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Statistical Academic Evaluation of the Teaching Process in Engineering Education

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التقييم الأكاديمي الإحصائي للعملية التعليمية في التعليم الهندسي

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Abstract:
Statistics is a valuable and reliable tool for extracting meaningful insights from raw data and has wide applicability across disciplines. This study demonstrates the effective application of statistical methods in evaluating the teaching process within the Engineering Science department at the Libyan International University. Fundamental statistical tools—mean, standard deviation, and analysis of variance (ANOVA)—were employed to analyze student performance across various courses, revealing that the instructional process remains consistent and under control, with no significant differences observed between courses. Additionally, multiple linear regression was utilized to predict students' grade point averages based on key instructional variables: number of weeks per course, weekly teaching hours, and number of lectures per course. To complement quantitative data, a comprehensive satisfaction questionnaire was administered to both students and faculty members two weeks prior to final exams. Student feedback addressed the quality of content presentation, teaching and learning methods, evaluation strategies, and faculty interaction. Faculty responses focused on the adequacy of learning resources, instructional strategies, assessment quality, and student engagement. Results affirmed overall satisfaction and alignment between teaching practices and student expectations. This integrative approach underscores the utility of combining statistical analysis with perception-based assessments to holistically evaluate and improve educational quality.

Keywords: descriptive statistics, engineering education, data analysis tools, analysis of variance (ANOVA), statistics in education, teaching process evaluation.

الملخص
تُعد الإحصاءات أداة قيّمة وموثوقة لاستخلاص رؤى ذات معنى من البيانات الخام، ولها تطبيقات واسعة عبر مختلف التخصصات. تُظهر هذه الدراسة التطبيق الفعال للأساليب الإحصائية في تقييم عملية التدريس ضمن قسم العلوم الهندسية في الجامعة الليبية الدولية. حيث تم استخدام أدوات إحصائية أساسية — مثل المتوسط الحسابي والانحراف المعياري وتحليل التباين (ANOVA) — لتحليل أداء الطلاب عبر مقررات دراسية بالفصل الأول، وكشفت النتائج أن العملية التعليمية تظل متسقة وخاضعة للسيطرة، دون وجود فروق ذات دلالة إحصائية بين المقررات. بالإضافة إلى ذلك، تم استخدام تحليل الانحدار الخطي المتعدد للتنبؤ بمتوسطات الدرجات النهائية للطلاب بناءً على متغيرات تعليمية رئيسية: عدد الأسابيع لكل مقرر، وساعات التدريس الأسبوعية، وعدد المحاضرات لكل مقرر. ولتكملة البيانات الكمية، تم توزيع استبيان شامل لقياس مستوى الرضا على كل من الطلاب وأعضاء هيئة التدريس قبل أسبوعين من الامتحانات النهائية. ركزت تعليقات الطلاب على جودة عرض المحتوى، وأساليب التدريس والتعلم، واستراتيجيات التقييم، وتفاعل أعضاء هيئة التدريس. بينما تناولت ردود أعضاء هيئة التدريس مدى كفاية الموارد التعليمية، واستراتيجيات التدريس، وجودة التقييم، ومشاركة الطلاب. أكدت النتائج وجود رضا عام وتوافق بين الممارسات التعليمية وتوقعات الطلاب. يُبرز هذا النهج التكاملي فائدة الجمع بين التحليل الإحصائي والتقييمات القائمة على التصورات لتقييم جودة التعليم وتحسينها بشكل شمولي.

الكلمات المفتاحية: الإحصاء الوصفي، التعليم الهندسي، أدوات تحليل البيانات، تحليل التباين(ANOVA) ، الإحصاء في التعليم، تقييم العملية التعليمية.

Introduction

Understand the value of data-driven decision-making as engineers. This is where an accurate basis for statistics is provided in engineering programs. As they aid in evaluating student performance, ensuring the efficiency of the curriculum, and determining program accreditation, statistics play a crucial role in engineering education. The evaluation of coursework and the evaluation of student achievement both depend significantly on statistical analysis. Additionally, statistical information can be used to indicate areas where teaching strategies need to be improved (Montgomery, D. C., 2009). Additionally, statistical methods can be used for identifying bias and accuracy problems in data, ensuring the accuracy and dependability of the information utilized for decision-making. Statistics have many advantages, but they also have problems and restrictions. Taking care of these problems would help them perform better in challenging engineering environments. Using quantitative tools and procedures for data analysis and interpretation, statistics plays a critical role in the evaluation of engineering education. It enables educators and administrators to make decisions with knowledge, assess the success of programs, and promote ongoing development. Here are some crucial functions of statistics in the evaluation of data gathering for engineering education assessment: When creating and implementing data gathering techniques like surveys, questionnaires, and interviews to learn more about various facets of engineering education, statistics are helpful. It guarantees the accuracy and representativeness of the data gathered. Statistically descriptive data The properties of the engineering education data are summed up and described using descriptive statistical approaches, such as measures of central tendency (mean, median, mode) and measures of dispersion (variance, standard deviation) (Runger, 2011; Montgomery, 2013). Statistics provides a quantitative foundation for accreditation and certification procedures, which aids quality assurance efforts in engineering education. Universities are frequently required by accreditation organizations to gather and analyze data on a variety of parameters, including student-faculty ratios, student satisfaction, and employment results. Statistics aid in achieving these needs and proving conformance to quality standards. Decision-making and creating policies: Statistics provide evidence-based insights for making choices and creating policies in the field of engineering education. Policymakers and administrators can identify areas for improvement, allocate resources effectively, and implement evidence-based initiatives to improve the quality of engineering education by examining data on student performance, program outcomes, and other important features. Many engineering students believed that probability and statistics courses were challenging, tedious, and pointless. These classes seemed to have no relation to the technical topics they studied and were very theoretical. Noted: "We too frequently teach what looks to the students to be a collection of unrelated processes shown by examples derived from coin-tossing, card-playing, and dice-rolling. Then, using straightforward gambling examples, we anticipate that the students will be able to convert the vast range of procedures to complicated industrial problems involving the use of numerous methods. Since that time, a lot of educators have come to the realization that statistics education needs to alter A constant effort has been made to improve statistics education in response to industry demands. In order to assist students in learning more efficiently, many statistics courses increasingly utilize real-world examples, real data, and simulation. To enhance statistics teaching and learning, a lot of effort has been made. Nonetheless, the work is getting more difficult because industry demands are increasing faster than statistics education is improving (Wei Zhan, 2010). Analysis of Variance (ANOVA) is a statistical method commonly utilized in higher education to investigate the effects of many variables on student outcomes and compare variations in group means. An organized framework for comparing various groups and determining if observed differences are statistically significant is provided by ANOVA. Here is an example of how to use ANOVA assessment in higher education. evaluating groupings. With the aid of an ANOVA, researchers can compare the means of three or more groups to see if there are significant differences between them. This can be applied to compare student performance across programs, departments, or grades in higher education. ANOVA can be used, for instance, to determine whether there are appreciable variations in the average GPA scores of students with various majors (Montgomery, D. C., 2013). This study aims to contribute to understanding the usefulness of the application of statistics and analysis of variances (ANOVA) in the processes of monitoring and evaluation of the education process through the analysis of the variability of the student's examination marks. Specifically, the analysis of the mean and variance in engineering studies taught at Libyan International University Based on this goal, the examination marks of the seven academic courses Engineering Physics, Math I, and Probability and Statistical for Engineering, Engineering Physics lab, English Language I, Arabic Language, and Engineering Drawing are analyzed to evaluate the teaching process. For this purpose, the next section outlines the methodology of this study. Subsequently, the paper presents the application of the methodology and the results, and the last section discusses the conclusions.

Literature Review

The paper reported the findings of an attempt to apply statistical process control (SPC). The Business Administration bachelor's degree program is used as an example. The last ten years have seen a considerable rise in the public's interest in educational outcomes; yet, quality management and statistical process control have not yet made significant inroads into the administration of academic institutions. In order to identify a significant impediment to continuous improvement in the academic setting and to support continuous improvement of educational performance, this study used statistical quality control (SQC) to help with the outcomes of an educational program that runs smoothly and has competent students. It might be difficult to evaluate and enhance student performance in higher education. 20 departments of the Technical Engineering Mechanics Course 2 at the Addis Ababa Institute were used to choose students at random. The creation of a new categorization approach involved using paper-based statistical quality control. The new way of determining scores compares favorably to the old one. Also, a method based on SQC would enable instructors to assign more grades in an objective manner than students would have probably understood from a fresher, more equitable, and consequently more inspiring method (Beshah, 2012). The purpose of this study was to develop a technique for processing data from student evaluations of instruction. Creating a regression model for instructor categorization based on the anticipated grade of the student is the first stage in the procedure. Following that, all good and poor outcomes were identified using sigma plots of the individual assessment scores (section averages) and residuals from the regression model. evaluation of a person's performance across the two domains (Anupam Khan, 2022). A randomized controlled study investigated the effects of an inquiry-oriented statistics curriculum supported by teacher professional development. Schools were randomly assigned to treatment or control conditions with equal probability. Teachers in the treatment group attended four days of professional learning workshops focused on delivering a 20-day instructional unit. Instructional quality was measured using the Instructional Quality Assessment, while student outcomes were assessed via the Levels of Conceptual Understanding in Statistics instrument. Hierarchical linear modeling revealed statistically significant improvements in instructional practices (effect size = 0.99) and student understanding of statistics (effect size = 0.25). These findings suggest that implementing inquiry-based lessons, coupled with structured teacher development, can enhance teaching effectiveness and student learning in statistics (Robert C. et al., 2025). Global and regional studies (Romero & Ventura, 2013; Al-Khazaleh et al., 2021) have highlighted the value of educational data mining in enhancing curriculum and pedagogy. Within the MENA context, research underscores challenges in aligning teaching strategies with student engagement (Zohair, 2020). Bloom's Taxonomy provides a hierarchy for evaluating cognitive learning outcomes, while Biggs' Constructive Alignment framework emphasizes coherence between learning outcomes, activities, and assessments. In Libya, limited studies have investigated course-specific performance indicators in technical and higher education. This study addresses this gap by applying statistical tools to evaluate educational alignment and instructional impact.

Methodology

This study uses a wide range of statistical methods to analyze survey data by using statistical software packages designed for research professionals. Popular programs include Minitab 17. However, many forms of data collection can be done using the Qualtrics system for online questionnaires, which was relied upon in our study and is part of a premium cloud data collection package. Other spreadsheet programs are easy to use and excellent for entering, coding, and storing survey data. This cross-sectional study analyzes students' final grades through statistical analysis. This study aims to examine the grades of College of Engineering students for the spring semester of 2023 in seven academic courses: Engineering Physics, Mathematics 1, Probability and Engineering Statistics, Engineering Physics Laboratory, English 1, Arabic Language, and Engineering Drawing. Descriptive statistics (mean and standard deviation) and inferential methods (analysis of variance, multiple regression) were used for each course.

Regression Model

Multiple linear regression was used to predict students' grade point averages in courses using the following variables: number of weeks per course, number of teaching hours per week, and number of lectures per course.

Qualitative Component

A satisfaction questionnaire was distributed to students and faculty members two weeks before the start of final exams, covering the following topics:

Student satisfaction with:

- Evaluation of the quality of academic content presentation
- Evaluation of the quality of student performance assessment methods
- Evaluation of the quality of teaching and learning methods
- Evaluation of professor interaction and teaching skills
- Evaluation Coordination
- Evaluation Coordination

Faculty satisfaction with:

- Evaluation of the quality of learning resources
- Evaluation of the quality of learning and teaching methods
- Evaluation of the quality of assessment methods
- Evaluation of student behavior and interest

Results And Discussion

Table 1. Final grades for the courses of the Department of Sciences of Engineering (First Semester)

Courses						
Arabic Langu age	Enginee ring Physics Lab	English Language I	Engineering Drawing	Probability and statistical for Engineering	Engineering Physics	Mat h I
47	90	94	76	55	42	59
86	60	98	55	60	43	50
93	68	52	80	44	81	67
82	99	62	87	65	51	98
67	71	99	65	52	41	57
100	50	78	85	98	59	92
84	61	73	63	54	95	66
85	71	50	74	62	31	50
63	89	70	62	53	57	99
89	51	95	54	100	34	52
89	87	93	60	53	96	66
83	99	93	72	61	52	100
85	91	94	82	100	54	81
95	76	93	96	66	96	87
84	50	62	75	60	67	66
82	87	64	82	53	54	80
68	97	80	55	57	53	89
89	69	53	80	85	69	85
76	80	53	50	80	79	93
59	85	94	55	80	74	95

93	99	55	92	100	86	79
64	70	73	34	90	94	79
71	63	57	71	50	78	66
22		73		39	51	98
		29		96	42	50
		67		97	88	59
				50	95	94
				52	44	50
				90	45	88
				33	99	50
				67	25	
					61	

Tables 2 to 8 show statistical and descriptive statistics among students' grade courses: engineering physics, math I, probability, and statistics for engineering, engineering physics lab, English Language I, Arabic Language, and engineering drawing, respectively. Note that the value of the standard deviation is rather large, and the reason for this is the value of the large range. These courses cannot be judged by these numbers alone. Several tests, such as the analysis of variance (ANOVA), will be reviewed with other courses to obtain an accurate result for monitoring the courses.

Table 2. Descriptive Statistical of Engineering Physics.

Maximum	Minimum	Range	Standard Deviation	Mode	Median	Standard Error	Mean
99	25	74	22.06	42	58	3.90	63.62

Figure 1 proves that the distribution of students' grades in the Engineering Physics course is slightly skewed to the left. Furthermore, the standard deviation is found to be 22.06, the average is 63.62 out of number of 32 students, which ensures the reliability and consistency of students' grades.

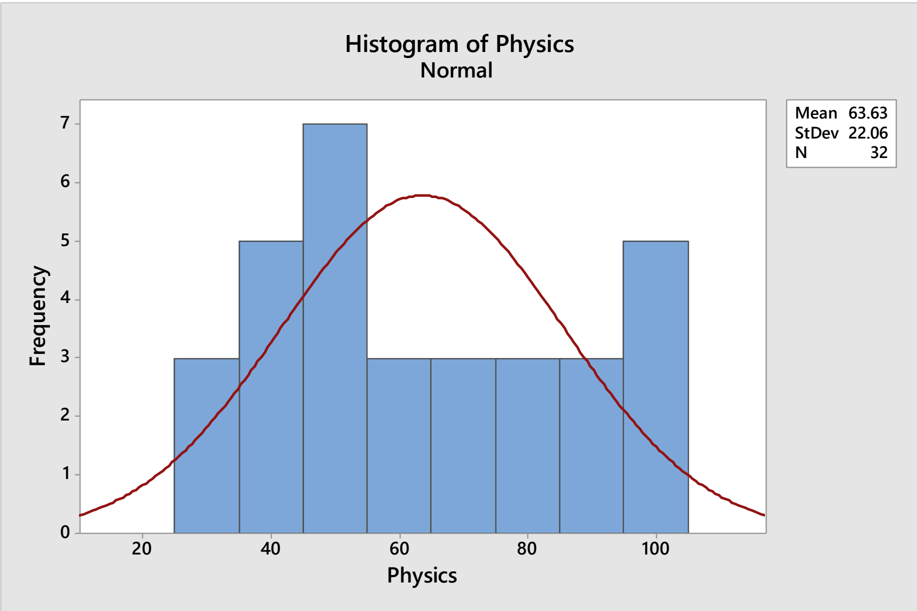

Figure 1. Histogram for Engineering Physics course.

Table3 shown is statistical and descriptive among students' grades in the Math I course. Note that the value of the standard deviation is rather large, and the reason for this is the value of the large range. This course cannot be judged by these numbers alone.

Table 3. Descriptive Statistical of Math I

Maximum	Minimum	Range	Standard Deviation	Mode	Median	Standard Error	Mean
100	50	50	17.82	50	79	3.25	74.83

Figure 2 proves that the distribution of students' grades in the Math I course is skewed to the left. Furthermore, the standard deviation is found to be 17.82, the average is 74.83 out of number of 30 students, which ensures the reliability and consistency of students' grades.

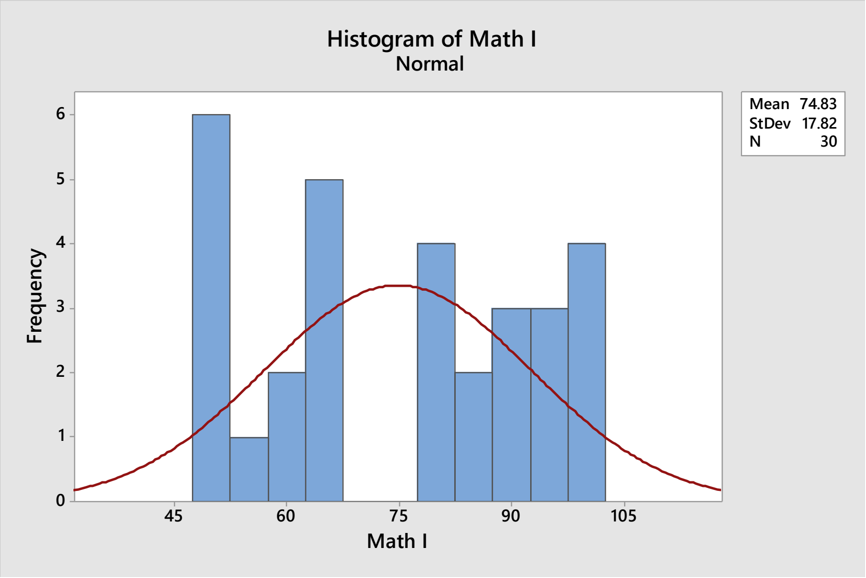

Figure 2. Histogram for Math I course.

Table 4 shown is statistical and descriptive among students' grades in the for Probability and Statistical for Engineering course. Note that the value of the standard deviation is rather large, and the reason for this is the value of the large range.

Table 4. Descriptive Statistical of for Probability and Statistical for Engineering course.

Maximum	Minimum	Range	Standard Deviation	Mode	Median	Standard Error	Mean
100	33	67	20.27	53	61	3.64	67.8

Figure 3 proves that the distribution of students' grades in the Probability and Statistical for Engineering I course is slightly skewed to the right. Furthermore, the standard deviation is found to be 20.27, the average is 67.8 out of number of 31 students, which ensures the reliability and consistency of students' grades.

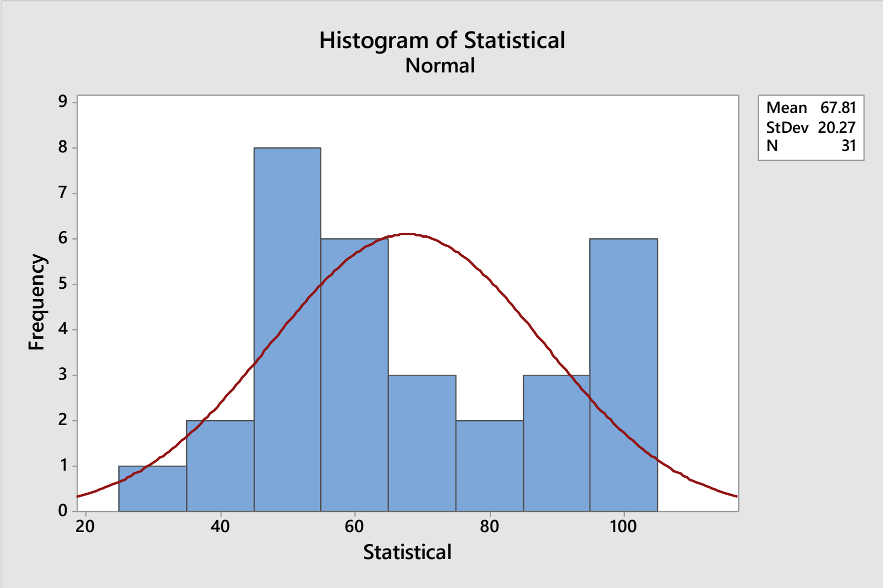

Figure 3. Histogram for Probability and Statistical for Engineering course.

Table 5 shown is statistical and descriptive among students' grades in the for-Engineering Physics Lab course. We note that the value of the standard deviation is rather large, and the reason for this is the value of the large range.

Table 5. Descriptive Statistical of for Engineering Physics Lab course.

Maximum	Minimum	Range	Standard Deviation	Mode	Median	Mean
99	50	49	16.19935	99	76	76.65217

Figure 4 proves that the distribution of students' grades in the Engineering Physics Lab course is slightly skewed to the right. Furthermore, the standard deviation is found to be 16.19, the average is 76.6 out of number of 23 students, which ensures the reliability and consistency of students' grades.

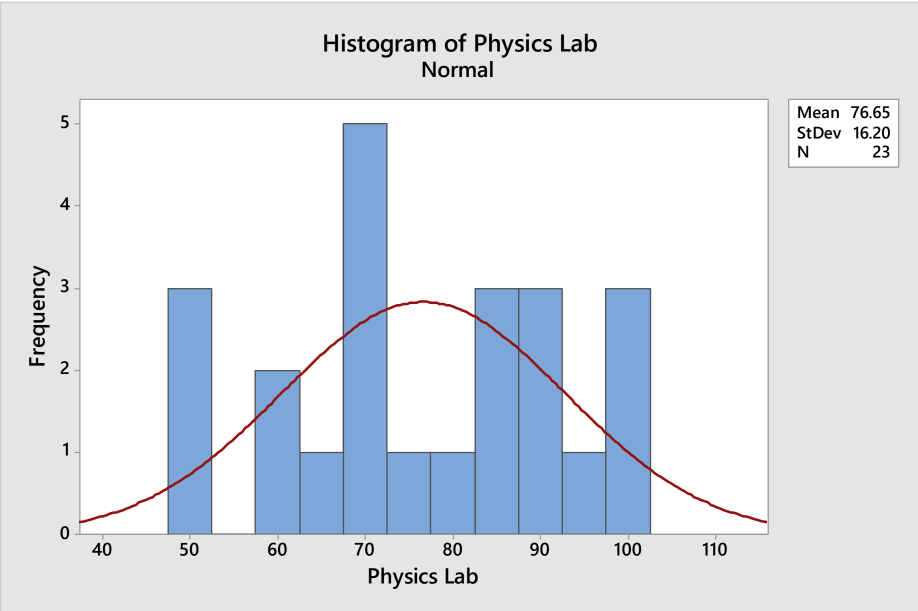

Figure 4. Normality distribution of grades for Engineering Physics Lab.

Table 6 shown is statistical and descriptive among students' grades in the for English Language I course. Note that the value of the standard deviation is rather large, and the reason for this is the value of the large range.

Table 5. Descriptive Statistical of for English Language I course.

Maximum	Minimum	Range	Standard Deviation	Mode	Median	Standard Error	Mean
99	29	70	19.01	94	73	3.72	73.23

Figure 5 proves that the distribution of students' grades in the English Language I course is slightly skewed to the right. Furthermore, the standard deviation is found to be 19.01, the average is 73.23 out of number of 26 students, which ensures the reliability and consistency of students' grades.

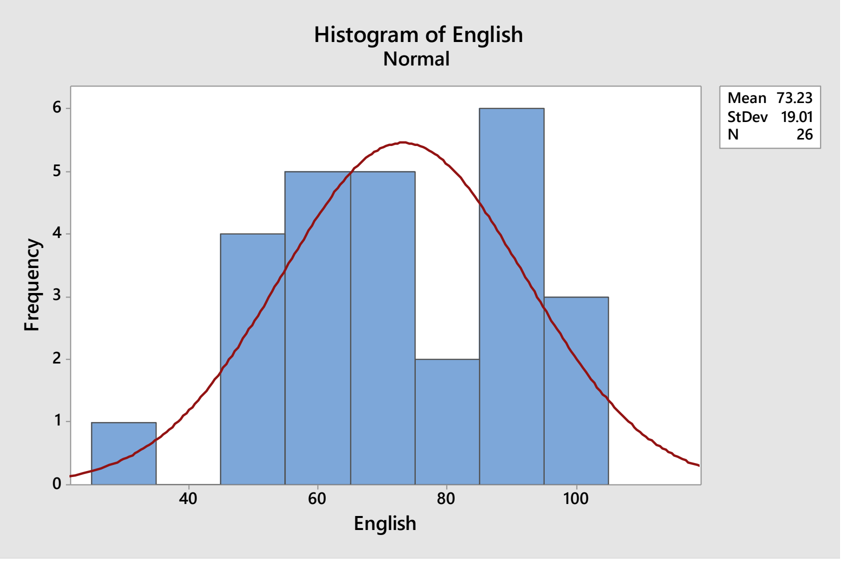

Figure 5 Normality distribution of grades for English Language I

Table 7 shown is statistical and descriptive among students' grades in the for Arabic Language course. Note that the value of the standard deviation is rather large, and the reason for this is the value of the large range.

Table 5. Descriptive Statistical of for Arabic Language course.

Maximum	Minimum	Range	Standard Deviation	Mode	Median	Standard Error	Mean
100	22	78	17.46	89	83.5	3.56	77.3

Figure 6 proves that the distribution of students' grades in the Arabic Language course is slightly skewed to the right. Furthermore, the standard deviation is found to be 17.46, the average is 77.3 out of number of 24 students, which ensures the reliability and consistency of students' grades.

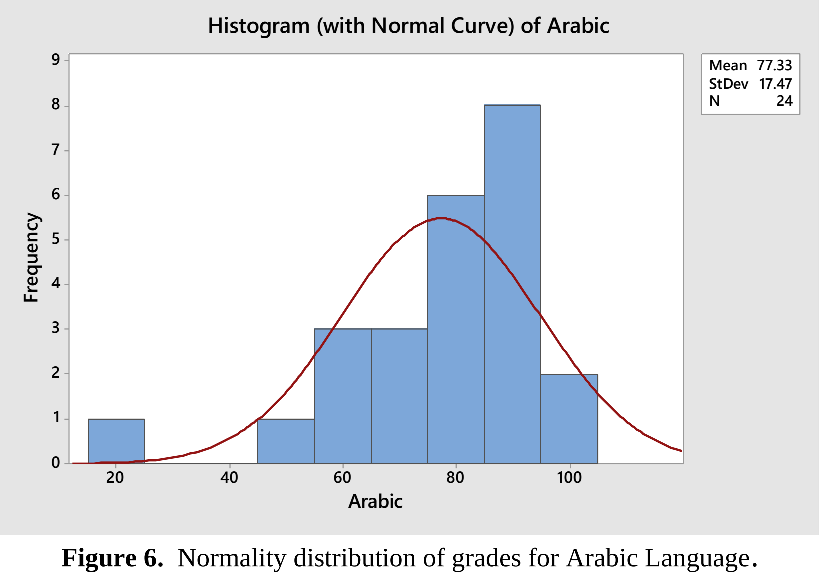

Figure 6. Normality distribution of grades for Arabic Language.

Table 8 shown is statistical and descriptive among students' grades in the for-Engineering Drawing course. Note that the value of the standard deviation is rather large, and the reason for this is the value of the large range.

Table 8. Descriptive Statistical of for Engineering Drawing course.

Maximum	Minimum	Range	Standard Deviation	Mode	Median	Standard Error	Mean
96.35	34.1	62.25	15.24167733	#N/A	72.125	3.178109	69.7663

Figure7 proves that the distribution of students' grades in the Engineering Drawing course is slightly skewed to the right. Furthermore, the standard deviation is found to be 15.24, the average is 72.125 out of number of 23 students, which ensures the reliability and consistency of students' grades.

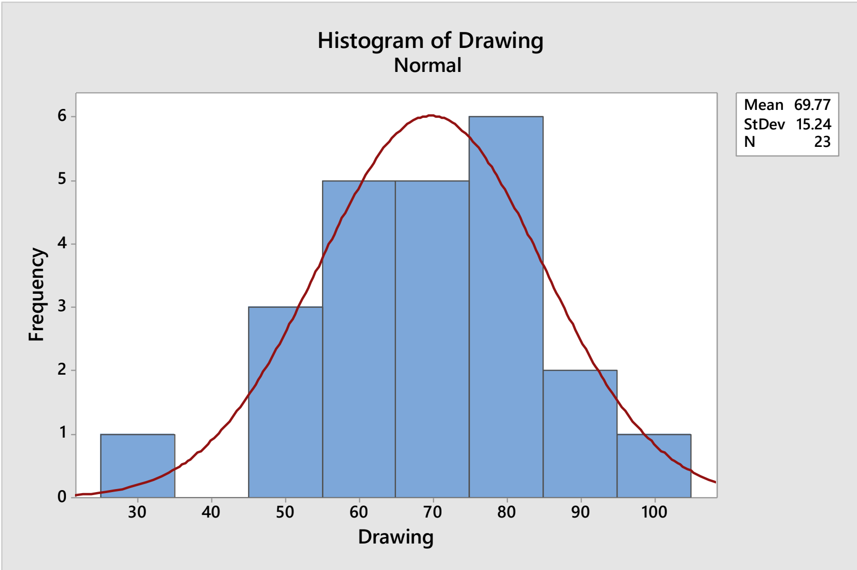

Figure 7. Normality distribution of grades for Engineering Drawing.

Using the Qualtrics system for online questionnaires, a questionnaire was distributed to the students and the extent of their satisfaction with the final exam. The questionnaire was divided into seven questions, based on a five-point Likert scale shown Table 9. The target evaluation rate is 3.5/5.00. The Probability and statistical for Engineering course received a lower-than-target evaluation. Corrective action was taken after meetings with students, the department head, and the course instructor. The final results were presented to students, along with the course and final exam evaluations, to identify the root cause and prevent recurrence.

Table 9. Evaluation of Final Exam by students

Questions	Courses						
	Engineering Physics	**Math I**	**Probability and statistical for Engineering**	**Engineering Physics lab**	**English Language I**	**Arabic Language**	**Engineering Drawing**
Questions Covered all topics	4.54	4.58	3.48	4.24	4.00	4.70	4.79
Questions were Clear	4.62	4.35	3.48	4.43	3.84	4.70	4.57
Medium Level of Exam	4.31	4.31	2.88	4.19	3.58	4.60	4.29
Time was enough	3.46	4.88	1.60	4.00	3.21	4.50	3.36

Includes different types of question (True-False /MCQ /Short answer/ Essay)	4.69	4.85	2.60	4.71	4.42	4.70	NA
Did the teaching methods used during the semester support the preparation process for the final exam	4.69	4.77	2.40	3.10	3.32	4.80	4.21
Were the procedures followed for the examination clear	4.62	4.42	3.12	3.76	4.00	4.70	4.71
Overall Mean	**4.41**	**4.59**	**2.79**	**4.06**	**3.76**	**4.68**	**4.32**
St.DV	**0.48**	**0.26**	**0.65**	**0.56**	**0.45**	**0.106**	**0.52**

Figure 8 describes the variance between all courses depends on grades of students in the final exam. Note that there is no significant effect between all courses.

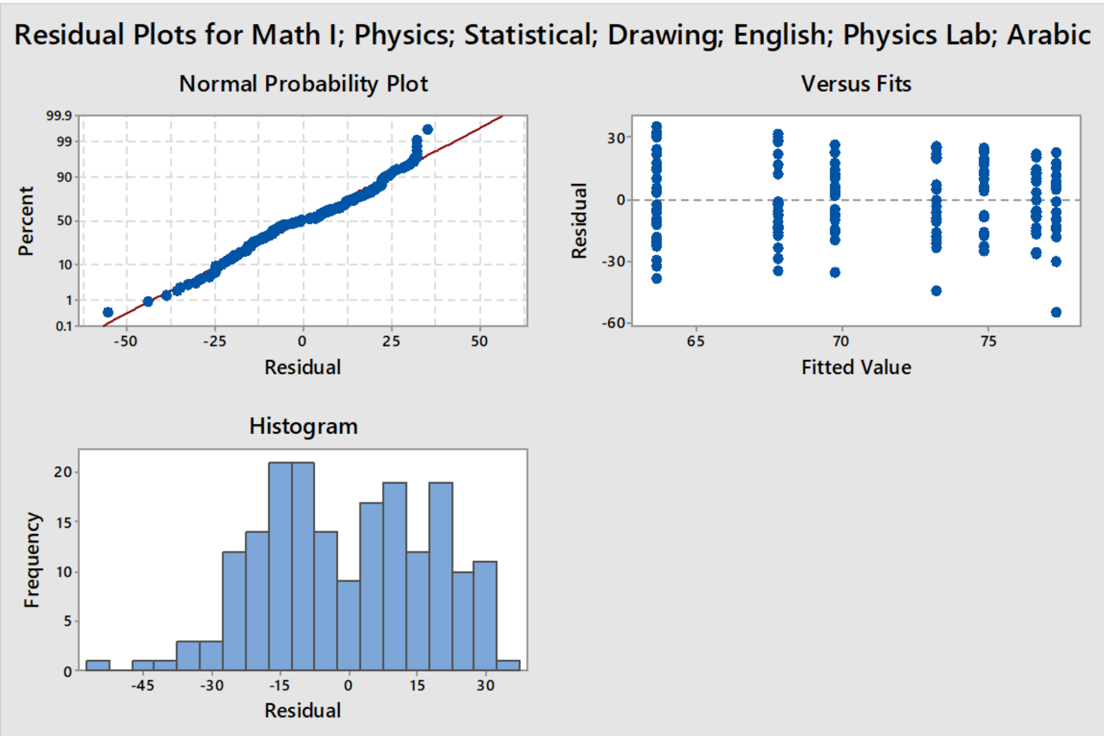

Figure 8. Residual Plots for Math I; Physics; Statistical; Drawing; English; Physics Lab; Arabic (First Semester).

Table 10 shown the test of hypotheses using to test of variation between all courses, null hypothesis H0: all means are equal and alternative hypothesis H1: At least one mean is different significance level alpha α = 0.05. Equal variances were assumed for the analysis; the factor contain seven level (seven courses).

Table 10. Analysis of Variance Table (First Semester)

Source	DF	SS	MS	F-Value	P-Value
Factor	6	4315	719.2	2.06	**0.060**
Error	182	63570	349.3		
Error	188	67885			

Don't reject H_0 and conclude that the courses mean not differ, that is the courses setting in significantly affects the mean grades. We could also compute a P-value for this test statistic, shows the reference distribution ($F_{6,182}$) for the test statistic F_0. Clearly, there are no significant differences between courses because the P-value is greater than 0.05. Test for Equal Variances: Grades versus Courses, Bartlett's method is used Null hypothesis: all variances are equal Alternative hypothesis: at least one variance is different, Significance level α = 0.05. Table11 shown Std. Deviation between courses.

Table 11. Grades versus Courses**.**

Courses	N	Std. Deviation
Engineering Physics	32	17.82
Probability and statistical for Engineering	31	20.27
Math I	30	17.82
Engineering Physics lab	23	16.19
English Language I	26	19.01
Arabic Language	24	17.46
Engineering Drawing	23	15.24

The P-value is 0.401 so we cannot reject the null hypothesis. There is no evidence to counter the claim that all five variances are the same. This is the same conclusion reached by analysing the plot of residuals versus fitted values. Table 12 shows students' grade point averages in courses using the following variables: the number of weeks per course, the number of teaching hours per week, and the number of lectures per week for each course.

Table 12. Variables that affect students' grade point average.

Course Name	Number of weeks	Number of teaching hours per week X1	Number of lectures per week X2	Average evaluation of Final exam X3	students' grade point averages Y
Engineering Physics	16	4	2	4.41	63.62
Probability and statistical for Engineering	16	3	2	4.59	74.83
Math I	16	4	2	2.79	67.80
Engineering Physics lab	16	3	1	4.06	76.65
English Language I	16	3	2	3.76	73.23
Arabic Language	16	2	1	4.68	77.30
Engineering Drawing	16	3	1	4.32	69.76

Table 13 shown the regression analysis was conducted to investigate the relationship between the dependent variable (Y, presumably student grades or course performance) and three independent variables: x1, X2, and x3. The overall model explains approximately 77.79% of the variance in Y (R-squared = 77.79%), though the adjusted R-squared drops to 55.58%, and the predicted R-squared is notably low at 2.17%. This indicates that while the model fits the sample data reasonably well, its predictive power for new observations is limited, suggesting potential overfitting or omitted variables. The ANOVA table reveals that the regression model is not statistically significant overall (F(3,3) = 3.50, p = 0.165), indicating that the independent variables collectively do not explain a significant portion of the variance in the dependent variable at the 0.05 significance level. Among the predictors, only x1 shows a marginal association with the dependent variable (p = 0.079), approaching statistical significance.

This suggests that x1 may have a meaningful influence on student performance and warrants further exploration in future models or with a larger sample size. Neither X2 ($p = 0.828$) nor x3 ($p = 0.484$) contributed significantly to the model, and their coefficients suggest minimal practical impact. The low variance inflation factors (VIF < 2.5) for all predictors indicate no substantial multicollinearity issues.

Table 13. Analysis of Variance Table.

Source	DF	SS	MS	F-Value	P-Value
Regression	3	118.257	39.4189	3.50	0.165
X1	1	77.513	77.513	6.89	0.079
X2	1	0.631	0.631	0.06	0.828
X3	1	7.127	7.127	0.63	0.484
Error	3	33.766	1132553		
Error	6	152.023			

The fitted regression equation 1 is:

$$Y=103.3-7.74x2+0.79X3-2.05x4 \quad (1)$$

This model suggests that, holding other variables constant:

- A one-unit increase in x2 is associated with a decrease of 7.74 units in Y.
- A one-unit increase in X3 is associated with a slight increase of 0.79 units in Y.
- A one-unit increase in x4 corresponds to a 2.05 unit decrease in Y.

However, given the lack of statistical significance for most coefficients, these interpretations should be viewed as preliminary and not definitive. Further data collection and model refinement are recommended to validate these relationships.

Conclusion

This study employed statistical methods to evaluate student performance and teaching effectiveness in the Engineering Science program at the Libyan International University. Descriptive statistics, ANOVA, and multiple linear regression were used to analyze academic outcomes, while satisfaction surveys provided insights into the perceptions of both students and faculty. The findings revealed that student performance across courses remained consistent, with no statistically significant variations, indicating stable instructional quality. Regression analysis suggested that certain instructional variables, such as teaching hours and lecture frequency, may influence academic outcomes, though further investigation is needed to confirm these relationships. The satisfaction surveys highlighted overall alignment between teaching methods and student expectations, with areas for improvement identified in exam preparation and time allocation. These results underscore the importance of integrating quantitative and qualitative assessments in educational evaluation. By combining statistical analysis with stakeholder feedback, institutions can enhance teaching strategies, optimize course structures, and foster continuous improvement.

Recommendations and Future Studies

To build on the current findings, it is recommended that educational policymakers invest in long-term, content-specific professional development as a strategic tool for academic improvement. Future research should explore the longitudinal effects of such interventions on teacher retention, instructional fidelity, and student achievement across diverse demographic settings. Additionally, replicating the study across different mathematical domains may provide broader insights into the generalizability of inquiry-oriented teaching approaches. In future studies, we will suggest the application of six sigma, control charts, multivariable charts, capability analysis, and time horizons, thereby widening the scope of this study**.**

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