2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
Paper ID #37077

# Statistical Validation of Growth in the Entrepreneurial Mindset of Students Resulting from Four Years of Interventions

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Ron Harichandran is Dean of the Tagliatela College of Engineering and is the PI of the grant entitled Developing Entrepreneurial Thinking in Engineering Students by Utilizing Integrated Online Modules and a Leadership Cohort. Facilitated by this grant, a comprehensive program to develop an entrepreneurial mindset in all engineering and computer science undergraduate students in the Tagliatela College of Engineering was implemented.

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## Introduction

Integrating entrepreneurship elements into the college classroom and beyond is gaining momentum across higher education institutions in the U.S. Engineering faculty are adopting Entrepreneurial Minded Learning (EML) to help students develop entrepreneurial skills. A wide range of approaches are used including offering a minor or specialized courses, incorporating entrepreneurial mindset (EM) elements into existing courses, running student competitions that focus on ideation and value creation, providing physical spaces to support EM development, and so on.

At the University of New Haven, we employ both curricular and extracurricular activities to foster EM in students including integration of EM in specific courses in all four years of students' programs, a few competitions held throughout the academic year, a living learning community with a focus on EM, and an entrepreneurial engineering certificate. These activities are summarized in Figure 1. Extracurricular activities are offered to all in the same manner but are optional. Through these activities and events, we foster student participation and provide them different platforms to enhance their EM thinking and practice their EM skills. On the curricular side, students mainly go through similar experiences. Short e-learning modules that are integrated into courses are used to expose students to a wide range of entrepreneurial concepts. EML class activities and assignments that are associated with these modules further foster development of an EM. The other two curricular components, the entrepreneurship course and the entrepreneurial engineering certificate, are elective and customized to the student.

Our efforts to foster an EM in students span back more than a decade. Most of the focus during the initial years was on the program implementation [1,2] with some preliminary assessments based on data collected. Assessment of educational interventions is of particular importance because it helps to determine whether the interventions are effective. As we collected more data over time, we were able to expand our assessments [3-5]. In this paper, we present findings of a longitudinal study related to our EML efforts that provides a more comprehensive evaluation. The study was performed with a cohort of undergraduate engineering and computer science students who started in fall 2017 and were exposed to curricular EML experiences in our college and the extra-curricular ones they chose to participate in during their studies. The data was collected using a survey instrument with 50 questions loaded on 14 factors and then analyzed using statistical methods. Students completed the survey during the incoming first-year orientation in fall 2017 and then again at the end of their senior year in their capstone design courses in spring 2021. In the following sections, we present the statistical validation of growth in the EM of these students resulting from our interventions. Surveys are the most popular form of assessment data collection tools in engineering entrepreneurship education [6]. Therefore, the assessment approach and analysis presented here can serve as a useful resource to educators in the field of engineering entrepreneurship.

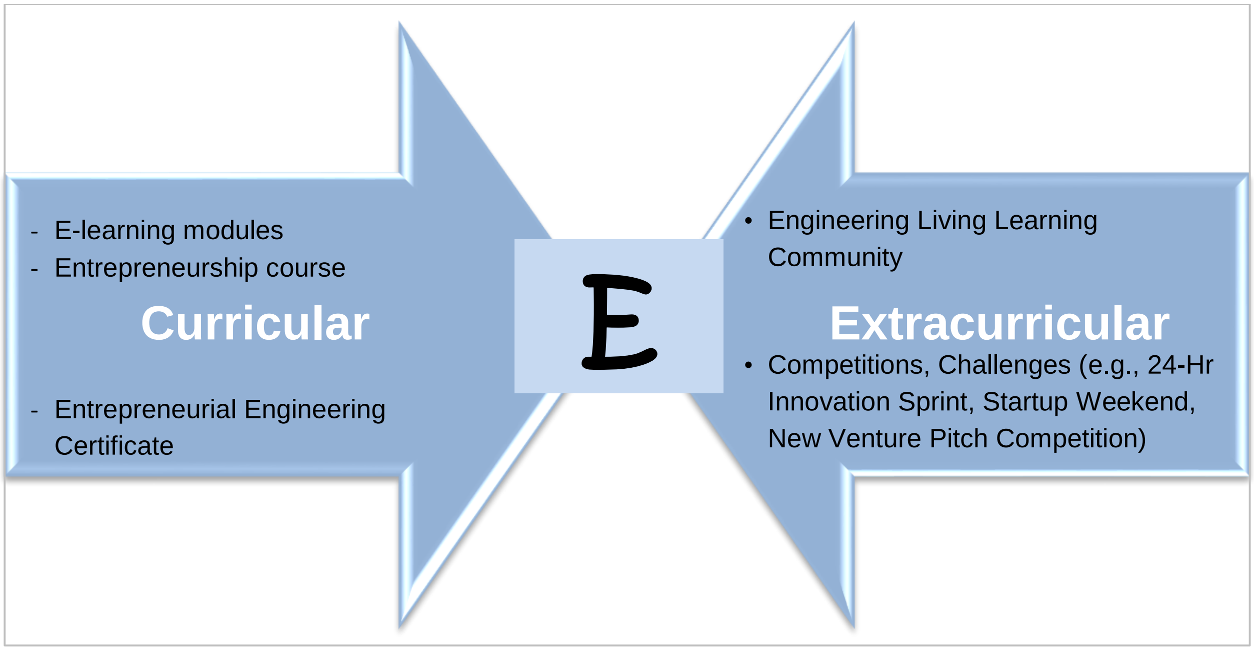


Figure 1. EM Development Components

**Literature Review**

We considered the type of data, level of measurement, aggregated rating scale, and sample size as the foremost factors in selecting the methods employed in this study, which led us to the selection of a two-sample *t*-test. In typical scenarios of selecting statistical tests for inferences, we first decide if we have categorical or continuous data and whether we have paired or unpaired data [6]. If the data is categorical, then tests such as Chi-square, Fisher's exact test, or McNemar's test are considered as choices. If the data is continuous then a normality check is performed to determine whether parametric or non-parametric tests are suitable for the study. For parametric tests, *t*-tests and ANOVA are the most common; for non-parametric tests, Wilcoxon rank sum, Mann-Whitney U test and Kruskal-Wallis tests are the typical choices depending on the comparison to be performed. While these are the usual steps, not all data fits neatly into a category that allows a final choice with these set of questions.

A common example of such a data type is the Likert scale, which is the one used in our study. Likert scale questions generate categorical-ordinal data in their raw form when responses are ranked from 1 to the highest category [8]. In our study this was 1 through 5. However, the way R. Likert proposed the use of Likert scale questions might make them suitable for an interval level of measurement, which is for continuous data. He proposed equal distances between the numbers in the response, and furthermore, he combined a set of selected items together to measure one trait by taking the arithmetic mean or summation [9-11].

The varied use of the Likert scale resulted in two schools of thoughts on how to handle data. One school proposed that it should be treated as ordinal [12], while the other proposed that it should be treated as interval [13]. There are many studies in the literature that support the latter and provide guidelines to determine the appropriate statistical inference methods for Likert scale data [8,10,11,14-18]. Norman [14] and Batterton and Hale [17] address the issue about the sample size, non-normality and ordinal level measurement on the use of parametric tests on Likert scale data and argue that parametric tests are robust unless there are serious violations to the assumption and concludes that parametric tests can be used on Likert scale data. Harpe [10], in his detailed examination of Likert scale data analysis, provides five recommendations and explains how treating Likert scale data as interval data is suitable in each case.

The data we had for our study aligns with Harpe's following recommendations: "Scales that have been developed to be used as a group must be analyzed as a group, and only as a group"; "Aggregated rating scales can be treated as continuous data"; and "Individual rating items with numerical response formats at least five categories in length may generally be treated as continuous data." Therefore, our choice of inferential method was a *t*-test. In an ideal case, a paired *t*-test would have been a desired selection since our objective is to assess an educational intervention which is best performed with before and after comparisons with the same subjects. However, we did not have sufficient paired responses to obtain meaningful inferences. Therefore, we opted for a two-sample *t*-test.

**Methods**

The study reported herein is based on student responses to a 50-question EM survey instrument that was administered to 99 incoming first-year students in fall 2017 and to 68 seniors just before they graduated in spring 2021. The development and validation of this survey instrument is reported elsewhere [19]. Detailed analysis indicated that the 50 questions could be categorized into the 14 factors shown in Table 1. Most of the factors are associated with four questions, while a few were associated with three questions, and one factor — prior exposure to entrepreneurship — was associated with two questions.

Table 1. Factors associated with EM

| | |
|---|---|
| 1. Problem solving/logical thinking | 2. Engaging stakeholders |
| 3. Value creation | 4. Risk Management |
| 5. Ability to learn | 6. Analyze market conditions |
| 7. System thinking | 8. Team building |
| 9. Prior exposure to entrepreneurship | 10. Ability to anticipate technical developments |
| 11. Intrinsic curiosity | 12. Ability to assess financial value |
| 13. Data driven decision making | 14. Career plan |

There is no single definition of an *entrepreneurial mindset* (EM) but there is commonality in the attributes and skills associated with an EM by various sources. Among the most emphasized elements are creativity, curiosity, critical thinking, flexibility, adaptability, communication, collaboration, comfort with risk, resilience, initiative, future focus, opportunity recognition, innovation, reflection, independence, and value focus [20-24]. The factors identified by the survey questions used in our study align with these elements.

As explained earlier, a two-sample *t*-test was selected for analysis. While each of the 50 questions represented a Likert-type item, their loadings into 14 factors generated a Likert scale item and allowed calculation of a single composite score. A 2-sample variance test was conducted with all 14 data sets and showed that an equal variance assumption was reasonable. While the data sets did not pass the normality test, all histograms showed a bell-shaped distribution (see appendix). Based on the graphical results combined with the large sample sizes we concluded that the normality assumption was reasonable, which is supported by recommendations in the literature [25]. Therefore, we used a two-sample *t*-test with the equal variance assumption in our analysis.

**Relationship of Our EML Components to the Factors**

As mentioned earlier, short e-learning modules is one of the curricular components in EM development at our institution that all students experience. These modules are listed in Table 2. The modules cover a wide range of topics and are tied to EM attitudes and skills. The modules are embedded in existing courses and integration is done in a hybrid format. Students complete the e-learning modules in the courses outside of class hours in a self-paced manner within a two-week period. In addition to the module content, the students complete a contextual activity related to the course material that includes elements that target the EML outcomes covered by the module. We believe that these modules have the most significant contribution on the students' EM. Figure 2 shows a mapping of the factors associated with our survey instrument to the e-learning modules. The modules cover almost all the factors except for factors *9. Prior exposure to entrepreneurship* and *14. Career plans.* Furthermore, the topics are reinforced by multiple modules addressing multiple factors. Students complete these modules throughout their four-year study; this approach fosters development of an EM over a reasonably long period through reinforcement of learning.

Another curricular element available to students is an entrepreneurship course. This elective course is also an effective element in fostering an EM in our students. In the cohort of students considered in this study, 14 students completed the course.

The last curricular component is the Entrepreneurial Engineering Certificate. The certificate is offered to recognize those students who have substantial participation in extracurricular EML activities. The extracurricular activities are events held within the Engineering Living Learning Community (ELLC) and immersive experiences such as competitions and challenges. The ELLC offers students monthly discussion dinners aimed at promoting entrepreneurial thinking. The competitions and challenges included a 24-hour Imagination Quest, a 10-day EML camp, a 2.5-day startup weekend, and a half-semester long experience. These events provide students a platform to practice their EM skills and enhance their entrepreneurial thinking. In the sample of senior students considered in this study, 7 earned this certificate.

Table 2. E-learning modules

| Module Name | Short Title (Abbreviation) |
|---|---|
| Adapting a business to a changing climate | Adapting a business (AB) |
| Applying systems thinking to complex problems | Systems Thinking (ST) |
| Building relationships with corporations and communities | Building relations (BRC) |
| Building, sustaining and leading effective teams and establishing performance goals | Effective teams (ET) |
| Defining and protecting intellectual property | Intellectual property (IP) |
| Determining market risks | Market risks (DMR) |
| Developing a business plan that addresses stakeholder interests, economics, market potential and regulatory issues | Developing a business plan (DBP) |
| Developing customer awareness and quickly testing concepts through customer engagement | Customer awareness (CA) |
| Establishing the cost of production or delivery of a service, including scaling strategies | Cost of production (CoP) |
| Financing a business | Financing a business (FB) |
| Generating new ideas based on societal needs and business opportunities | Generating new ideas (GNI) |
| Innovating to solve problems under organizational constraints | Organization constraints (OC) |
| Innovative client centered solutions through design thinking | Design thinking (DT) |
| Learning from failure | Learning from failure (LFF) |
| Role of product in value creation | Role of product (RP) |
| Resolving ethical issues | Ethics (REI) |
| The elevator pitch: advocating for your good ideas | Elevator pitch (EP) |
| Thinking creatively to drive innovation | Thinking creatively (TC) |

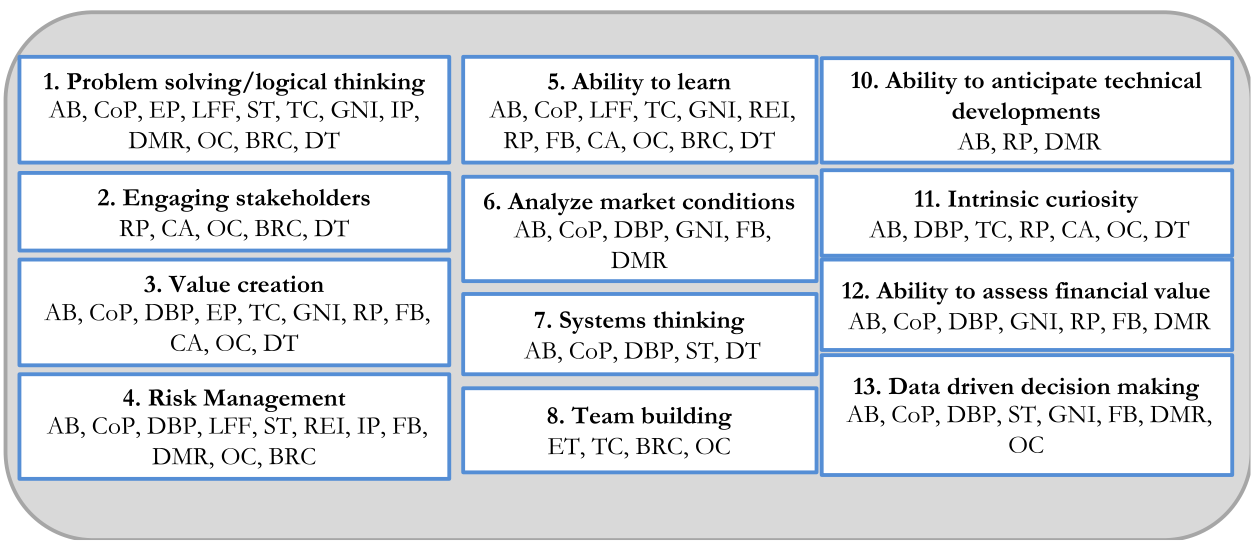


Figure 2. Mapping of EM factors and e-learning modules

## Results and Discussion

As seen from the *p*-values shown in Table 3, the students' entrepreneurial mindset increased in all areas except *9. Prior exposure to entrepreneurship* and *14. Career plans*. Therefore, the results indicate that our approach to developing an EM in students is generally effective.

The result for the factor *Prior exposure to entrepreneurship* is expected since the responses to the two questions related to this factor — "I have had exposure to entrepreneurship concepts before entering college," and "There is/are entrepreneur(s) among my relatives" — are not likely to change between the first and senior years. This factor was also not covered by any of the e-learning modules.

Table 3. Average ratings for factors and *p*-values for two-sample *t*-tests

| Factor | F17 Average | S21 Average | *p*-value |
|---|---|---|---|
| 1. Problem solving/logical thinking | 3.542 | 3.652 | 0.037 |
| 2. Engaging stakeholders | 3.306 | 3.805 | 0.000 |
| 3. Value creation | 3.823 | 4.140 | 0.001 |
| 4. Risk Management | 3.702 | 3.934 | 0.008 |
| 5. Ability to learn | 4.025 | 4.169 | 0.026 |
| 6. Analyze market conditions | 3.680 | 3.917 | 0.013 |
| 7. System thinking | 4.076 | 4.228 | 0.015 |
| 8. Team building | 4.157 | 4.401 | 0.001 |
| **9. Prior exposure to entrepreneurship** | **3.330** | **3.456** | **0.201** |
| 10. Ability to anticipate technical developments | 3.641 | 3.835 | 0.025 |
| 11. Intrinsic curiosity | 4.091 | 4.309 | 0.006 |
| 12. Ability to assess financial value | 3.495 | 3.846 | 0.000 |
| 13. Data driven decision making | 3.835 | 4.245 | 0.000 |
| **14. Career plan** | **3.694** | **3.863** | **0.057** |

The three questions related to the factor *Career plans* — "I have a clear plan for my professional development," "I want to become a good engineer as well as a successful entrepreneur," and "I plan to start up my own business in the future" — are targeted toward assessing interest in new business ventures. Our EM program on the other hand, targets both entrepreneurship and intrapreneurship, i.e., identifying opportunities and creating value in organizations as employees. Anecdotally, we know that only a very few students are interested in launching new businesses and most are inclined toward intrapreneurship with the EM mindset that they gained during their studies. Therefore, the lack of significance in the student ratings for this factor from the first to the senior years is understandable. This also was the second factor not addressed by any of the e-learning modules, although it was covered by the entrepreneurship course and some of the ELLC discussion dinners.

## Relevance to Other Engineering Education Studies

The work reported in this paper could be useful to other researchers engaged in engineering education research. Many student surveys are structured with Likert scales for responses to questions. Sometimes several questions that have similar characteristics may be lumped together into a common theme such as the factors described in our study. The statistical approach used in this study could be adopted when comparing survey results across different years or across different student groups.

## Conclusions

An entrepreneurial mindset survey instrument was administered to engineering and computer science students at the University of New Haven in fall 2017 and spring 2021. Previous work indicated that the responses to the 50-question survey instrument could be loaded into 14 factors. A detailed literature review indicated that a two-sample *t*-test is appropriate to compare the differences in responses related to the 14 factors. Statistical analysis of the responses of students who experienced curricular and extra-curricular components related to entrepreneurial mindset development shows that among the 14 factors there was a statistically significant increase related to 12 factors. The lack of statistical significance in the increase for the other two factors is explainable. The results indicate that the curricular and extra-curricular components deployed at the University of New Haven are effective in developing an entrepreneurial mindset in engineering and computer science students.

## Acknowledgments

The work reported herein was funded by the Kern Family Foundation. We are grateful to Professors Cheryl Li, Maria-Isabel Carnasciali, Jean Nocito-Gobel for their contributions toward developing the EM survey instrument and for coordinating the collection of assessment data from course instructors.

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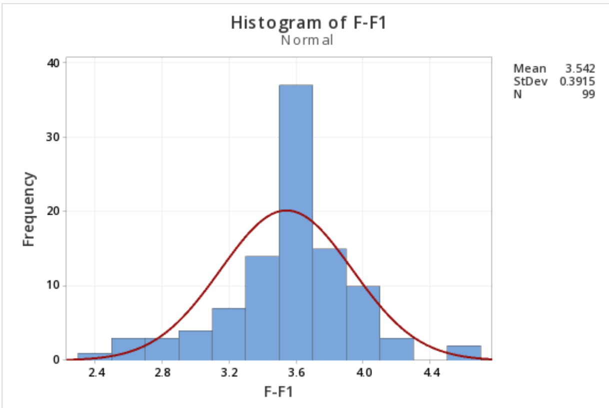
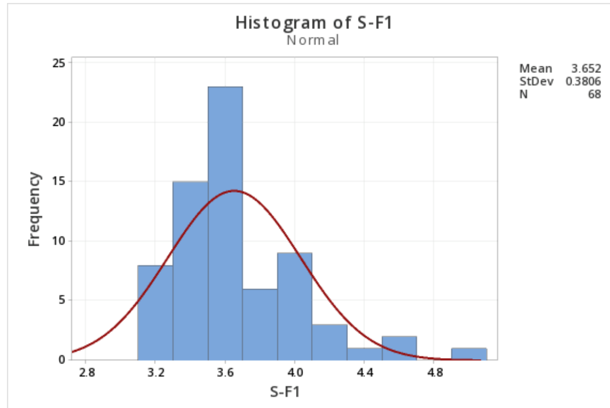
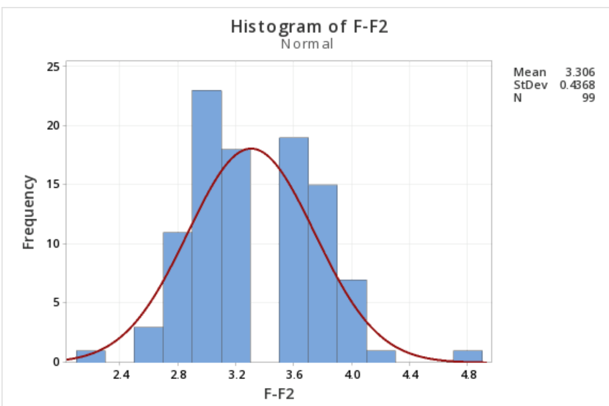
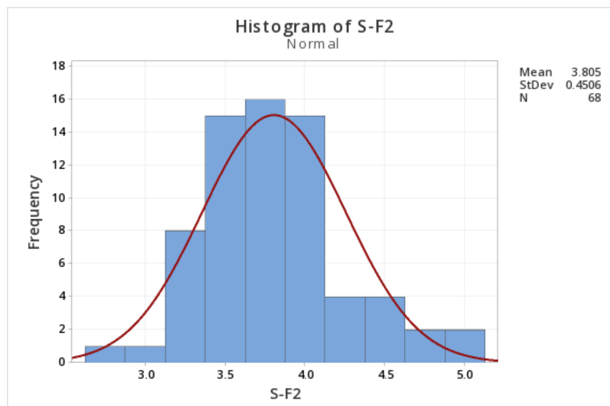
## Appendix

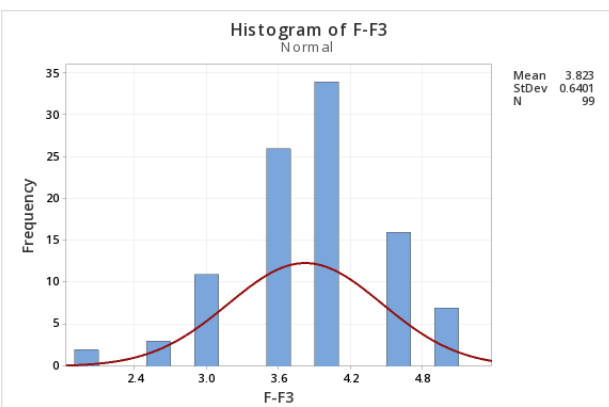
Histograms of the student responses related to the 14 factors are shown in the figures below. The figures on the left are for fall 2017 and the figures on the right are for spring 2021.

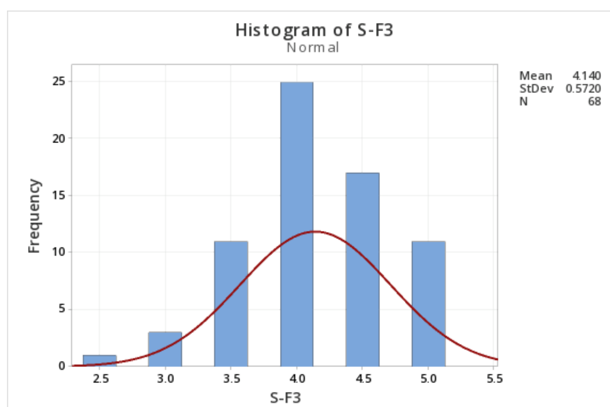


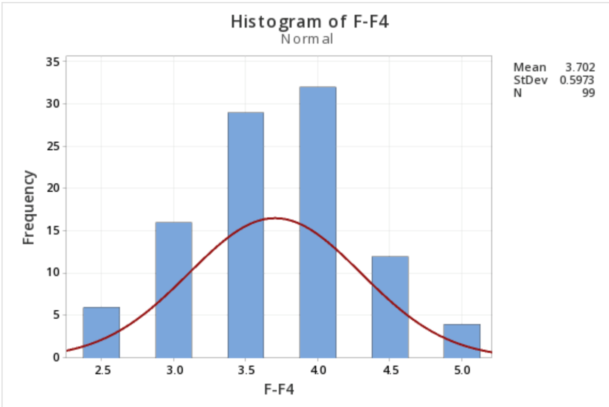

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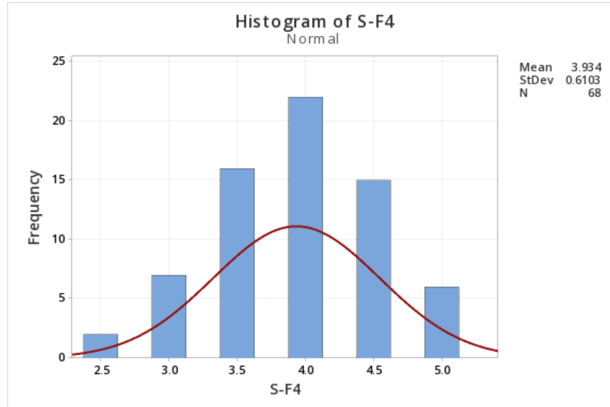
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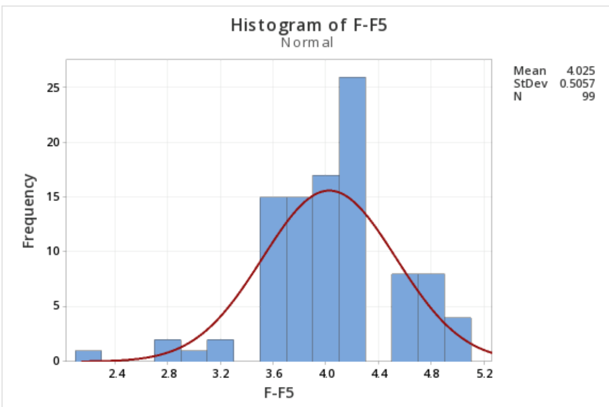
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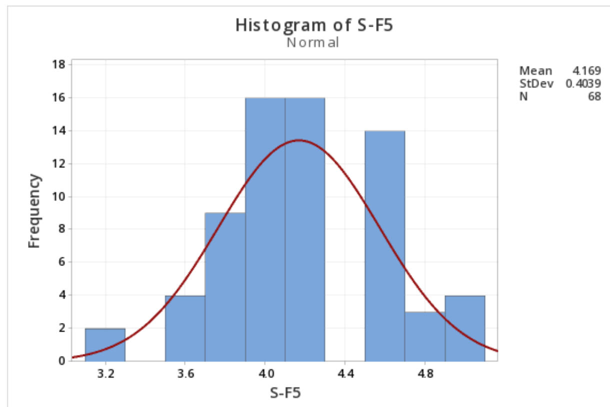
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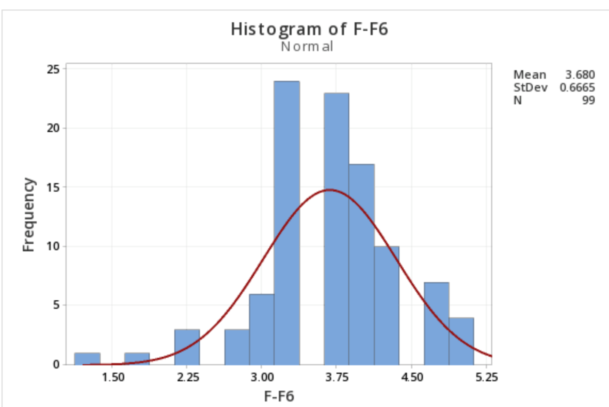
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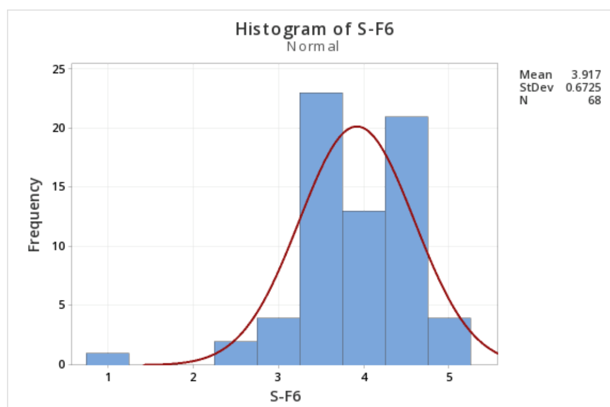
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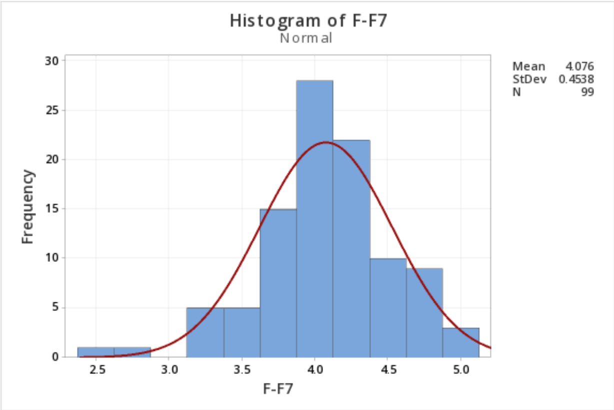
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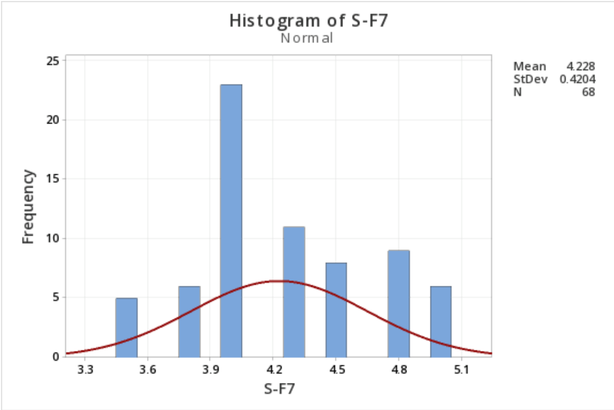
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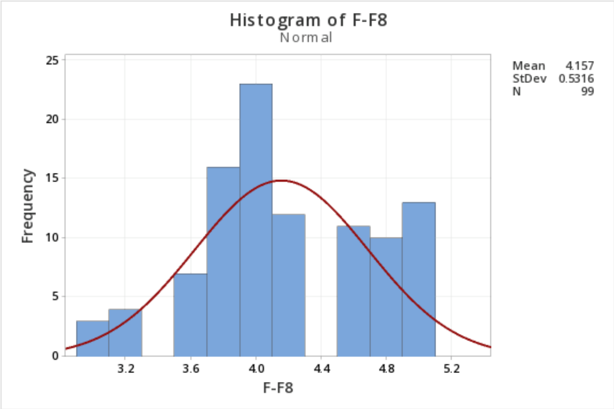
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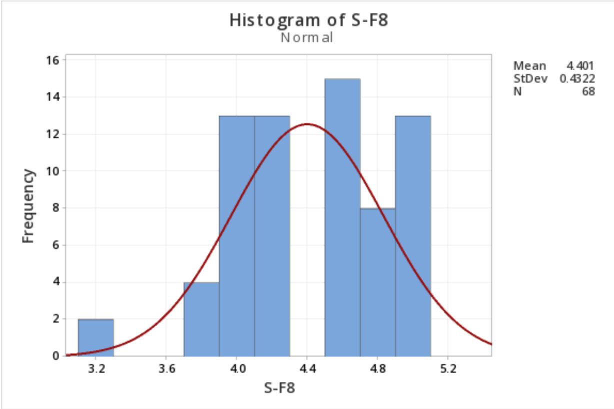
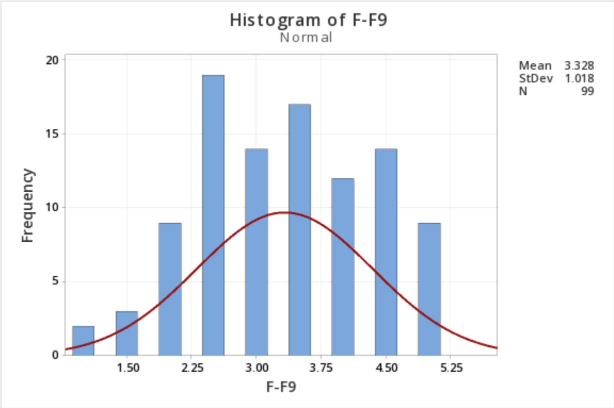
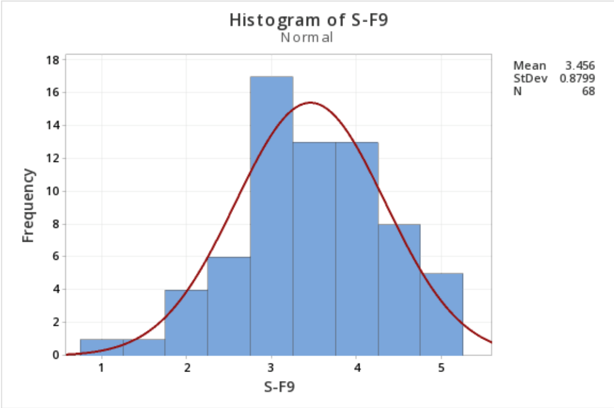
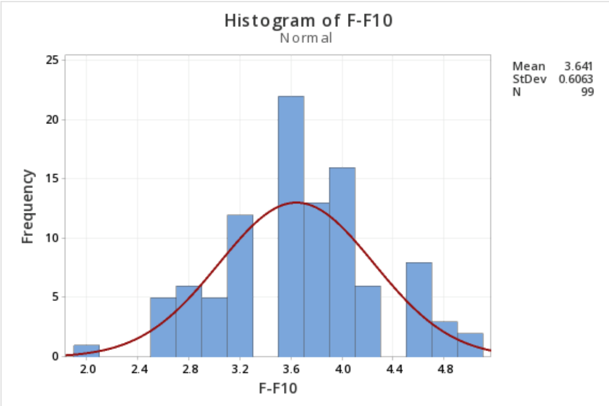
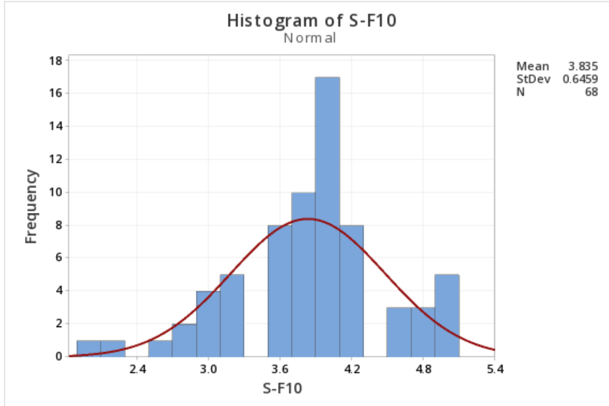
Frequency
F-F8

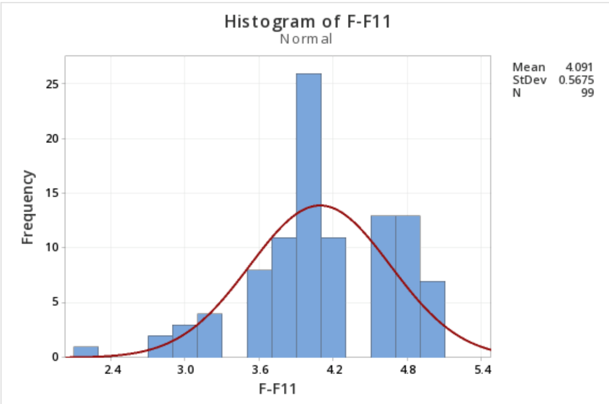

Histogram of S-F8
Normal
Mean 4.401
StDev 0.4322
N 68
Frequency
S-F8

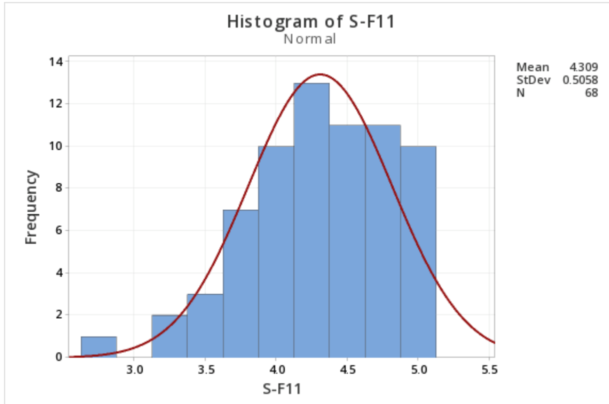

Histogram of F-F9
Normal
Mean 3.328
StDev 1.018
N 99
Frequency
F-F9

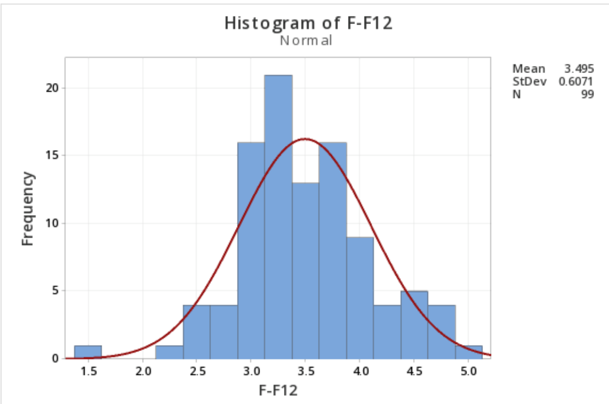

Histogram of S-F9
Normal
Mean 3.456
StDev 0.8799
N 68
Frequency
S-F9

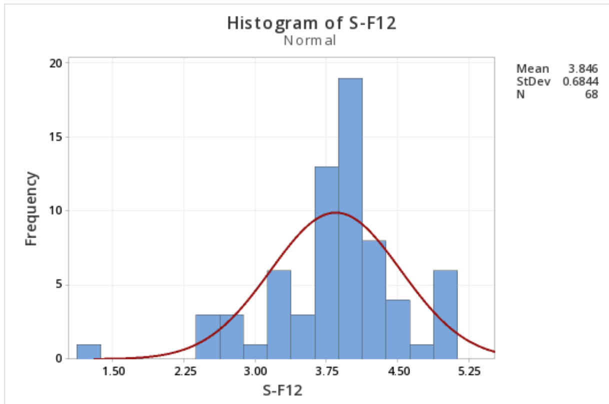

Histogram of F-F10
Normal
Mean 3.641
StDev 0.6063
N 99
Frequency
F-F10

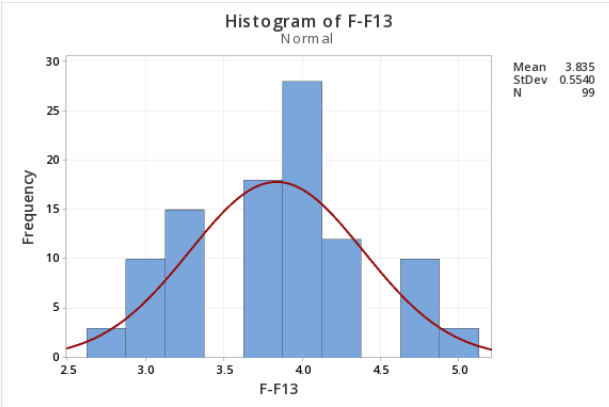

Histogram of S-F10
Normal
Mean 3.835
StDev 0.6459
N 68
Frequency
S-F10

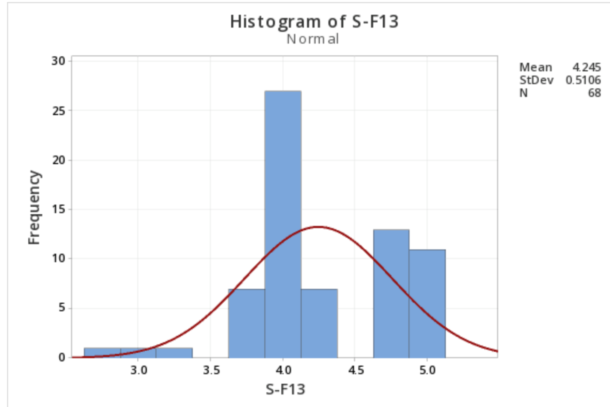

Histogram of F-F11
Normal
Mean 4.091
StDev 0.5675
N 99
Frequency
F-F11

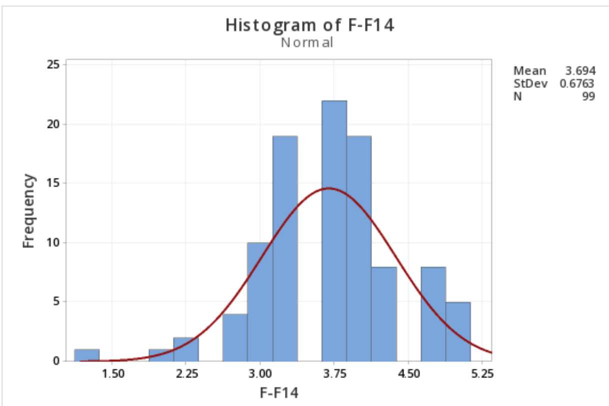

Histogram of S-F11
Normal
Mean 4.309
StDev 0.5058
N 68
Frequency
S-F11

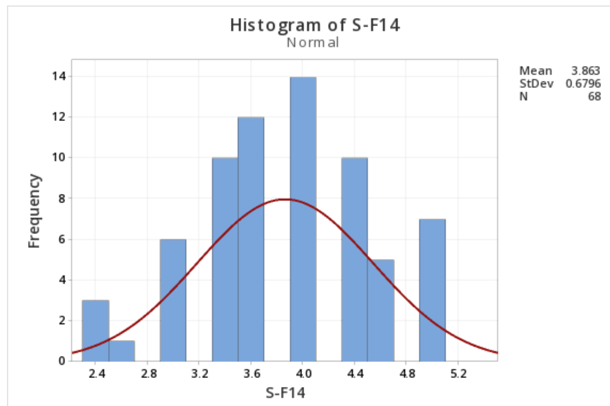

Histogram of F-F12
Normal
Mean 3.495
StDev 0.6071
N 99
Frequency
F-F12


Histogram of S-F12
Normal
Mean 3.846
StDev 0.6844
N 68
Frequency
S-F12


Histogram of F-F13
Normal
Mean 3.835
StDev 0.5540
N 99
Frequency
F-F13


Histogram of S-F13
Normal
Mean 4.245
StDev 0.5106
N 68
Frequency
S-F13


Histogram of F-F14
Normal
Mean 3.694
StDev 0.6763
N 99
Frequency
F-F14


Histogram of S-F14
Normal
Mean 3.863
StDev 0.6796
N 68
Frequency
S-F14