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IMPROVED GRADING APPROVAL PROCESS WITH RULE BASED GRADE DISTRIBUTION SYSTEM

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Abstract. *In academic institutions, the grading approval process is an important part of the educational quality assurance process. At Assumption University (Thailand), course coordinators can propose any grading distribution for their respective courses, but the grading would be scrutinized by internal/external committees in the grading approval process. The grading approval process is a manually intensive process that is error-prone and time-consuming especially when the grading committees provide suggestions for modifying the grading distribution. The research proposes a grading approval system that helps streamline the process by providing multiple features that are tailored to stakeholders in the grading approval process. One of the key features of the proposed system includes a rule-based grading distribution system that allows grading coordinators to quickly set up grading distributions that are based on patterns that are commonly suggested by the internal/external grading committees of the Department of Digital Business Management at Assumption University. Comparing the proposed system's grading distribution, the course coordinator's grading distribution, three standard distributions, and the bell curve distribution with the approved grading distribution of courses offered by the Department of Digital Business Management at Assumption University for the academic year of 2019 to 2020, the proposed system has shown good fit with the approved grades when compared to other control grading distributions.*

Keywords: Grade distribution system, Rule based system, Rule based extraction, Grading application, Process streamlining

1. **Introduction.** In any academic organization, the grading system is used to evaluate the student's achievement in the course and is recorded by utilizing multi-point letter grades. The letter grades represent different meanings and are assigned different weights on a grading scale.

Grading coordinators would set up the grading criteria and then tally the raw grades before proposing a grading distribution approach that would transform the raw grades into letter grades. As part of the quality assurance process [1] in Thailand, the submitted grades of the grading coordinators will be scrutinized by internal and external committees in the grading approval process. Suggested changes to the proposed grading distribution may be proposed in the grading approval process. The result of the grading approval process would be approved by the faculty/school level and academic affairs of the university before the grades would be finalized.

At Assumption University (Thailand), the grading approval process is a manual process. The original workflow utilizes printouts of the grading files to be distributed between the grading committee for feedback. With a lack of specialized IT tools to help in the grading approval process, the process is generally time-consuming and error-prone in multiple

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facets. Rudimentary tools such as Excel could be used to help, but many features are not tailored toward the task required. Details of this issue are discussed in the first subsection of the background. Discussions of other popular grading distribution approaches that could be used by grading coordinators are discussed in the next subsection.

With all the details and issues addressed, the proposed system section provides details about the suite of tools that were developed for the grading approval process for the Department of Digital Business Management. Tools were created to help visualize different grading distributions, automate the grading distribution change requests, and provide a rule-based grading distribution system for grading coordinators to use that is more likely to be approved by the specific grading approval committees. The rule-based distribution system was created by deriving the regular patterns that the internal/external grading approval committees have suggested over the years and would help grading coordinators propose better grading distributions that are less likely to be modified compared to other approaches. The experiment section would provide details on the experiment done to test the fit of the rule-based grading distribution system with the final approved grades when compared with the originally proposed grading distribution and 4 other control grading distributions, using data from the Department of Digital Business Management from the academic year 2019 to 2020. At the end of the paper, the conclusion is provided to recap the benefits of the proposed system, before addressing some outstanding issues, and potential areas for future work.

2. **Background.**

This background section is divided into two subsections. The first subsection examines the grade submission and grading approval process at Assumption University[1] and highlights some of the existing issues with the current workflow.

The second subsection introduces some common grading distribution approaches. The popular approaches to grading distribution via pre-defined standards and distribution/curves would be discussed in more detail including the pros and cons when using the approach. However, this section omits the discussion of the grading system and policies [2, 3] as it is beyond the scope of the research. The grading distribution approaches discussed in this section are used as the control in the experiment.

2.1. **Grade submission and approval process at Assumption University.**

At the end of the semester, grading coordinators of the subjects will compile the raw scores of students and propose the grading distribution for the subject based on the grading scale[2]. Assumption University does not require the coordinator to use a specific grading distribution approach and provides the freedom for the coordinator to propose what is deemed appropriate for the subject. The grade tally and the grade distribution of every subject are then submitted by the coordinator online via the Grade Calculate application[3]. To maintain check and balance mechanisms, all grade distributions would later be scrutinized by the grading approval process.

2.1.1. *Grading approval process.* The department would compile the list of all grade distribution proposed for every subject offered by the department and arrange a grading approval meeting with internal/external committees. Printouts of the grade distributions of all the subjects are provided in which the committees would make suggestions regarding the grading distribution. The suggestions would be compiled into a grade distribution report of the department. The secretary of the grading approval process would then contact the grading coordinators to request grading distribution changes. The coordinators

[1]Assumption University – https://www.au.edu/

[2]Assumption University Academic Information – https://www.au.edu/academics/academic-information.html

[3]Grade Calculate Application (EGrading System from Office of Information Technology Services) – http://its-4.au.edu/home_content/Files/faculty/manual-eGradingInstructorNEWen17032017.pdf

would then change, and update the grades via the Grade Calculate application. Finally, the full grading approval report will then be sent to the University for approval before the official release to the public.

2.1.2. *Issues with grading approval process.* One of the common issues faced by many universities is that many processes are not automated by IT and mainly rely on manual processes. There is an increased drive towards utilizing more IT for educational purposes [4, 5, 6], which can help improve the workflow inside. At Assumption University, the Grade Calculate application helps in the process of grade distribution submission by course coordinators but lacks functionality in the grade approval workflow. There had been some examples of third-party applications [7, 8] focused on grading, and it is possible to develop highly specific applications to help with the workflow, especially in the grading approval process in many aspects.

The grading distribution of all subjects examined is provided as printouts/PDF copies. The grading committees found that it was difficult to visualize the new grading distribution after changes to the intervals are suggested. The grading approval committees could not visualize how the changes in the grading distribution may affect the tally of each letter grade, the average GPA of the subject, and grading patterns visually. Without a visual guide, the process of finding the optimal grade interval is time-consuming and could be improved.

With any grade change requests, the secretary of the meeting would have to file a grade change report and notify the grading coordinator regarding the recommended changes. The requested change is error-prone due to the manual transcription of the revised grading distribution and tally, and inefficient as the secretary has to manually contact the grading coordinators of the requested changes. This process is inefficient and should be avoided when possible.

2.2. **Grading distribution approaches.** At some universities, the grading distribution approaches are dictated by policies, whereas in other universities such as Assumption University, the grading coordinators are given the freedom to decide which grading distribution approach they want to use. The two most common approaches are the pre-defined standards and grading based on the curve which would be covered in more details in this section. Alternative grading systems such as standards-based grading [9], assurance of learning [10], and criteria-based assessment [11] are not discussed since they are used only as secondary indicators with the present system.

2.2.1. *Grading distribution based on pre-defined standard.* Grading distribution based on the pre-defined standard is one of the approaches that is widely used. The processes involved are explained in the following flow:

1) Define the intervals of each of the letter grades;
2) Obtain the raw score of the student via evaluation;
3) Assign the letter grade based on where the raw score lies on the grading interval.

This approach is straightforward and conceptually easy to understand. Students are given the grading scales and would be evaluated with respect to their contributed work and examination without having to worry about the performance of other students in the class. The grading from different batches could be compared if the difficulty has been maintained due to the static nature of pre-defined standards.

The main drawback of the pre-defined standard approach comes from the potential mismatch between the standard of the class in regards to the difficulty of the class. An example of that is when the difficulty of the class is significantly higher than the standard of the class. In that scenario, the grading distribution would be skewed towards failing grades. In the opposite case where the difficulty of the class is significantly lower than the

standard of the class would result in a grading distribution that would be skewed towards excellent grades.

Another major drawback of the pre-defined standard approach is that the grading intervals are split at an arbitrary value. The interval may split a uniform group, which is one of the factors that may lead to grading complaints that are filed.

2.2.2. *Grading scale based on distribution/curve.* Another popular approach in creating the grading scale of the subject utilizes the grade curve/distribution. The bell curve approach is the most common, though variations exist. To obtain the scale, the following steps are utilized:

1) Obtain the total grade as a numerical score of the students in the class;
2) The numerical scores are converted to percentiles;
3) The percentile values are transformed into letter grades based on a percentile scale converted to the desired intervals of each letter grade (e.g., Mapped to Normal/Bell Curve (Figure 1)).

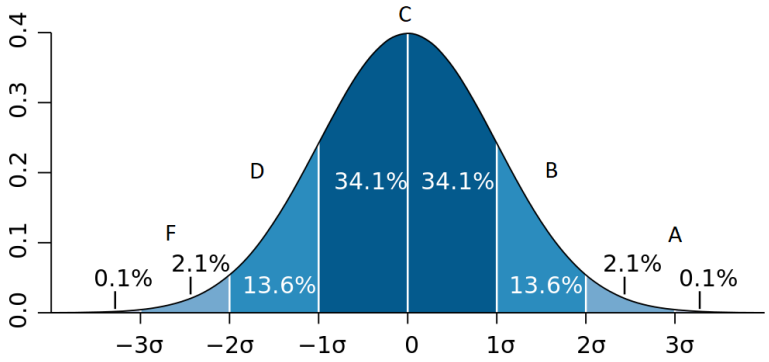

FIGURE 1. Example of bell curve grade distribution

Based on the nature of the grading curves, the grading curve approach would provide a more balanced distribution of letter grades regardless of the differences in factors such as different instructors in the course, the difference in section evaluation, or other factors related to the conduct of the class.

Though the grading by the curve approach provides a more balanced grading distribution, there are numerous issues [12, 13, 14] that have to be considered when utilizing the approach. The grading scale is dependent on the performance of the class [15], where the class performs significantly above or below average, and the bell curve will cause the grading scale to be skewed. The use of this grading approach in exceptionally performing classes may lead to unhealthy competition between students. Another reported scenario is that the exceptional students in the class may be persuaded to slightly reduce their performance to help with the curve for weaker performing students. As a result, the curve may not be a good reflection of the performance of the class.

3. **Proposed System.** The proposed system aims to address the issues that were common in the grading approval process that was discussed earlier. An application for the grading approval committee was proposed, and many features were developed to address many of the challenges and issues in the grading approval process. The proposed system was developed using Python[4]. To provide GUI functionality, the Tkinter[5] package was utilized. The Matplotlib library[6] was used for plotting and producing the figures in the

[4]Python – https://www.python.org/
[5]Tkinter – https://wiki.python.org/moin/TkInter
[6]Matplotlib – https://matplotlib.org/

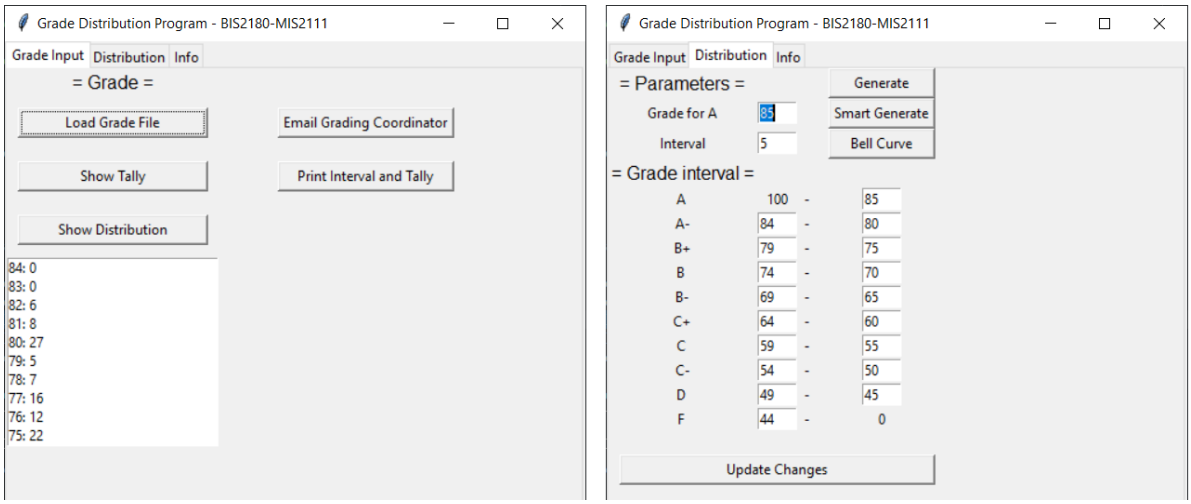

FIGURE 2. Main interface of the proposed system

application. The Yagmail[7] library with App Password[8] was used for automated emailing services. The main interface of the proposed system is displayed in Figure 2.

3.1. **Grading distribution visualization.** The first feature provided would be the grade distribution visualization functionalities. Any changes done with the grading distribution will be reflected by showing the letter grade distribution, the visualization of the grade distribution, and the overall GPA of the course after the changes have been made. By providing visualization tools, the grading approval committees would be able to quickly examine the effects of any grading distribution changes with the selected subject directly by examining the visualization plots. A sample of the visualized output of the letter grade distribution and the grade distribution can be viewed at Figures 3 and 4.

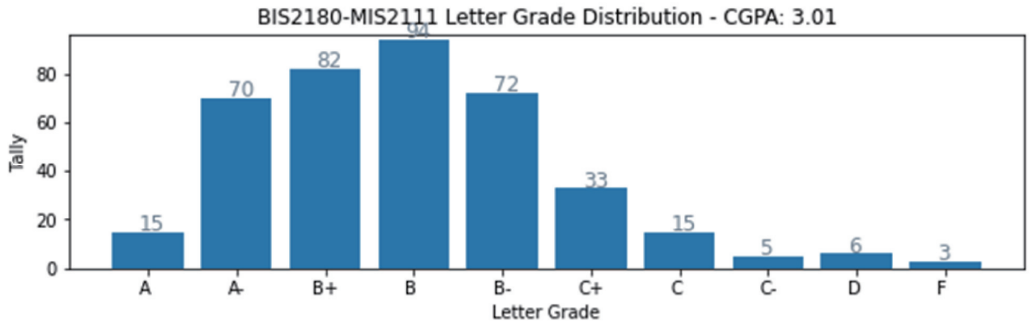

FIGURE 3. Plot of letter grade distribution from the proposed system

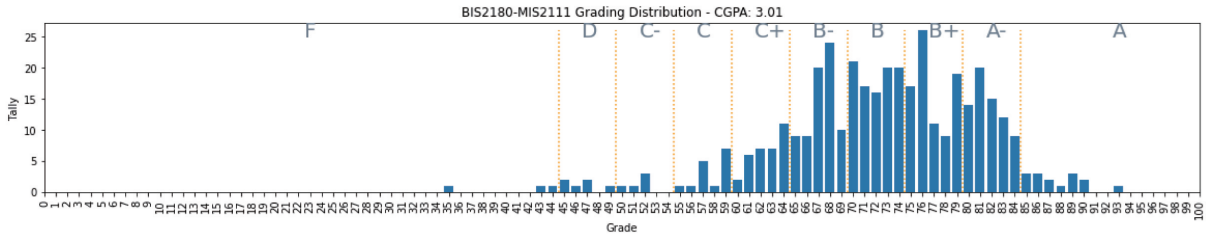

FIGURE 4. Plot of grade distribution from the proposed system

[7]Yagmail – https://pypi.org/project/yagmail/
[8]App Passwords – https://support.google.com/accounts/answer/185833?hl=en

The letter grade distribution plots are plotted to show the overall performance of the class as in average GPA, and the tally of each of the letter grades. The letter grade distribution plots are used to see if there are any issues with the letter grades, such as irregular patterns and tallies that are too high or low with respect to the other letter grades. The grade distribution plot will show the tally of all the scores in the class and highlight where the letter grades change. The grade distribution plot is used to help the grading approval committees to examine the grading intervals of letter grades and pin-point modified positions that might better fit their expectations.

3.2. **Grading changes and contacting grading coordinators.** After visualizing the grading distribution of the specific subject, the grading approval committee can propose the grading change. In this process, the proposed grading distribution changes would have to be formatted first. Then the tally of each letter grade should be compiled, and the average GPA of the subject is calculated. This process is finished after the proposed grading distribution changes are sent to the grading coordinator. The feature is provided in the application and Figure 5 shows the formatted sample output. This feature can reduce occurrences of incorrectly transcribed grade distribution changes and contact the correct grading coordinator promptly via email.

```
BIS2180-MIS2111
= Grade Distribution =
A       :       100     -       85      :       15
A-      :       84      -       80      :       70
B+      :       79      -       75      :       82
B       :       74      -       70      :       94
B-      :       69      -       65      :       72
C+      :       64      -       60      :       33
C       :       59      -       55      :       15
C-      :       54      -       50      :       5
D       :       49      -       45      :       6
F       :       44      -       0       :       3
CGPA: 3.01
```

FIGURE 5. Transcribing the grading distribution and tally output

3.3. **Grading distribution approaches.** The proposed system comes with several built-in grading distribution approaches that could be applied to the grading distribution of the subject. Manual input of intervals, generated pre-defined standards, and the bell curve intervals functions are provided in the system. To help provide better-conforming grading distributions regarding the grading approval committees' expectations for the Department of Digital Business Management, a rule-based grade system that helps propose a grading interval that is likely to conform with the grading committees addressed in the study. This feature could be used by grading coordinators to propose better-conforming grading distribution. This can potentially reduce the number of grading change requests leading to a more streamlined grading approval process. The details of the system would be explained in detail in the next subsection.

3.4. **Rule-based system for finding a suitable grading distribution.** To reduce the number of change requests in the Department of Digital Business Management at Assumption University, the proposed system proposes a rule-based grade distribution that is explicitly derived from patterns of grading change requests by the grading approval committees during the grading approval process. Using the records of the grade change

modification requests from the grading approval committees, some patterns that are contributing factors leading to grade change requests are extracted. The most common issues are summarized by the following patterns.

The first pattern observed was the irregular intervals for the letter grades. This pattern is usually formed when the lecturer attempts to help certain student groups by increasing the interval for certain grades that have a huge impact (e.g., between failing and passing grades) beyond the average interval size. This pattern is commonly picked up by the grading approval committees and changes are usually requested to make the intervals more uniform.

The second pattern observed was that grading committees prefer the grading intervals to be placed where there are huge changes in the grading interval so that a pattern can be observed. Huge changes in the tally values form a valley pattern that is visually distinct and provides a logical explanation for the grading interval. Based on previous student complaints regarding grading intervals from pre-defined standards that the intervals can split a uniform group, by shifting the interval to more distinct patterns, the complaints would be minimized. The grading coordinators can easily rationalize the grading pattern by following the valley pattern as opposed to splitting the interval with uniform intervals. Figure 6 demonstrates an example of changing the interval position to better fit the valley pattern for the grading interval of A− by shifting the $A-_{min}$ from 80 to 81. The shift creates a pattern that divides the grading group better.

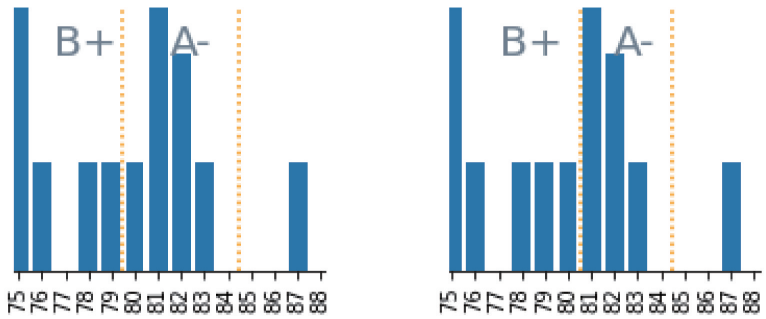

FIGURE 6. Shifting grading interval for a better interval position with valley patterns

The third pattern observed was that the grading approval committee may request changes with the interval for A and cascade the rest of the intervals. This is not commonly requested unless there is a huge anomaly in the grading, such as a very high/low proportion of A's, or a very high/low average GPA in the class. However, this request is not quite common due to the difficulty of reaching a consensus between all committees.

Of the three observed patterns for grade change requests, the first and second pattern were most consistently requested by the grading approval committees and would be resolved by the proposed system. Algorithm 1 displays the derived rules for finding the suitable interval for the letter grade. The assigned A_{min} grade and the planned intervals range would be given by the grading coordinator. The system would generate the grade interval for all the letter grades similar to the pre-defined system, but shifts the intervals based on the extracted patterns observed earlier. The tally values observed at the initial interval and neighboring positions would be recorded. If the proposed interval does not have a distinct group, the interval could be shifted up or down to a limit to find a more suitable valley pattern in the grading. Once the best position has been established, the intervals are shifted to the new position. In summary, the interval can be shifted when a better valley position close to the interval would be selected as an alternative interval. This process is repeated until all the letter grades have been established.

Algorithm 1 Finding suitable grading distribution interval

```
1: Grade[0]_max ← 100
2: Grade[0]_min ← A_min
3: pre ← 0
4: cur ← 1
5: while Grade[cur].exists() and indexToGrade(cur) ≠ "F" do
6:    Grade[cur]_max ← Grade[pre]_min − 1
7:    pos ← Grade[cur]_max − interval
8:    if Tally[pos].isEmpty()||Tally[pos].isValley() then
9:       Grade[cur]_max ← pos
10:   else
11:      Found ← FALSE
12:      for i ← 1 to Floor(Interval/2) do
13:         if Tally[pos − i].isEmpty() then
14:            Grade[cur]_min ← pos − i
15:            Found ← TRUE
16:            BREAK
17:         end if
18:         if Tally[pos + i].isEmpty() then
19:            Grade[cur]_min ← pos + i
20:            Found ← TRUE
21:            BREAK
22:         end if
23:         FIT[pos − i] = Tally[pos − i].calcValley()
24:         FIT[pos + i] = Tally[pos + i].calcValley()
25:      end for
26:      if Found == FALSE then
27:         pos ← FindMaxFit(FIT, pos, Interval/2)
28:         Grade[cur]_min ← pos
29:      end if
30:   end if
31:   pre ← cur
32:   cur + +
33: end while
34: Grade[cur]_max ← Grade[pre]_min − 1
35: Grade[cur]_min ← 0
```

The results of the proposed system would generate a grading distribution that is similar to pre-defined standards but would have the flexibility of proposing better fitting intervals within an interval limit that would be more likely to be approved by the grading approval committee. To test the system, an experiment was set up to test the proposed system against several control grading approaches, the grading coordinator's original grade proposal against the approved grades. The details of the experiment are discussed in the next section.

4. **Experiment and Results.** To test the suitability of the proposed grading distribution system, the grading distribution for the academic semester of 1/2019, 2/2019, 1/2020, and 2/2020 for the Department of Digital Business Management was used. The approved grading distribution of all the distinct subjects is used as the target goal. The closer the proposed system is to the approved distribution, the better the results are.

To test the performance of the proposed grading distribution system, several different approaches were selected. The first grading distribution would be the original grading distribution that was proposed by the grading coordinators. Additional comparisons are done by creating the bell curve distribution, and three pre-defined standards as a benchmark. The bell curve is calculated from the basic statistical information of each respective subject. For the pre-defined standards, the A_{min} grade was set up to start with 90, 85, and 80. An interval of 5 was used to calculate the remaining grades for each of the pre-defined standards, respectively. The proposed grading distribution system was set up using the A_{min} grade score and the average interval rounded of each proposed grading coordinator was used as the parameter.

To measure the fit, Average Absolute Deviation (AAD) was selected. The AAD calculation provides an overview of dispersion from a selected central point that is more resilient to outlier values as opposed to standard deviation. The formula of AAD is displayed in Equation (1). The set of values is defined as $x_1, x_2, \ldots, x_n$ and $m(X)$ which is the central point for the calculation is the approved grading interval position.

$$\frac{1}{n}\sum_{i=1}^{n}|x_i - m(X)| \tag{1}$$

To provide a better overview of the performance, the AAD is calculated for every letter grade interval. By drilling down to the grading interval, it is possible to see the dispersion from the approved value of every letter grade. The AAD is calculated for all of the letter grades from A to F from the approved values to the proposed approach and control approaches that include the grading coordinators' original distribution, the bell curve, and the three pre-standard grading distributions, respectively. Tables 1-4 contain the calculations from the experiment from academic semester of 1/2019, 2/2019, 1/2020, and 2/2020, respectively. For the results, a lower score indicates a better fit with the approved grading intervals.

From the results, the bell curve was the worse fit. The bell curve emphasizes providing a balanced distribution of letter grades. When exploring the approved distribution of the letter grades, it was observed that the grading approval committees did not focus on the balanced distribution. For the example of major required courses where C is the

Table 1. AAD of the proposed system vs other approaches for semester 1/2019

	A	A−	B+	B	B−	C+	C	C−	D	Total
Proposed system	0.4	0.3	0.5	0.5	0.4	0.5	0.8	0.8	1.4	5.5
Grading coordinator	1.1	1.4	1.5	1.5	1.5	1.3	1.3	1.3	1.4	12.2
Bell curve	8.6	9.7	11.0	13.2	15.1	17.2	19.5	19.8	20.3	134.4
Standard (90/5)	9.9	9.7	9.8	9.7	9.3	9.6	9.5	9.3	9.7	86.5
Standard (85/5)	4.6	4.5	4.7	4.6	4.5	4.5	4.4	4.5	4.9	41.4
Standard (80/5)	2.1	2.5	2.9	2.7	3.0	2.8	2.5	2.5	2.6	23.5

Table 2. AAD of the proposed system vs other approaches for semester 2/2019

	A	A−	B+	B	B−	C+	C	C−	D	Total
Proposed system	0.4	0.4	0.2	0.4	0.5	0.5	1.0	1.1	1.6	5.8
Grading coordinator	0.5	0.3	0.4	0.6	0.6	0.5	0.6	0.9	1.7	5.9
Bell curve	7.9	9.1	11.4	13.7	16.1	19.0	21.9	23.5	23.9	146.4
Standard (90/5)	8.0	7.6	7.4	7.1	6.9	7.1	7.4	7.6	7.6	66.4
Standard (85/5)	3.4	3.3	3.5	3.2	3.4	4.0	4.0	4.5	5.2	34.4
Standard (80/5)	3.6	4.0	4.2	4.5	4.7	4.5	4.1	4.0	3.4	36.7

TABLE 3. AAD of the proposed system vs other approaches for semester 1/2020

	A	A−	B+	B	B−	C+	C	C−	D	Total
Proposed system	0.1	0.3	0.3	0.4	0.3	0.7	0.8	1.0	1.2	5.1
Grading coordinator	0.3	0.2	0.3	0.1	0.1	0.3	0.4	0.6	0.2	2.4
Bell curve	8.2	10.3	11.9	14.1	17.5	19.4	22.4	23.2	23.9	150.9
Standard (90/5)	7.8	7.6	7.6	7.4	7.3	7.4	7.8	7.7	7.7	68.2
Standard (85/5)	4.0	4.6	4.5	4.7	4.7	4.8	4.9	5.3	5.5	43.0
Standard (80/5)	4.0	4.5	4.5	4.8	4.9	4.6	4.0	4.1	4.2	39.7

TABLE 4. AAD of the proposed system vs other approaches for semester 2/2020

	A	A−	B+	B	B−	C+	C	C−	D	Total
Proposed system	0.1	0.2	0.2	0.3	0.3	0.7	0.7	0.8	0.9	4.1
Grading coordinator	0.3	0.3	0.3	0.5	0.7	0.8	0.9	0.4	0.4	4.9
Bell curve	8.6	10.5	12.6	14.8	17.2	19.7	22.6	23.7	24.3	154.0
Standard (90/5)	7.6	7.4	7.3	7.2	7.1	7.2	7.6	7.5	7.4	66.2
Standard (85/5)	3.9	4.4	4.3	4.5	4.5	4.6	4.7	5.0	5.3	41.3
Standard (80/5)	4.3	4.7	4.7	5.0	5.1	4.9	4.4	4.6	4.6	42.3

passing grade, using a bell curve would be deemed that a high percentage of the students will fail the course regardless of the overall class performance. Based on Thai University regulations, any class with unusual grade distribution would have to report in the Course Report (TQF5) regarding the high failure rates which would be investigated by the School and University level. Due to that, there are pressures not to use the bell curve, and it reflects when exploring the C, C−, and D letter grades generated by the bell curve to have the highest AAD values, which signifies a bad fit with the approved distribution.

The three variations of the pre-defined standard had a closer fit to the approved distribution. It is observed that many grading coordinators in the department have utilized a form of pre-defined standard distribution for the grades. As the University did not dictate the pre-defined standard, a cursory observation is that many grading coordinators have chosen to shift the pre-defined standard around the course material where more difficult subjects use an easier pre-defined standard, whereas easier subjects utilize higher pre-defined standards. Based on the variations, 85 and 80 grades for $A_{\min}$ with 5-grade intervals were quite close to the approved distribution.

The distribution proposed by the proposed system and grading coordinators is a closer fit than the four control approaches with lower overall AAD. This is not surprising as the University does not dictate a grading distribution approach, and utilizes the mechanisms of the grading approval committee to scrutinize the grading distribution. It is observed that the proposed system proposes grading distribution for semesters 1/2019, 2/2019, and 2/2020 that are better than the grading coordinators. The exception was in semester 1/2020 in which the grading coordinators proposed a better fit than the proposed system. For semester 1/2019, the proposed system performed better significantly than the other approaches as there were numerous instances of irregular grade intervals that were proposed by the grading coordinators that the grading approval committees have requested changes. This is consistent with the proposed system's requirements. For semesters 2/2019 and 2/2020, the results are quite similar to the grading coordinator, but with a slightly lower AAD, which signifies a slightly better fit. The exception in 1/2020 is when the grading coordinator has proposed a better fit. From this semester, it was observed that there was a shorter than usual review cycle for the grading approval committee due to the semester shift for the academic year 2020 at the University. Due to the limited time, it was observed that fewer than average grading changes were requested by

the grading approval committees as opposed to regular semesters. With the scenario, the distribution proposed by the grading coordinator is a better fit for the semester 1/2020 when compared with the proposed system.

Overall, the proposed system performs well in proposing a grading distribution that is a good fit with the approved grading distribution for the Department of Digital Business Management based on the experiment results and could be recommended for future use. If the grading approval committee is chaired by the same external committees, there is a likelihood that the proposed approach would work well. If the external committees invited for the grading approval committee are shared, there would be the likelihood that many grading change request patterns would be consistent.

The caveat is that the grading distribution may not be a good fit if the external committee invited to the grading approval committee utilizes a different grading distribution paradigm. Examples might include committees that focus on the average GPA, which is a completely different approach. In such cases, the proposed system would not conform with the scenario well, and additional rules would have to be created based on the patterns observed by the external committees.

5. Conclusion and Future Work.

The grading approval process is an important process for any academic institute. At Assumption University, the grade approval process is still a manual process and could be improved in many areas. A grading approval system was created to help improve the workflow for the grading approval process that includes grading distribution visualization, transcription of the grading intervals, calculation of the revised average GPA, compiling the tally, and mailing the grading distribution changes requested directly to the affected grading coordinators.

For grading coordinators, the creation of various grading distribution tools was provided. The proposed system provides manual input, automated bell curve distribution, generated pre-defined standard distribution, and a smart grading distribution system that extracts the patterns from the external committees that regularly chair the grading approval process at the Department of Digital Business Management at Assumption University. The proposed grading distribution system extracts the patterns of grade change requests and generates the grading distribution that avoids such scenarios to help improve the quality of the grade distribution proposed to the grading approval committees. The results of the proposed grading distribution system have generally provided better results when compared to the grading coordinators' grading distribution, the bell curve, and three standard curves when comparing the results from the academic year 2019 to 2020. The system failed to perform better than the distribution provided by the grading coordinator only in semester 1/2020, but that is likely to be an outlier case as discussed earlier.

Based on the results of the grading distribution system and the potential advantages of the grading approval process, the system is likely to help the grading approval committees of the Department of Digital Business Management for the coming academic year of 2021 and could be adopted for wider use.

Though the proposed system solves many outstanding issues, there are many potential improvements for future work. The interface provided does the job, but usability tests [16] could be implemented to help streamline the interface design for stakeholders.

One of the main issues is that the study focuses on addressing the grading issues at the Department of Digital Business Management at Assumption University. The proposed approach may not fit other grading approval committees due to having different rationales for requesting grading changes. To deal with those requests, additional functionalities could be implemented. Generating grading distribution to target a specific average GPA for the subject, and finding the grading distribution to fit is one feature that would be useful. In the past, the committees had requested grading distribution

shifts to increase or decrease the subject's average GPA, and this additional feature could help in that respect. Another observation is that the approval grading committees and grading coordinators may approach grading distribution slightly differently when faced with basic courses, major required courses, and major elective courses. Slight modifications could be implemented to help deal with and improve the fit with the differences between the types of courses.

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