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Relative and Absolute grading: Techniques and Traits

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***Abstract*— This study examines the effectiveness of absolute and relative grading techniques within Indian engineering education, focusing on Faculty-Driven Grading (Normal Distribution), Mean-Standard Deviation Method, and Fixed Distribution Grading through Max-Min. Data from 1,054 first-year B.Tech students across three core engineering courses were analysed using Analysis of Variation (ANOVA) to compare grading outcomes. Results show that Faculty-Driven and Mean-Standard Deviation relative grading methods produce grade distributions closely approximating a normal curve, with comparable results for average performers to absolute grading, but significant differences for high achievers. Fixed Distribution Grading displayed greater variability and less alignment with absolute methods. These insights suggest that selecting a grading approach requires balancing fairness, flexibility, and transparency, offering guidance to autonomous institutions and universities in choosing optimal evaluation methods.**

***Keywords*—Relative Grading, normal curve, normal distribution, Standard Deviation, mean**

***JEET Category*— Research**

I. INTRODUCTION

Outcome-Based Education (OBE) emphasizes clearly defined learning outcomes or competencies that students are expected to achieve by the end of a course or program. These outcomes guide curriculum design, instructional methods, and assessment strategies. Unlike traditional input-based approaches, OBE prioritizes measurable results and student-centered learning. These outcomes serve as the basis for designing curriculum, instructional methods, and assessment strategies. The emphasis on outcomes, as opposed to just inputs or processes, is intended to ensure that education is more results-oriented and student centered. OBE emphasizes the assessment of student outcomes at different levels and in various aspects. This involves evaluating not only the acquisition of knowledge [in form of grading] but also skills, attitudes, and competencies relevant to the discipline or profession.

As a crucial aspect of the assessment process, grading plays a pivotal role in evaluating individual students' academic progress. In the educational set- ting, grading involves the assignment of standardized grades to students based on their performance in a given course. These grades can be presented in the form of letters (typically A through F), a numerical range (such as 1 to 6), a percentage, or a specific numerical value out of a potential total (often out of 100).

In the historical context of education, the practice of using letter and numerical grades did not originate with the commencement of student evaluations. In ancient Greece, assessments were primarily formative tools rather than evaluative measures. Harvard, in 1646, mandated exit exams as a prerequisite for degrees. The initial grading scale in the United States, introduced by Yale president Ezra Stiles in 1785, comprised four designations: Optimi, Second Optimi, Inferiores, and Perjores. Over time, the grading system evolved into an integral component of the education system. Despite its enduring significance, criticism persists, asserting that grading merely provides a short-term numerical snapshot of students' learning for a specific period and fails to adequately consider individual development. Furthermore, it has been argued that students often prioritize grades and associated status over genuine interest or preparation for future life, fostering a superficial approach to learning. Despite these criticisms, grading continues to maintain prominence in the global education system.

In current study, we focused to overcome aforementioned difficulties in grading system with three techniques and traits of Relative Grading. Also, we aimed to compare three techniques for assigning grades in Relative Grading, namely:
Faculty Driven Grading-Normal Distribution, and Mean-Standard Deviation Method-Normal Distribution, Fixed Distribution Grading through Max-Min Method. These techniques take into account various parameters such as flexibility, transparency, instructor's experience, and expertise.

II. LITERATURE SURVEY

Effective academic evaluation consistently produces positive results when implemented with suitable procedures. Additionally, existing literature across different levels indicates

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that, despite certain inherent limitations, the academic community has continued to utilize these procedures over a specified period. Consequently, to uncover pertinent information in the chosen study area and pinpoint potential gaps, the present study has conducted a critical review of a limited yet relevant body of literature. This review serves as a foundation for the current research and assists in shaping an appropriate methodology for its execution.

A critique of Relative Grading highlights that students' success is assessed in relation to their peers rather than emphasizing individual abilities. In response to this concern, some educators and researchers propose the adoption of Cooperative learning. Cooperative learning, which involves organizing small groups of students to maximize their collective study efforts was studied [Roger, T. et al, 1994]. This approach represents a significant aspect of active learning, encouraging students to engage actively in the learning process, think critically, make decisions, and take responsibility for their learning. Therefore, incorporating active learning strategies like problem-based learning, project-based learning, and inquiry-based learning, which enhance outcomes in science education, necessitates integrating cooperative activities was recommended [Frank M., 2003 and Brookhart S. M., 2016], and also they have reviewed grading methods evolved from a century with analysis of all methods suggested by many researchers.

The influence of grading standards on student achievement, educational attainment, and entry-level earnings indicate that policymakers should gain a deeper understanding of the nuanced ways in which students respond to elevated standards before making them the focal point of educational reform policies [J. R. Betts, et al, 2003].

Reddy Y. M., et al. examined prevailing rubrics within higher education. They identified appropriate rubrics in higher education, specifically focusing on ensuring grading quality and accountability [Reddy Y. M., et al., 2010]. The impact of relative performance feedback information on students' performance, considering theoretical and empirical perspectives was studied [G. Azmat. et al., 2010]. Additionally, the research reveals a potential positive effect, demonstrating that providing relative performance feedback information can motivate high school students.

Sayin A. investigated the classification accuracy of letter grades, assessing students' success through relative and absolute criteria, focusing on decisions regarding course pass or fail statuses. The study aimed to identify the appropriate cut-off point for students to pass a course. Results indicated that the relative criterion exhibited superior accuracy in classifying letter grades, while the absolute criterion proved more accurate in determining pass/fail decisions. The relative criterion offered greater advantages to students regarding both letter grading and the decision-making process for passing a course. Additionally, it was observed that the cut-off points align more closely with the absolute criterion for deciding students' course pass statuses [Sayin A.,2016]. Furthermore, few researchers have analytically studied the impact of Grade Point Average on various courses like Economics, Science, Technology, Engineering, Mathematics, and many other courses. Similarly, they identified that Relative Grading has no significance concerning the person's gender, the role of incentive mechanism on relative performance among a group of students, or employee performance [Brookhart S. M. 2016].

Study reveals that students with lower ability and slower learning pace may transform into more proficient performers when placed within a larger cohort [Brownback A. 2018 and Doz D. 2023]. Both papers explored the influence of factors such as gender, socioeconomic status, school type, and location on student assessment. A case study is presented using data from the Italian institute INVALSI. The grading process significantly influences students' lives, impacting their confidence in academic abilities, which, in turn, can shape their future careers. Selecting an appropriate grading policy poses a complex challenge for educators. In his further research, Doz D. thoroughly examined educational grading policies in the literature, providing unbiased recommendations for choosing the most suitable approach [Doz, D.,2023]. Nevertheless, teachers and educators must ensure that students remain focused on learning and are motivated to progress through effective assessment and grading practices. A controlled experiment was carried out to investigate how providing students with relative performance information feedback influences their examination scores within the context of a Relative Grading system in a real educational setting. The experiment results revealed a positive effect of relative performance information feedback on students' examination scores in the Relative Grading environment. The consistent application of this feedback, along with an increased frequency of examinations, contributed to improved performance by fostering a sense of continuity in the Relative Grading setting [S. Kajitani, et al. 2020 and Kiesel A. 2023].

The context on Relative Grading served as the foundation for our ongoing research. Our investigation delved into grading methodologies, considering factors such as the normal curve, mean, Standard Deviation, and ANOVA.

A. Absolute Grading

Absolute Grading is an assessment method that appraises a student's performance based on predetermined criteria rather than comparing it to the performance of their peers. This grading approach is widely adopted in educational institutions, including schools, colleges, and universities. In an Absolute Grading system, students are evaluated against fixed standards, typically outlined in a grading rubric or syllabus. Criteria encompass various aspects such as work quality, subject proficiency, adherence to project requirements, and overall performance. Absolute Grading systems often utilize predefined grading scales, with common examples being letter grades (A, B, C, D, E, F) or numerical scales (e.g., out of 100 points). According to the 'Evaluation Reforms in Higher Educational Institutes, University Grant Commission, 2019,' grades in Absolute Grading systems may be designated as O, A+, A, B+, B, C, P, F. It's noteworthy that the specific grading scale may vary between different institutions.

Absolute Grading enhances transparency in the grading process by clearly outlining the expectations for students to attain specific marks. Typically, grading standards are communicated through instructional manuals or rubrics. The

Journal of Engineering Education Transformations, Volume 39, No.3, January 2026, ISSN 2349-2473, eISSN 2394-1707

final grade is often determined by averaging or summing scores from various assessments according to predefined grading scales or criteria. The method for calculating the final grade may vary across institutions and courses.

Despite the advantages of fairness and transparency, the Absolute Grading system faces several challenges, including Lack of Flexibility, Subjectivity in Grading Criteria, Limited Differentiation, Stress and Competition, Inequity in Assessment, Instructor Bias, Pressure to Meet Criteria, Lack of Motivation for High Achievers [Barrows, J, 2013; Abdul G. K.& Jisha P. 2014; Singh, H. 2015; Brookhart, S. M. 2016; Kibble, J. D. 2017]

Gowda and Viswanathan conducted a comparative study on absolute and relative grading systems, focusing on their impact on academic performance among learners in autonomous engineering institutions. Their analysis employed normalization techniques and Standard Deviation-based grade intervals to evaluate grading fairness. The study concluded that relative grading systems, particularly those using statistical parameters, offer a more balanced representation of student performance compared to fixed absolute thresholds. However, the study centered primarily on GPA trends and lacked exploration of instructor roles or diverse grading methods, leaving scope for broader methodological comparisons [Gowda and Viswanathan 2022].

The system needs to be more flexible, potentially overlooking the proper abilities and accomplishments of specific students. Sometimes, every student in the class receives the same grade, be it a B or C. This uniformity makes it challenging to obtain individualized information about each student and their performance, hindering opportunities for further improvement. These findings from the literature drive us to focus on the need for different Relative Grading techniques that can consider various parameters such as flexibility, transparency, instructor experience, and expertise.

B. Relative Grading

Relative Grading, often referred to as curve grading or grading on a curve, is an evaluation approach employed in education to assess and rank students' performance, considering the distribution of scores within a class. Unlike absolute standards, where grades are determined solely based on achieving a specific percentage of correct answers, Relative Grading adjusts grades based on how well students perform in comparison to their peers.

The origins of Relative Grading trace back to the early 20th century and have undergone various developments in educational contexts. The concept of grading on a curve can be attributed to the work of Frederick J. Kelly in the 1920s. Kelly, an American psychologist and educational theorist, played a key role in developing the precursor to modern standardized tests. He introduced the use of statistical techniques to analyse test results and establish a bell curve distribution of scores, allowing for the assignment of grades based on relative student performance.

The Influence of World War II and Norm-Referenced Testing: Standardized tests gained significant importance during World War II for selecting candidates for military service and training programs. Norm-referenced testing, closely aligned with Relative Grading, became prominent during this period. These tests were designed to rank students based on their performance relative to a norm group, often resulting in a bell curve distribution.

In the post-World War II era, educational institutions persisted in the use of Relative Grading and norm-referenced testing. The rationale behind this practice was to ensure that the distribution of scores accurately represented the inherent variability in student abilities. This approach sought to accommodate variations in the difficulty of different test versions and aimed to offer a fairer method for assigning grades [Thorndike, L. 1903, Barrows, J. et al., 2013, Kibble, J. D. 2017, Kajitani, S. et al., 2020, Brookhart, S. M. 2016]. We can acknowledge the advantages and criticism of Relative Grading as follows: Advantages of relative are listed as-

- Mitigates Assessment Variability: Relative Grading can help account for variations in the difficulty of assessments, ensuring that students aren't unfairly penalized by challenging exams.
- Consistency across Sections: In courses with multiple sections or instructors, Relative Grading can help maintain consistent grading standards by adjusting for differences in exam difficulty or teaching style.
- Promotes Healthy Competition: Relative Grading can motivate students to strive for improvement and perform better than their peers, fostering healthy competition that can lead to higher levels of effort and engagement.
- Ensures Fixed Distribution: Some institutions or courses require a predetermined distribution of grades (e.g., a certain percentage of students receiving each grade). Relative Grading helps achieve this distribution, ensuring a balanced representation of student performance.
- Neutralizes Instructor Bias: By comparing students' performances to each other, Relative Grading can mitigate potential biases that an individual instructor might have in assessing students

In spite of these advantages, Relative Grading has faced criticism and controversies in aspects as follows:

- Limited Number of High Grades: In a highly competitive class, only a limited number of top grades are available, which can create stress and pressure among students.
- Discourages Collaboration: Relative Grading might discourage collaboration and cooperation among students, as they might perceive their peers as competitors rather than allies.
- Inaccurate Reflection of Mastery: Relative Grading may not accurately reflect individual mastery of the subject matter, as it prioritizes comparison to peers over absolute understanding.
- Unintended Consequences: The curve can lead to situations where students who performed relatively well receive lower grades if the overall class performance is strong.
- Deflates Motivation: Students who consistently perform well might find it discouraging if their high performance doesn't translate into the top grades due to class distribution.

Journal of Engineering Education Transformations, Volume 39, No.3, January 2026, ISSN 2349-2473, eISSN 2394-1707

- Complicated Grading Process: Implementing and explaining Relative Grading can be complex and time-consuming, potentially leading to confusion and misunderstandings among students.
- Lack of Transparency: The lack of clarity in how grades are determined can lead to frustration and dissatisfaction among students who don't fully understand the Relative Grading process.

Critics argue that Relative Grading may not provide an accurate representation of students' true mastery of the material. Criticisms have been raised, especially in cases of small class sizes or when instructors feel compelled to fit scores into a predetermined distribution, deeming it unfair.

In contrast to Absolute Grading, Relative Grading has a historical foundation rooted in the necessity to evaluate and rank students' performance within educational contexts. While widely utilized, it has faced scrutiny and undergone adaptations as educational systems evolve, aiming for fairer and more effective methods of assessing student learning.

Both absolute and Relative Grading systems carry their own sets of advantages and drawbacks. Absolute Grading centres on individual mastery of the subject matter, offering clear insights into a student's understanding. On the other hand, Relative Grading helps mitigate the impact of variations in exam difficulty or instructor effectiveness. The selection between these systems often hinges on the educational institution's philosophy, the specific subject matter, and the objectives of the assessment process.

III. GRADING METHODOLOGIES

A fundamental theory of Statistics and Probability is Normal Distribution. Many naturally-occurring phenomena tend to approximate the normal distribution. It is important for a variety of reasons, including ubiquitous data representation, standardization and comparison, data transformation, robustness, and symmetry. The normal distribution is crucial because it provides a mathematical framework for understanding and analysing data, it includes:

1. Theory course where both summative and formative assessments are applicable.
2. Laboratory work/ Tutorial/ Seminars/ Project Based Learning/ Mini Projects/ Projects etc. where only formative assessments are applicable.

All three methods of Relative Grading are discussed for both categories.

A. Absolute Grading:

Based on the Examinations and Evaluation, students will be awarded letter grades after combining performance of all Evaluations for the respective course. These letter grades will be derived from quantitative and qualitative Evaluation converted into a 10-point scale called as grade point for credit courses. See the Table I:

TABLE I
A PERFORMANCE [IN %] WITH GRADE POINTS AND EQUIVALENT LETTER GRADES [UNIVERSITY GRANT COMMISSION, INDIA (2019)]

Performance	Grade point	Letter grade
90≤(Performance) ≤100	10	O
80≤(Performance) ≤89	9	A+
70≤(Performance) ≤ 79	8	A
60≤(Performance) ≤ 69	7	B+
50≤(Performance) ≤ 59	6	B
45≤(Performance) ≤ 49	5	C
40≤(Performance) ≤ 44	4	P
< 40	0	F

B. Faculty Driven Grading-Normal Distribution

Under this method, we set up guidelines to distribute the students using the statistical approach of Normal Distribution [Wetzel W. A. 1921, Kulick, G. 2008].

Preparation of data: All students are distributed into two parts: Failed Grade [FG] and Not in Failed Grade [NIFG] based on passing criteria. All NIFG categories are arranged in descending order.

Determine grade ranges: Seven grades are determined for summative courses [For formative courses it may vary]. Selection of percentage of students under each grade is according to normal distribution and grades are assigned accordingly as per the Table II:

TABLE II
PERCENTAGE DISTRIBUTION OF STUDENTS FOR GRADES

Letter Grade	% Students
O	5% of NIFG students
A+	10% of NIFG students
A	20% of NIFG students
B+	30% of NIFG students
B	20% of NIFG students
C	10% of NIFG students
D	5% of NIFG students
F	All students in failed grade

Assign the grades: Students performance is relative to performance of peers. Therefore, as per guided threshold values [refer Table II], grade intervals will be formed and grades will be assigned to the students based on their performance**.** Normal distribution is the foundation of many statistical approaches, and it is commonly used as a suitable approximation for real-world phenomena. However, not all data follows a normal distribution, and in such circumstances, different probability distributions and statistical methods may be more suited.

We believe under Relative Grading normalization of performance is very important. There can be various ways to normalize the performance of students. Here we are discussing the three methods that track the performance grades of students under Relative Grading. The cases are discussed with real time data of evaluation process in Engineering Institute at First year level. The data comprises marks and grades of 1054 students of

Journal of Engineering Education Transformations, Volume 39, No.3, January 2026, ISSN 2349-2473, eISSN 2394-1707

different courses, SGPA [Semester Grade Point Average]. The courses included in this analysis featured both formative and summative assessment components. For the purpose of applying Relative Grading techniques, we analyzed them based on the dominant assessment method used.

Normalize the distribution: Keep in mind that the actual distribution of scores might not perfectly match a normal distribution. In practice, adjustments might be necessary to ensure that the grade distribution doesn't produce extremely skewed results or unintended consequences. Faculty can change the threshold values of each grade to get the normal distribution.

C. Mean-Standard Deviation Method-Normal Distribution

Preparation of data: Normal distribution is continuous probability distribution characterized by symmetry about the mean. In second method we used key characteristics of a normal distribution as follows:

Mean (μ): The centre of the distribution, around which it is symmetric. Standard Deviation (σ): A measure of the spread or dispersion of the data points. The empirical rule that applies to normal distributions is: 68.3% of the data falls within one Standard Deviation (σ) of the mean, 95.5% falls within two Standard Deviations of the mean, 99.7% falls within three Standard Deviations of the mean [See the Fig.1].

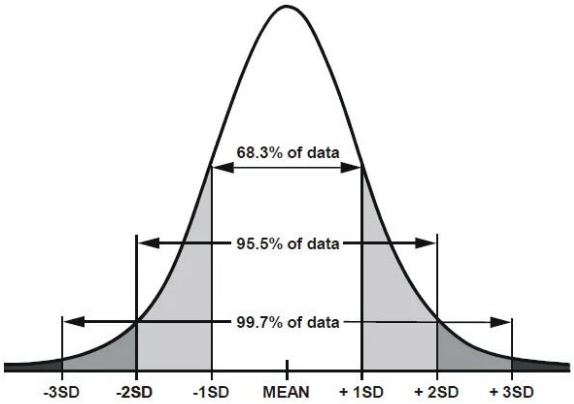


Fig. 1. Bell Shaped Curve with confidence interval [Sharma R. (2016)]

Determine grade ranges: In this method grades are determined on the basis of confidence intervals around the mean using standard distribution as per the Table III:

TABLE III
GRADE DISTRIBUTION FOR MEAN-STANDARD DEVIATION METHOD-NORMAL DISTRIBUTION

Letter Grade	No. of students
O	$\mu+3\sigma/2 \leq$ (Performance)
A+	$\mu+\sigma \leq$ (Performance) $\leq \mu+3\sigma/2$
A	$\mu+\sigma/2 \leq$ (Performance) $\leq \mu+\sigma$
B+	$\mu \leq$ (Performance) $\leq \mu+\sigma/2$
B	$\mu-\sigma/2 \leq$ (Performance) $\leq \mu$
C	$\mu-\sigma \leq$ (Performance) $\leq \mu-\sigma/2$
P	$\mu-3\sigma/2 \leq$ (Performance) $\leq \mu-\sigma$
F	$\mu-3\sigma/2 \leq$ (Performance)

Assign the grades: Grades will be assigned as per the Table III to all students based on their performance

Normalize the distribution: Here, also we may not get normal distribution of the grades and faculty assistance may require to get the normal curve.

D. Fixed Distribution Grading through Max-Min Method

Preparation of Data: As we discussed earlier, Relative Grading signifies the comparison of students with reference to performance of peers. Acknowledging the same, we determined the range of performances of all students and distributed it into seven grades.

Determine grade ranges: The range of performances is divided into a fixed number of equal length intervals. All these intervals are carrying grades in ascending order. See example: Let the maximum marks obtained in any course 98 [out of 100] and lowest marks obtained 49 [out of 100] then the difference between maximum and minimum value (98-49) is divided by no. of intervals that are expected to decide for grades as shown in Table IV:

TABLE IV
EXAMPLE OF FIXED DISTRIBUTION GRADING THROUGH MAX-MIN METHOD

Letter Grade	No. of students
O	98-91
A+	91-84
A	84-77
B+	77-70
B	70-63
C	63-56
P	56-49
F	<40

Assign Grades: Grades can be assigned to the students according to their performance.

In this method, as we are predefining the intervals and keeping it fixed, no manual alterations are possible to make normalization. To avoid overlapping, we include upper value of each interval in next interval. No scope for statistical normalization or faculty adjustment makes this method less adaptable.

IV. RESULTS AND DISCUSSIONS

We conducted our study on 1054 first year B. Tech. students to evaluate the effectiveness of these methods. The target group was divided into two categories: average performers and good performers among first-year B.Tech. students. We present a comparative analysis of all three methods using bar graphs, and these findings are further compared to the results obtained using the Absolute Grading method. Additionally, we examined three courses, with two being evaluated in a summative form [Engineering Mechanics, Engineering Chemistry] and one in a formative form [Engineering Graphics].

A. Summative assessment for Engineering Mechanics:

Using the above four methods, we assigned the seven grades to the students on the basis of their performance in Engineering Mechanics. Bar charts for all four methods, including Absolute Grading, have been generated for this course as illustrated in Fig. 2.

Journal of Engineering Education Transformations, Volume 39, No.3, January 2026, ISSN 2349-2473, eISSN 2394-1707

B. Summative assessment for Engineering Chemistry:

We drafted bar charts all four methods for Engineering Chemistry including Absolute Grading as shown in Fig. 3:

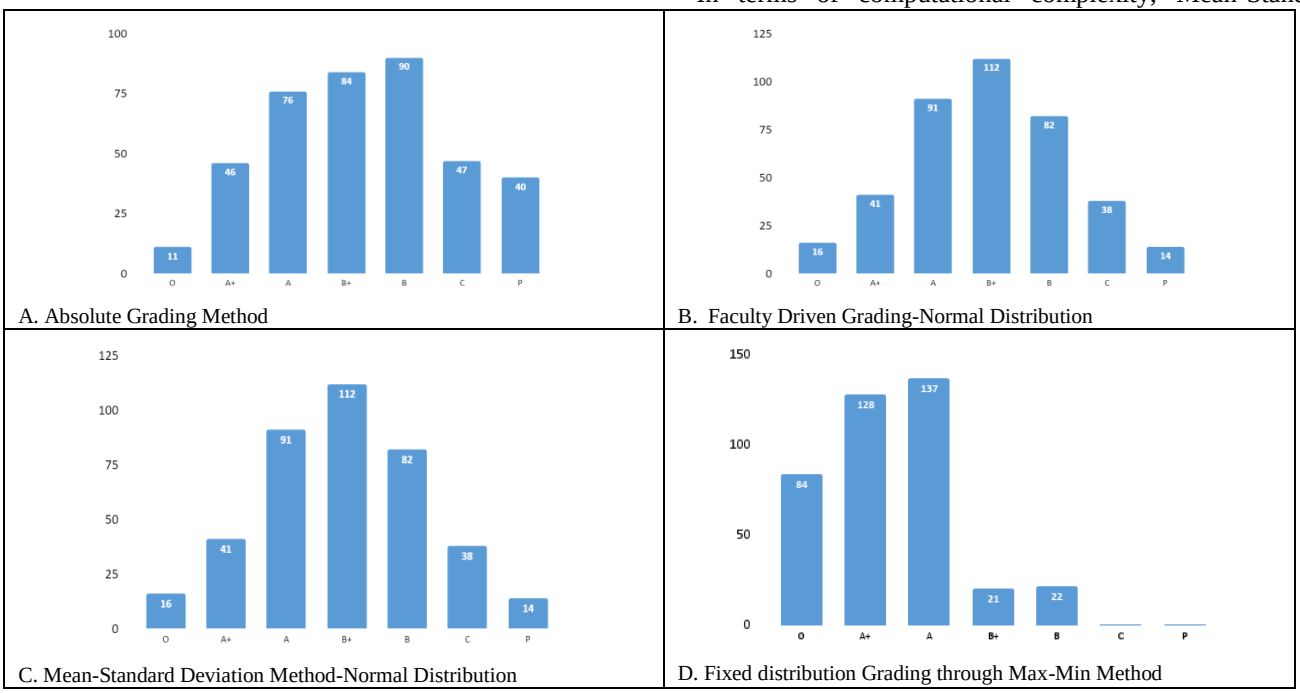


Fig. 2. Comparison of Relative Grading Methods with Absolute Grading method for the summative evaluation of course [Engineering Mechanics], [In all graphs horizontal axis represents 'Grades' and vertical axis represents 'Count of students']

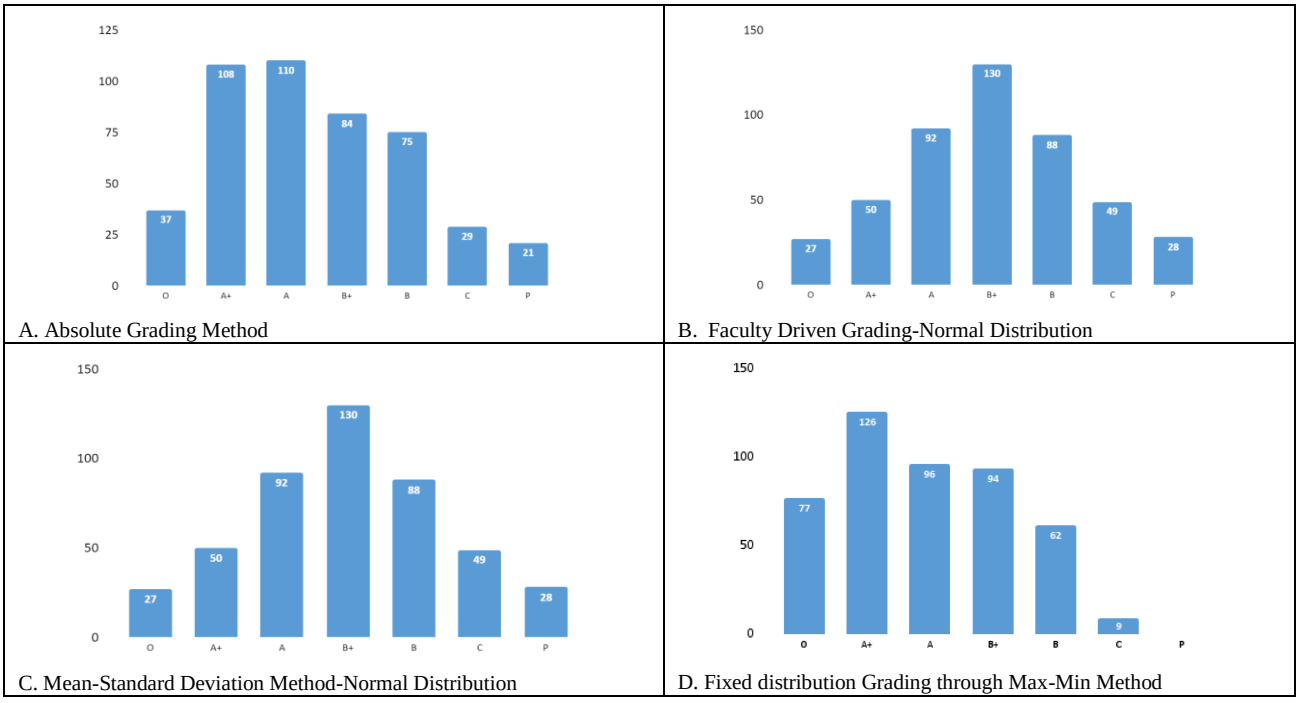
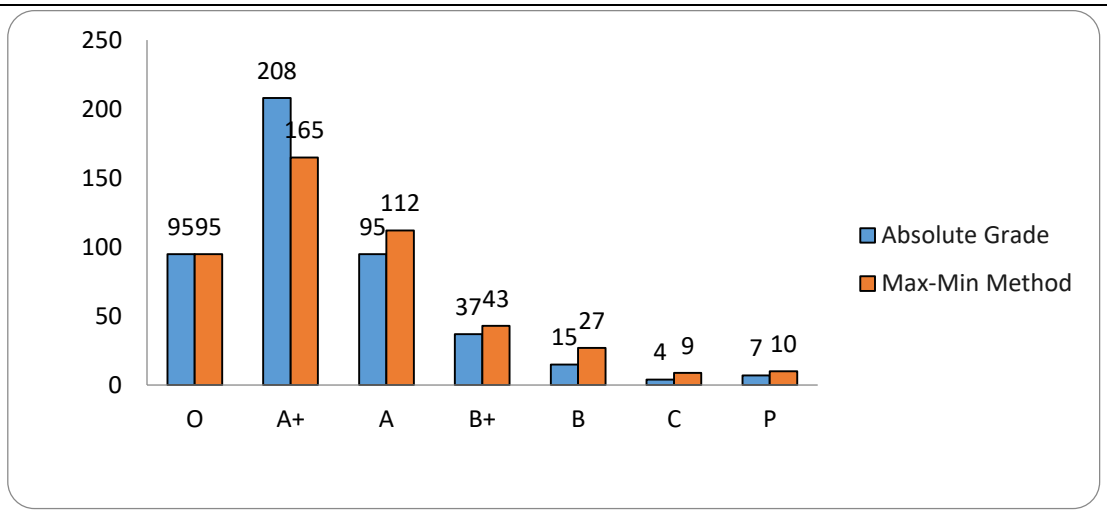


Fig. 3. Comparison of Relative Grading Methods with Absolute Grading method for the summative evaluation of course [Engineering Chemistry] [In all graphs horizontal axis represents 'Grades' and vertical axis represents 'Count of students']

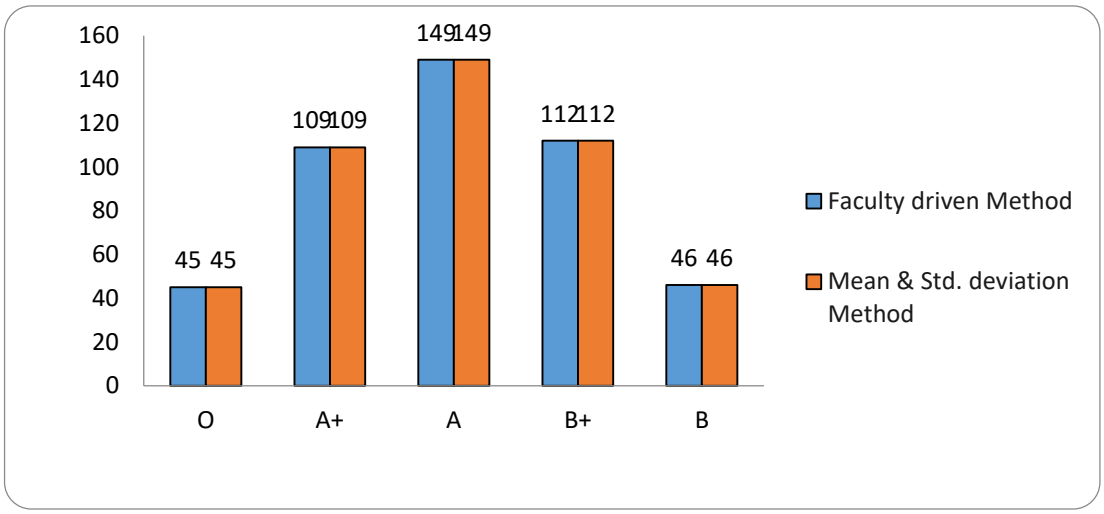
From Fig. 2 and Fig. 3, Faculty Driven Grading- Normal Distribution and Mean-Standard Deviation Method- Normal Distribution exhibit a normal distribution of grades, unlike Absolute Grading methods and Fixed Distribution Grading through Max-Min Method for both the courses. The commonality in the graphs of Faculty Driven Grading-Normal Distribution and Mean –Standard Deviation Method-Normal Distribution can be attributed to the involvement of faculty intervention in the selection of thresholds, resulting in near-identical outcomes.

In terms of computational complexity, Mean-Standard Deviation Method -Normal Distribution stands out, as it involves more intricate statistical computations to generate its results. In contrast, Faculty Driven Grading- Normal Distribution keeps things simpler by using fewer calculations. This subtle difference in how they compute things shows a balance between making grading systems less complex and more straightforward, giving us useful information about how well they work in real situations.

Journal of Engineering Education Transformations, Volume 39, No.3, January 2026, ISSN 2349-2473, eISSN 2394-1707



A. Absolute Grading and Fixed distribution grading through Max-Min method



B. Faculty-Driven Grading- Normal Distribution and Mean- Standard Deviation Method-Normal Distribution

Fig. 4. Comparison of Relative Grading Methods with Absolute Grading method for the formative evaluation of course [Term work for Engineering Graphics], [In all graphs horizontal axis represents 'Grades' and vertical axis represents 'Count of students']

C. Formative assessment for Engineering Graphics:

Utilizing the aforementioned four methods, we allocated seven grades to students based on their performance in the course Engineering Graphics. To visually represent the grading outcomes, bar charts for all four methods, including the Absolute Grading system, have been created. These charts are presented in Fig. 4, offering visual overview of the distribution of grades achieved by the students across the various grading methods employed in the study.

From Fig. 3 and Fig. 4, it's noticeable that Faculty-Driven Grading-Normal Distribution and Mean-Standard Deviation Method-Normal Distribution yield a grading distribution similar to a normal curve, both in summative and formative assessments. Meeting standard norms, which involve a smooth and accommodating course delivery, a moderately challenging examination, and fair evaluation, is expected to result in a normal distribution of grades, especially for larger groups (>30).

In the context of formative assessment, when students showcase exceptional performance, it is recommended to omit a few lower grades instead of assigning all possible grades. Conversely, when confronted with below-average student performance, it is judicious to skip a few higher grades. Precision in determining the number of grades is crucial for preserving a balanced and normal distribution. Nevertheless, Fig. 4B illustrates that methods such as Faculty-Driven Grading, Normal Distribution and Mean- Standard Deviation Method with Normal Distribution produce a Normal curve, whereas Absolute Grading and Fixed Distribution Grading through Max-Min Method may not, as depicted in Fig. 4A.

TABLE V
ATTRIBUTES OF ANOVA FOR GROUP A, GROUP B AND OVERALL GROUP

Journal of Engineering Education Transformations, Volume 39, No.3, January 2026, ISSN 2349-2473, eISSN 2394-1707

Attributes	Faculty Driven Grading- Normal Distribution Vs Absolute Grading	Mean- Standard Deviation method- Normal Distribution Vs Absolute Grading	Fixed Distribution Grading through Max-Min Method Vs Absolute Grading
Group A [Average performing students]			
RG Variance	Faculty Driven Grading- Normal Distribution: 3.04	Mean- Standard Deviation method- Normal Distribution: 3.04	Fixed Distribution Grading through Max-Min Method: 3.52
Absolute Variance	3.13		
RG Mean	6.47	6.47	7.26
Absolute Mean	6.62		
P-Value	0.19	0.19	0.00
F Critical Value	3.85	3.85	3.85
Group B [Good Performing students]			
RG Variance	Faculty-Driven Grading- Normal Distribution: 2.14	Mean- Standard Deviation Method- Normal Distribution: 2.14	Fixed Distribution Grading through Max-Min Method: 3.14
Absolute Variance	2.22		
RG Mean	6.97	6.97	6.29
Absolute Mean	7.74		
P-Value	0.00	0.00	0.00
F Critical Value	3.84	3.84	3.84
Overall group [Mixed group of students]			
RG Variance	Faculty-Driven Grading- Normal Distribution: 2.60	Mean- Standard Deviation Method- Normal Distribution: 2.60	Fixed Distribution Grading through Max-Min Method: 2.26
Absolute Variance	2.94		
RG Mean	6.75	6.75	7.57
Absolute Mean	7.24		
P-Value	0.00	0.00	0.00
F Critical Value	3.84	3.84	3.84

D. ANOVA for Relative Grading

ANOVA (Analysis of Variation) is a statistical method used to explore the sources of variability in a dataset and determine whether notable differences exist among multiple categories. Commonly applied in experimental research, quality control, and corporate analytics, ANOVA helps investigate factors influencing data variability.

The analysis involves comparing the variation within groups to that between groups, calculating an F-statistic as the ratio of between-group to within-group variability. A significant deviation of the F-statistic from what would be expected by chance suggests substantial differences between the groups. ANOVA serves as a robust tool for comparing multiple groups and gaining insights into the factors contributing to data variability Brookhart S. M. (2016).

E. Inference through ANOVA:

If the p-value associated with the F-statistic is less than a predetermined significance level (e.g., 0.05), you reject the null hypothesis and infer that at least some of the groups have significant differences. If the p-value is greater than the significance level, the null hypothesis is not rejected, implying no significant differences.

For all discussed methods ANOVA is implemented with Absolute Grading and results obtained are as shown in Table V, we included ANOVA results for three groups Group A [Average performing students], Group B [Good performing students] and Overall [Mixture of both group A and B].

Table V represents details of application of ANOVA. See the Group A [Average performer students] category: For Faculty-Driven Grading-Normal Distribution and Mean-Standard Deviation Method, the P-Value is 0.19, higher than typical significance thresholds (e.g., 0.05), suggesting that the differences between these methods and absolute methods are statistically insignificant. Also these two methods are giving similar results. While the Fixed distribution grading, the P-Value is 0.00 is highly significant. This indicates that the grading distribution for this method is significantly different from the Absolute Grading.

Similarly, For Group B [Good Performer students], The P-value for all grading methods is 0.00, which is highly significant. This indicates that the differences of grading distributions for these methods with Absolute Grading are statistically significant, for good-performing students. While observing the other parameters for the for good-performing

Journal of Engineering Education Transformations, Volume 39, No.3, January 2026, ISSN 2349-2473, eISSN 2394-1707

students, Faculty-Driven Grading and Mean- Standard Deviation Method offer a fairer representation of their performance, with lower variance and higher average scores. The Fixed distribution grading method introduces significant variability and lowers average scores, which might not be ideal for recognizing the achievements of top performers.

For overall group [mixed group of students], The P-Value is 0.00 for all Relative Grading methods vs. Absolute Grading method indicating that the differences between the Relative Grading methods with Absolute Grading methods are statistically significant. This suggests that the choice of grading method substantially affects how the Relative Grading for the mixed group are distributed.

For average performing students, Faculty Driven & Mean & Standard Deviation method and Absolute Grading giving almost similar results, but for the higher performer and mixed group of students all Relative Grading methods are giving the variability in grades compare to Absolute Grading method.

The graphical representations in Fig. 2, 3, and 4, along with the results from ANOVA, mutually reinforce and substantiate the findings.

A significant difference exists between Relative Grading methods vs. Absolute Grading in ANOVA. However, one aspect easily observed in the Table V readings is that Faculty-Driven Grading-Normal Distribution and Mean & Standard Deviation Method have similar results. So, both of these methods are replaceable, and the choice of any one of them depends on the philosophy of the individual institute.

CONCLUSION

This discussion focuses on the significance of implementing a scientific method to enable course instructors to effectively map their students on a Normal curve. Careful consideration is required when applying grading methods to maintain fairness and motivation among high-achieving, average achieving methods and mixed group of students. By employing the appropriate approach in the evaluation process, several key conclusions can be drawn:

1. Adopting a scientific method ensures clear grading purposes.
2. Establishes a solid educational foundation
3. Utilizes practical tools for accurate progress measurement aligns with institutional philosophy.

In essence, embracing a scientific method in the evaluation process not only ensures fairness and accuracy in grading but also contributes to the overall effectiveness of the educational system by promoting transparency, objectivity, and alignment with institutional philosophies.

While choosing a grading method, one can acknowledge the attributes referred in Table VI and choose the grading method accordingly:

In engineering education, achieving fair and accurate student assessment is a persistent challenge. The Faculty-Driven Grading- Normal Distribution and Mean-Standard Deviation methods offer practical solutions by accounting for exam difficulty and class variability. These approaches reduce instructor bias, promote consistent grading, and align with the Outcome-Based Education (OBE) framework, enabling institutions to make informed decisions on student progression and curriculum improvement. In conclusion, adopting a scientific approach to grading enables institutions to fairly and effectively evaluate student performance. Among the methods analyzed, Faculty-Driven Grading- Normal Distribution and Mean-Standard Deviation methods produced consistent, normally distributed results and are suitable for diverse academic contexts. While Fixed Distribution Grading offers simplicity, it may not accurately reflect student variability. Institutions should choose grading methods that align with their pedagogical goals, curriculum structure, and student demographics to foster fairness, transparency, and academic excellence. The grading method's success depends on careful customization for each program or institution

TABLE VI
COMPARISON OF DIFFERENT GRADING SYSTEM BASED ON SAME ATTRIBUTES

Grading Method Attributes	*Absolute Grading*	*Faculty-Driven Grading*	*Mean- Standard Deviation Method*	*Fixed Distribution Grading through Max-Min Method*
Determination of grades	Grades based on predetermined standards and criteria.	A guideline will be used for percentage breakdown. But, faculty can decide the breakdown to meet condition of Normal Distribution	Distribution of grades is based on Mean and standard deviation in the range of $(\mu -3\sigma,\mu+3\sigma)$	Grades are distributed in equal intervals based on ratio of range of grades over no. of intervals
Focus	Mastery of subject matter and meeting predefined criteria	Comparison to peers' performance.	Comparison to peers' performance.	Mastery is subjective to high performer student
Variability Consideration	Consistent grading regardless of exam difficulty.	Accounts for variations in exam difficulty.	Accounts for variations in exam difficulty.	Accounts a little variation regardless of exam difficulty

Journal of Engineering Education Transformations, Volume 39, No.3, January 2026, ISSN 2349-2473, eISSN 2394-1707

Competition with peers	Focuses on individual performance reducing competition.	Encourages healthy competition among students. [Even small performance improvements may change grade]	Encourages healthy competition among students. [Even small performance improvements may change grade]	Competition is subjective to high performer student
Collaboration with peers	Encourages collaboration as students aren't directly competing.	Can discourage collaboration due to competitive nature. [one student's success can lower another's relative rank]	Can discourage collaboration due to competitive nature. [one student's success can lower another's relative rank]	Collaboration is subjective to many aspects.
Transparency	Easier to understand as grades are based on predefined criteria.	Might require clear communication due to complexity.	Might require clear communication due to complexity.	Easier to understand , but always variable with respect to high performer students.
Flexibility	Grades might lack flexibility to accommodate variations.	Allows for adjustment based on class performance.	Allows for adjustment based on class performance.	Though peer performance is taken into consideration, Grades might lack flexibility to accommodate variations.
Instructor Bias	Grades are not influenced by instructor's preferences.	Helps mitigate individual instructor biases.	Helps mitigate individual instructor biases.	Grades are not influenced by instructor's preferences.
Grade Compression/Expansion	Grades might not adapt to variations in student performance.	Grades can be compressed or expanded based on class performance	Grades can be compressed or expanded based on class performance	Grades might not adapt to variations in student performance.
Individual Mastery Emphasis	Strong emphasis on individual mastery and understanding	Less emphasis on individual mastery.	Less emphasis on individual mastery.	There is emphasis on individual mastery but grades will be allotted with reference to high performer students.

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