question. The median is also helpful because it means the researcher is where the middle of the  
172 distribution lies. The range for all variables will be four due to the five total response choices. Therefore, the  
173 interquartile range will provide a more accurate measure of dispersion. The interquartile content can be calculated  
174 by subtracting the 25 th and 75 th percentile. A minor difference between the first and third quartiles indicates  
175 consensus among the participants.

176 Due to this being ordinal data, the uncertainty of the distance between responses means some statistical  
177 functions will be less accurate. Therefore, other data types will find other interpretation methods valid. This  
178 will include the measure of central tendency, mean, which indicates the statistical average of the data results.  
179 In addition, different kinds of data will utilize the methods of dispersion, standard deviation, and variance.  
180 Standard deviation indicates the average distance between the response from the mean. Variance is equal to  
181 standard deviation squared and is only used when standard deviation cannot be used. Although this information  
182 is regarded as less suitable for ordinal data, some statisticians support this data's significance, so it may be  
183 beneficial to consider this information if it is not the sole basis for decision-making. Inferential statistics are used  
184 to make assumptions about an entire population based on sample data. For example, using the preliminary data  
185 from the survey of 9th-grade female students, we can conclude about the whole 9th-grade female population.  
186 Comparing the data to the post-survey data can clarify the hypotheses' validity. To interpret ordinal data, it is  
187 best to utilize non-parametric procedures. Non-parametric tests are performed using the median, making them  
188 ideal for ordinal data. Non-parametric analysis can be conducted using the Mann-Whitney, Wilcoxon, Kruskal  
189 Wallis, and Friedman tests.

190 The survey's preliminary data is summarized in the chart following the intervention. It is important to note  
191 that the data is obtained from a smaller sample size. However, the participants remain 9th-grade female students.

192 The corresponding descriptive statistics are compiled into the following tables for secondary visual analysis.  
193 The preliminary data also uses ordinal data descriptive statistics such as median, mode, range, and interquartile  
194 range. The Kruskal-Wallis test best analyzes the survey data from both samples. This test is the non-  
195 parametric equivalent of the ANOVA (analysis of variance) test (Lomuscio, 2021). It determines if the initial  
196 and postpreliminary data responses reflect the same frequencies or have identical medians. In addition, the test  
197 considers the following:

198 Null hypothesis H0: There is no statistical difference between the medians of responses regarding 9th-grade  
199 female student attitudes and abilities in the four areas of STEM before and after the intervention. For the  
200 data produced by the Kruskal Wallis Test, we assume a significance level of .05. If the asymptotic significance  
201 is less than or equal to .05, the medians between samples are statistically significant, and the null hypothesis  
202 is rejected. However, if the value is more significant than .05, the differences between the medians are not  
203 statistically significant (Kruskal-Wallis tests in SPSS). Therefore, the results for each question are interpreted  
204 as follows: After conducting the Kruskal Wallis Test, it is determined that for all responses, the asymptotic  
205 significance is greater than or equal to the significance level, .05. This allows the researchers to know there is no  
206 statistical difference between the medians from the survey data before and after the intervention. Therefore, the  
207 null hypothesis cannot be rejected. Therefore, conducting inferential statistics analysis is highly beneficial when  
208 comparing two datasets.

### 209 10 d) Correlation Analysis

210 Data gathered from the 9th-grade female students leads us to assume their abilities and feelings toward math,  
211 science, engineering, and technology remain the same. This data can further be interpreted with correlation  
212 analysis. Correlation analysis measures the strength of the relationship between variables. A high correlation  
213 indicates a strong relationship between the variables. The four areas of STEM are categorized into three groups:  
214 math, science, engineering, and technology. The results from the study can be used to determine if there is any  
215 connection between students' abilities and attitudes throughout each subject. For The correlation coefficient,  
216 .884, reveals a positive relationship between students who like to imagine creating new products and those who  
217 are good at building and fixing things. Once more, the significance level of <.001 agrees with this correlation.

218 Identifying correlations between variables is crucial for many research problems. For example, assessing this  
219 data for correlation allows us to know if a positive relationship exists between the sample students' feelings toward

220 a particular subject and their ability. This leads us to assume that one with positive feelings toward an issue will  
 221 likely perform well, and students with negative feelings toward a matter presumably do not perform well.  
 222 IV.

## 223 11 Conclusion

224 This study aimed to introduce various sciencelated topics to young, primarily Hispanic female students in a  
 225 Title I high school. This was accomplished through weekly STEM workshops with the faculty presenters from  
 226 the College of Education and the College of Arts and Sciences.

## 227 12 Specific steps included:

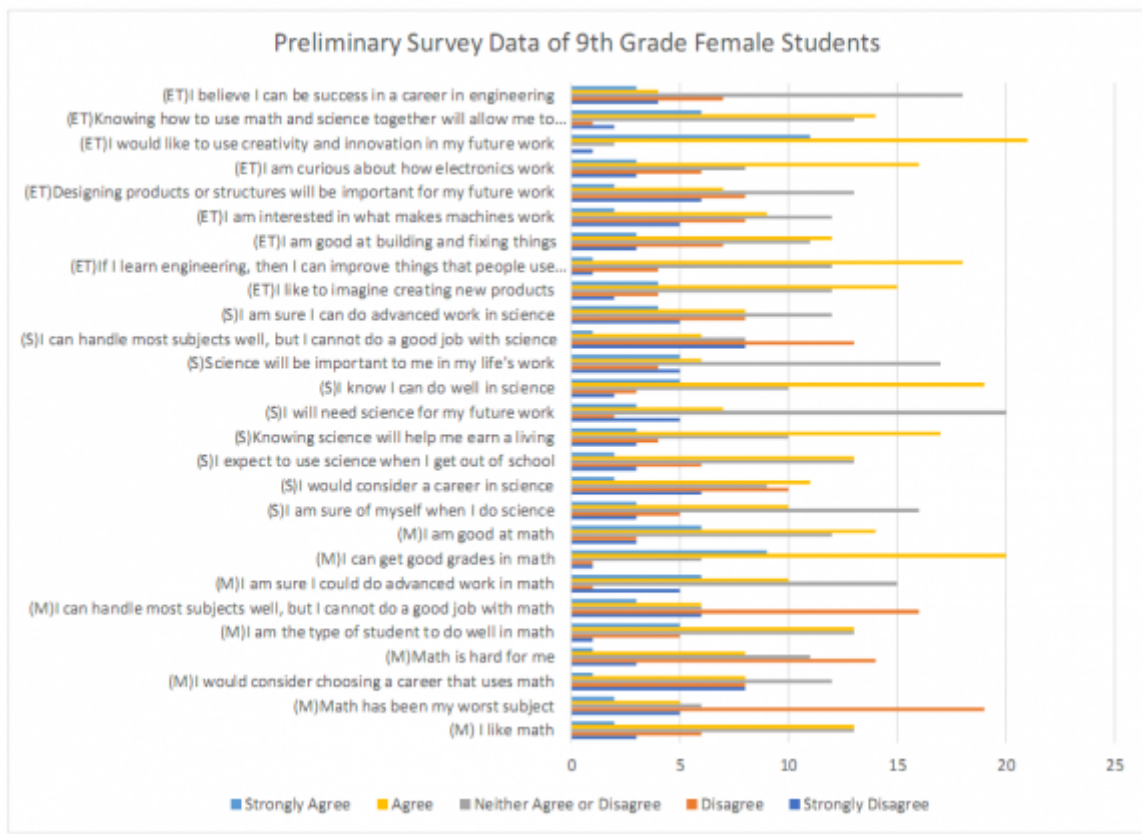
228 1. The principal and his leadership team identified a purposive sample of 37 9th-grade female students meeting  
 229 the required demographic characteristics to participate in the study. 2. At the first meeting, students completed  
 230 the S-STEM. The survey was also conducted at the end of the 15th-week workshop.

231 Fifteen weekly STEM lessons were scheduled with the ninth-grade female students.

232 Since the ongoing study, researchers have limited S-STEM data and no data from students involved in the  
 233 project management classes. To analyze the S-STEM data in the most meaningful manner possible, researchers  
 234 compared the data collected at the beginning of the 9 thgrade study to that of the end of the project.

235 Most researchers will agree that a study's validity lies in identifying an appropriate research problem,  
 236 developing a robust methodology, strict adherence to the methods during implementation, proper data analysis,  
 237 and an accurate interpretation of the results. If these guidelines are strictly adhered to, the results of a study  
 238 are strongly supported.

239 Studies cannot be invalidated; instead, we must recognize threats to our results' validity and try to control  
 240 them in the best manner possible. In this case, a sound study was designed and implemented. However, given the  
 241 ongoing issues in online classrooms and their effect on students, teachers, and administrators, we must continue  
 researching this area.



1

Figure 1: Figure 1 :

242

12 SPECIFIC STEPS INCLUDED:

**Statistics**

		M8	M9	S1	S2	S3	S4	S5
N	Valid	37	38	37	38	37	37	37
	Missing	2	1	2	1	2	2	2
Median		4.0000	4.0000	3.0000	3.0000	3.0000	4.0000	3.0000
Mode		4.00	4.00	3.00	4.00	3.00 <sup>a</sup>	4.00	3.00
Range		4.00	4.00	4.00	4.00	4.00	4.00	4.00
Minimum		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Maximum		5.00	5.00	5.00	5.00	5.00	5.00	5.00
Percentiles	25	4.0000	3.0000	3.0000	2.0000	2.5000	3.0000	3.0000
	50	4.0000	4.0000	3.0000	3.0000	3.0000	4.0000	3.0000
	75	4.5000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000

2

Figure 2: GFigure 2 :

**Statistics**

		M1	M2	M3	M4	M5	M6	M7
N	Valid	37	37	37	37	37	37	37
	Missing	2	2	2	2	2	2	2
Median		3.0000	2.0000	3.0000	3.0000	3.0000	2.0000	3.0000
Mode		3.00 <sup>a</sup>	2.00	3.00	2.00	3.00 <sup>a</sup>	2.00	3.00
Range		4.00	4.00	4.00	4.00	4.00	4.00	4.00
Minimum		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Maximum		5.00	5.00	5.00	5.00	5.00	5.00	5.00
Percentiles	25	2.5000	2.0000	2.0000	2.0000	3.0000	2.0000	3.0000
	50	3.0000	2.0000	3.0000	3.0000	3.0000	2.0000	3.0000
	75	4.0000	3.0000	3.5000	3.5000	4.0000	3.5000	4.0000

4

Figure 3: Figure 4 :

**Statistics**

		ET4	ET5	ET6	ET7	ET8	ET9
N	Valid	36	36	36	35	36	36
	Missing	3	3	3	4	3	3
Median		3.0000	3.0000	4.0000	4.0000	4.0000	3.0000
Mode		3.00	3.00	4.00	4.00	4.00	3.00
Range		4.00	4.00	4.00	4.00	4.00	4.00
Minimum		1.00	1.00	1.00	1.00	1.00	1.00
Maximum		5.00	5.00	5.00	5.00	5.00	5.00
Percentiles	25	2.0000	2.0000	2.2500	4.0000	3.0000	2.0000
	50	3.0000	3.0000	4.0000	4.0000	4.0000	3.0000
	75	4.0000	3.7500	4.0000	5.0000	4.0000	3.0000

5

a. Multiple modes exist. The smallest value is shown

Figure 4: Figure 5 :

		Statistics						
		S6	S7	S8	S9	ET1	ET2	ET3
N	Valid	39	37	36	37	37	36	36
	Missing	0	2	3	2	2	3	3
Median		4.0000	3.0000	2.0000	3.0000	4.0000	4.0000	3.0000
Mode		4.00	3.00	2.00	3.00	4.00	4.00	4.00
Range		4.00	4.00	4.00	4.00	4.00	4.00	4.00
Minimum		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Maximum		5.00	5.00	5.00	5.00	5.00	5.00	5.00
Percentiles	25	3.0000	2.5000	2.0000	2.0000	3.0000	3.0000	2.0000
	50	4.0000	3.0000	2.0000	3.0000	4.0000	4.0000	3.0000
	75	4.0000	4.0000	3.0000	4.0000	4.0000	4.0000	4.0000

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Figure 5: Figures 6 , 7 , 8 , & 9 :

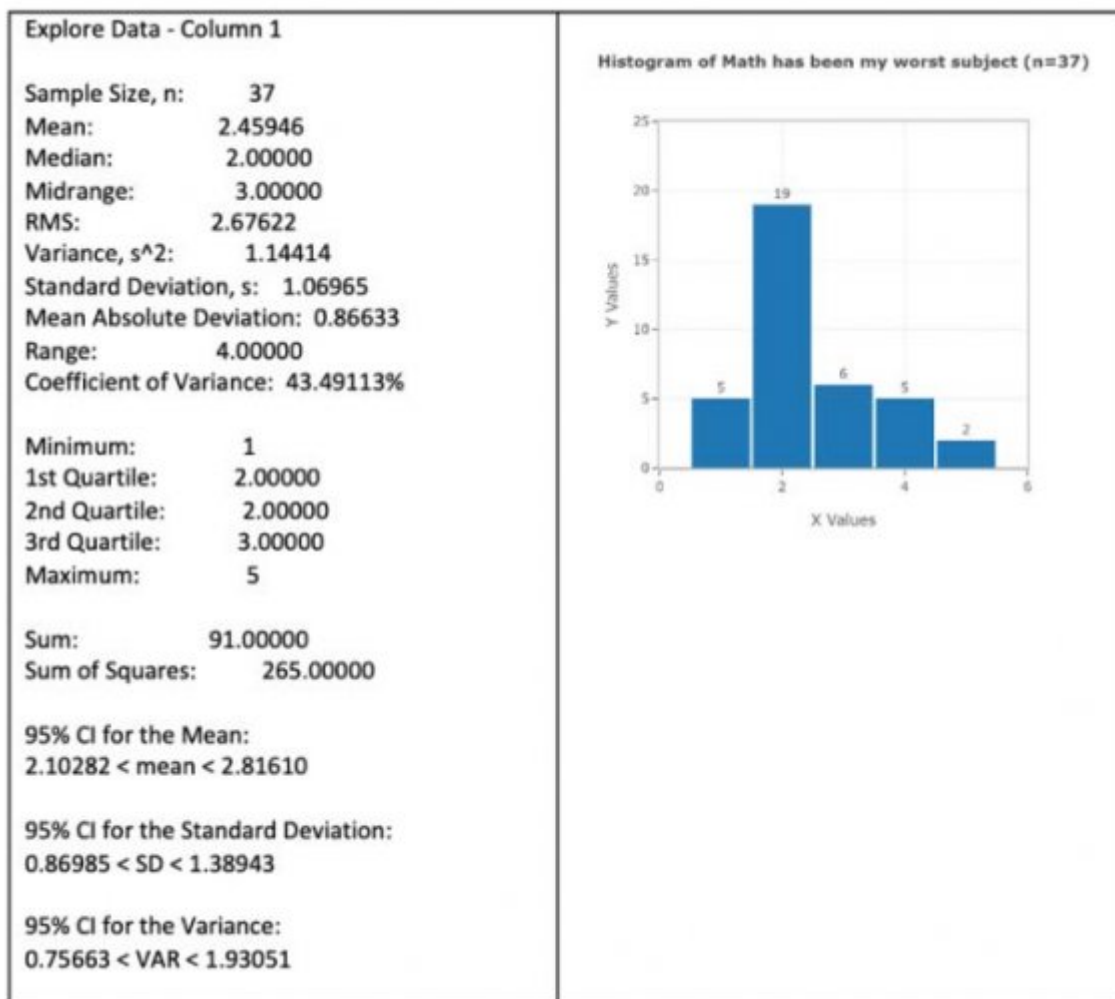
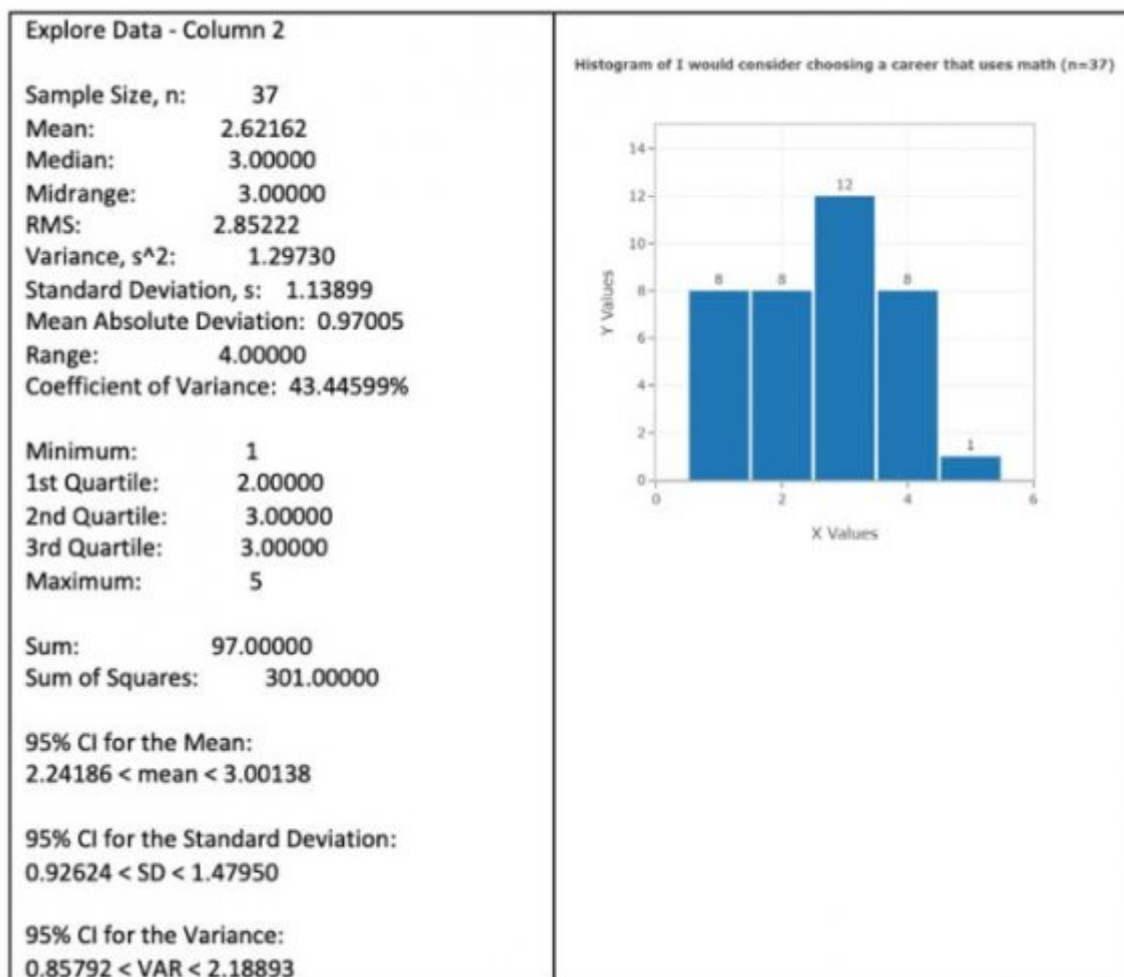


Figure 6:

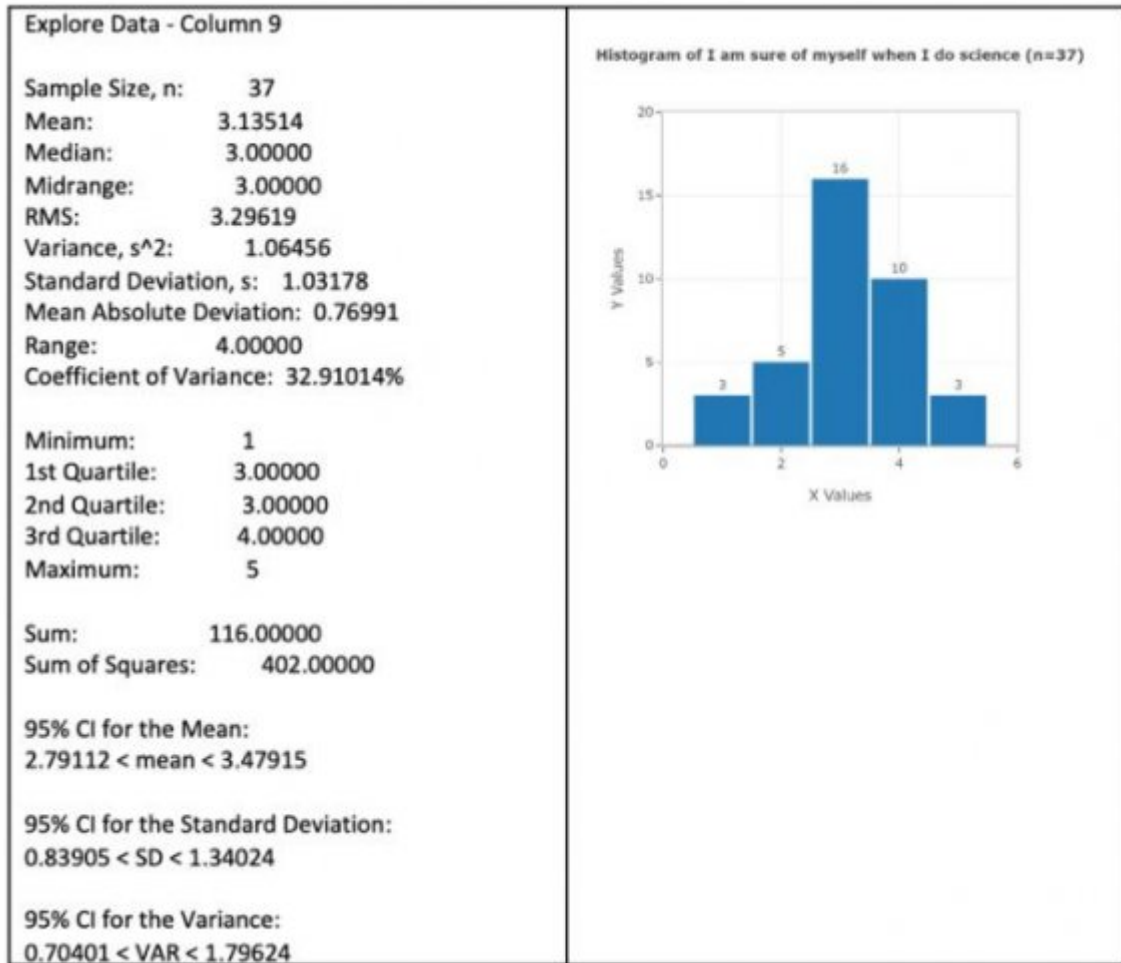
12 SPECIFIC STEPS INCLUDED:



11

Figure 7: Figure 11 :





12

Figure 8: Figure 12 :

## 12 SPECIFIC STEPS INCLUDED:

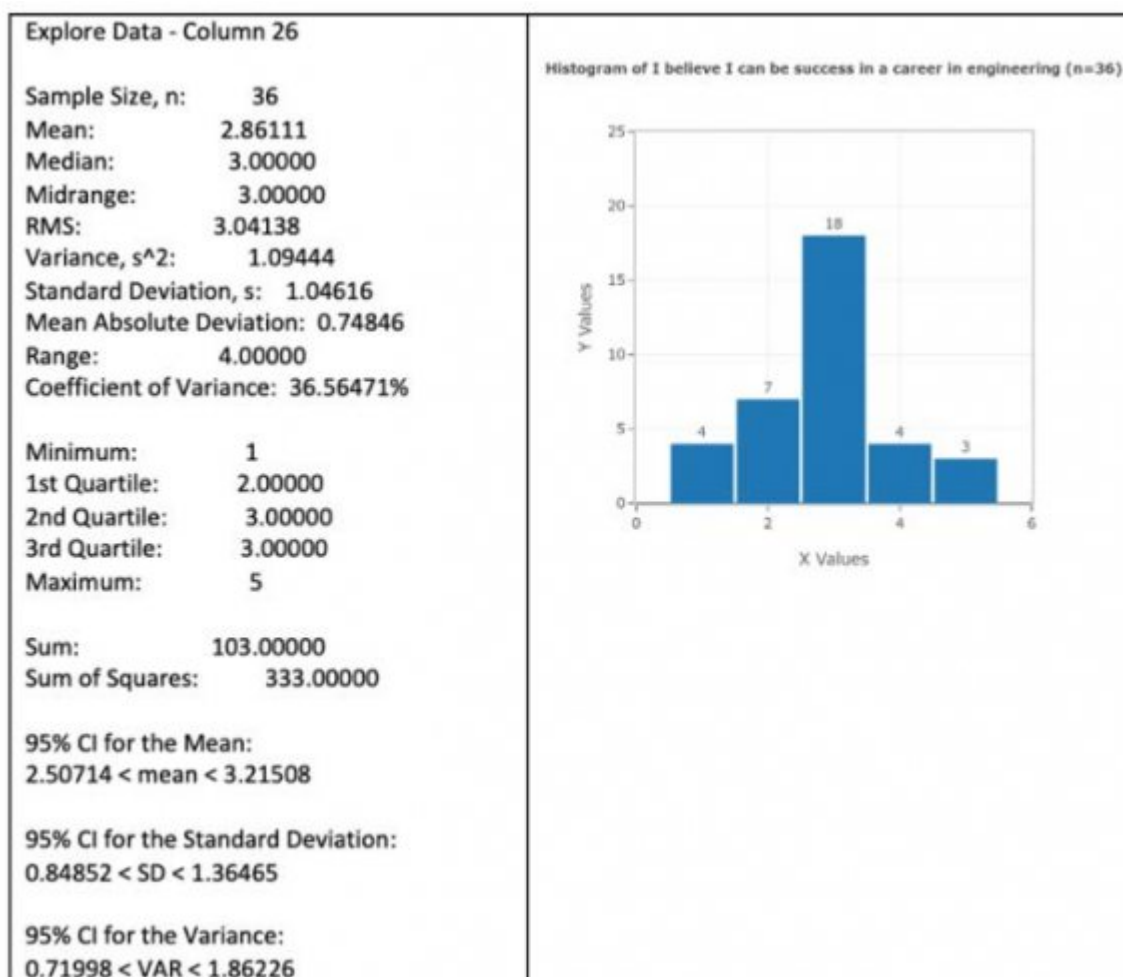


Figure 9:

		Statistics						
		M1	M2	M3	M4	M5	M6	M7
N	Valid	18	24	24	24	24	24	24
	Missing	10	4	4	4	4	4	4
Median		3.0000	2.5000	3.0000	3.0000	3.0000	2.5000	3.0000
Mode		3.00	3.00	3.00	3.00	3.00	2.00	3.00
Range		4.00	3.00	4.00	4.00	4.00	4.00	4.00
Minimum		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Maximum		5.00	4.00	5.00	5.00	5.00	5.00	5.00
Percentiles	25	2.0000	1.2500	2.0000	1.2500	3.0000	2.0000	2.0000
	50	3.0000	2.5000	3.0000	3.0000	3.0000	2.5000	3.0000
	75	4.0000	3.0000	3.0000	3.0000	4.0000	3.7500	4.7500

Figure 10:

instance, does a student who responds positively to "I like math" also react positively to "I am good at math"? Correlation analysis can be performed through several methods, the most popular being the Pearson and Spearman correlation. Both ways identify a degree of association between variables. However, the Spearman correlation is a non-parametric test suitable for ordinal data. For this analysis, the Spearman correlation is conducted with two questions simultaneously, ensuring one relates to ability and feelings. The questions will also be from the same subject. Finally, the compared questions have the same perspective, meaning they must be either positive or negative.

Two statements from each subject are compared to determine the correlation between students' attitudes and abilities. For mathematics, "I like math" (M1) and "I can get good grades in math" (M8) are analyzed. The science questions included are "I am sure of myself when I do science" (S1) and "I would consider a career in science" (S2). Lastly, the questions considered for engineering and technology are "I like to imagine creating new products" (ET1) and "I am good at building and fixing things" (ET3).

Several aspects of the resulting analysis can be used to determine the strength of the association between variables. A correlation coefficient is a number that lies between -1 and +1. A positive correlation coefficient indicates a positive relationship, while a negative correlation coefficient signifies a negative relationship. A value of 0 allows the researchers to know that no connection exists. The significance value is another important attribute, enabling one to understand if the result is statistically significant.

The correlation coefficient at the cross-sections of the questions, .865, is essential to note. This denotes a positive relationship between people who like math and people who can achieve good grades in math. The significance level of <.001 further supports this result.

The coefficient of .926 indicates a high positive correlation between students who are sure of themselves in science and would consider a career in science. Once again, the significance level, <.001, supports the correlation.

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