Implementation and Evaluation of Three Approaches for Maintaining Student GPAs During the COVID-19 Pandemic

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Abstract—The COVID-19 global pandemic quickly shifted in-person education systems to online learning environments due to the enforcement of public isolation and social distancing. Decision makers applied various measures to maintain the education process and performance of students. In the Kingdom of Saudi Arabia (KSA), the Ministry of Education (MoE) stated that all educational institutions must ensure the maintenance of students' grade point averages (GPAs) during pandemic semesters, requiring they do not fall below their cumulative GPA from the previous semester. In turn, each university had to identify and apply an appropriate approach to solve this dilemma. Ultimately, the revolved, involved, and evolved approaches were implemented. This study examines the three approaches via real data from the student information system (SIS) at Imam Abdulrahman Bin Faisal University (around 111,000 grades for approximately 20,000 students). The results were evaluated and compared in terms of effectiveness, precision, impact, and efficiency. This study explicitly demonstrates significant evidence in favor of the revolved approach as the most significant for maintaining student GPAs with minor grade inflation (2%+). This approach can, therefore, be adopted by SIS during other exceptional circumstances. This study is considered a precedent in its field; however, future research should study implicit challenges and opportunities related to student records.

Index Terms—Algorithm, COVID-19, Higher education system, Student performance, Student system, Information system, Technology system

I. Introduction

A. Background

Early 2020 witnessed the onset of COVID-19, a fast-spreading novel virus that caused significant global impacts. At the time of this publication, more than 770 million confirmed cases and 6.96 million deaths were recorded, including those caused by Delta and Omicron mutations [1]. This impact affected all aspects of life, the most important and complex of which is education in all its stages.

While the pandemic caused the cessation of normal life, the Kingdom of Saudi Arabia (KSA) upheld a measured reaction founded on its level of urbanization and system,

social, and religious norms [2]. The physical closure of educational institutions was immediately replaced with distance education, transforming curriculum, content, classes, and activities into what is hypothetically equivalent to in-person instruction [3]. This type of transition involved a period of adjustment, essential soft skills, and significant preparation [4]. Although the KSA is no different from other countries in terms of the intransigence of the pandemic, the government's measures, quick reaction, and compliance by all government agencies created a distinct difference between itself and other countries.

As the pandemic reached the KSA on March 9, 2020, a curfew was set and the ministry of education (MoE) announced several key decisions [5]. The MoE considered several academic exceptions that would affect university students, with the most impactful aiming to ensure that student grades would be no less than the previous semester. Saudi universities in this context use point system grading or the cumulative grade point average (CGPA), an average of the student's grade point average (GPA) from all completed semesters or terms. A GPA is derived from a point scale obtained from the equivalent alphabetical grades. These grades correspond to the overall score of 100 as assigned by the instructor. Consequently, the effect on the grade of a single course or group of courses propagates to the semester GPA and statistically impacts the CGPA.

B. Motivation

Due to an online shift during the pandemic, grade inflation in Saudi Arabia went beyond the reasonable limit [6]. As noted, Saudi universities were required to maintain student CGPA and prevent averages from falling below the CGPA of the previous semester. The implementation of the appropriate mechanism to achieve this requirement was assigned to the universities, leading to differing approaches (revolved, involved, and evolved). For this reason, this study investigates the approaches and determines the best method to mitigate the impact of inflation.

C. Research Questions

This study investigates the approaches taken by Saudi universities to maintain student GPAs. The following research questions are asked:

RQ1: Which approach maintains the GPA?

RQ2: Which approach produces the highest inflation compared to the original GPA?

RQ3: Which approach reaches the closest GPA to the CGPA of the last semester?

RQ4: Which approach generates the lowest uncounted (non-graded) GPA?

RQ5: Does academic discipline affect the results?

RQ6: Does the gender of the student affect the results?

RQ7: Which approach has less complexity in terms of computation?

These questions can be answered by the corresponding measures, including effectiveness (RQ1, RQ4), precision (RQ2 and RQ3), impact (RQ2, RQ3, RQ5, and RQ6), and efficiency (RQ7). These questions can be answered by the corresponding measures, including effectiveness (RQ1 and RQ4), precision (RQ2 and RQ3), impact (RQ2, RQ3, RQ5, and RQ6), and efficiency (RQ7). The structure of this article begins with an introduction section. Then, the article provides an overview of efforts and related studies. The next section contains the research methodology, including approaches, algorithms, data samples, implementation, and experiments. This is followed by an evaluation of results. The article concludes with a discussion of the findings, answering the research questions and summarizing the study's achievements.

II. Literature Review

The literature has focused on the impacts of COVID-19. Freeman [7] examined pandemic response plans of higher education institutes in the United States, observing the variability in prevention and testing strategies among institutions. This required a national unification of measures and principles aimed at reducing the impact of the pandemic in all aspects of education. Furthermore, Crawford [8] highlighted how universities in 20 countries responded to COVID-19. The 20 countries demonstrated that each university had different levels of responses to meet the requirements of their governments. Although their work aimed to discuss university responses around the world, Saudi universities (the focus of the current study) were not included. Bashir et al. [9] demonstrated that the Saudi government's measures and efforts (e.g., curfews, support, separations, strict fines, and instant punishment) significantly helped control the crises. More notably, cooperation and distinctive response from the public, as well as compliance with decisions and regulations, were positively reflected in the ability to overcome the pandemic in Saudi Arabia. In addition, Al-Khalifa et al. [10] presented the positive preparation of infection control measures against COVID-19 by Saudi dentists.

Other researchers focus on pandemic awareness. For example, Baig et al. [11] explored several cognitive and practical predictors of the impact of the pandemic among a sample of the Saudi population. The study observed various misconceptions, highly positive attitudes, good knowledge scores by educated participants, and good practice scores by younger participants. A study by Alhusseini et al. [12] examined awareness of the pandemic among the Saudi population, indicating the need to increase awareness measures about COVID-19 to mitigate misconceptions and related psychological distress. In contrast, some researchers concentrated on the impact of COVID-19 and mental health. For example, Alamri et al. [13] evaluated the occurrence of depression, anxiety, and stress among the general population in Saudi Arabia during the pandemic. They found that a considerable percentage of the study's participants reported moderate to severe depressive symptoms, anxiety symptoms, and stress levels. Alhusseini et al. [14] studied the frequency of depression and obsessive-compulsive disorder among Saudi Arabian individuals during the pandemic. Their study showed that single, unemployed women were more likely to have higher levels of depression. Additionally, older individuals, men, married individuals, higher income groups, individuals with higher levels of education, and employed individuals were more likely to have obsessive-compulsive disorder during the pandemic. Alshehri et al. [15] identified the prevalence, severity, and influencing factors of post-traumatic stress disorder (PTSD) related to the pandemic in Saudi Arabia. The study revealed that the pandemic significantly increased the demand for efforts to address vulnerable groups and psychological impact. Al-Hanawi et al. [16] also showed that some of the Saudi population had severe levels of COVID-19 distress. Demographic characteristics play a key role in distress levels. In terms of the outbreak, Alsaqri et al. [17] studied the public in Saudi Arabia to understand the levels of anxiety among people due to COVID-19. The results showed various levels of anxiety (from mild to moderate), where married respondents showed more anxiety than singles. Furthermore, Alfawaz et al. [18] explored the effects of home quarantine on the lifestyles and health behaviors of Saudi residents. They showed that home quarantine significantly affected physical activity and dietary habits. Consequently, this involves substantial preparations and improvements in lifestyle and health behaviors throughout the pandemic.

In addition, Srivastava et al. studied the anxiety levels of first-year students and its correlation with academic factors during remote emergency learning (ERL) [19]. The study, dominated by small-group online teaching and first-year medical students, showed 43.30% minimal, 31.96% mild, and 14.43% severe anxiety levels. However, there were advantageous gains like distance student-teacher interaction, tutor feedback, and mentor meetings. In Saudi Arabia, Khoshaim et al. [20] studied the anxiety level of university students during the pandemic. Their findings indicated extreme levels of anxiety experienced by some students associated with demographic variables. The study suggested that government agencies, policymakers, and researchers focused on addressing student anxiety to develop strategies that improve student skills in similar circumstances. In terms of the shift to distance learning,

Alashwal [3] presented six useful principles to mitigate the sudden transformation of online education, improve student performance, and ensure course maturity. In addition, Oyedotun [21] introduced effective suggestions and recommendations to mitigate the impact of the sudden transition to online education during the pandemic in the higher education sector of developing countries. The study specified that teaching and learning methods should prioritize comfort for staff and students during uncertain circumstances. Al-Zahrani et al. [22] indicated the valuable opportunity of shifting to e-learning platforms to maintain patient care and learning.

In fall 2020, after the COVID-19 outbreak in Poland, Cicha et al. [23] investigated the expectations of first-year students about the shift to distance learning by extending the technology acceptance model to e-learning. The study specified students' satisfaction with distance learning and a sense of usefulness. Rizun and Strzelecki [24] studied the impact of the shift to distance learning processes caused by COVID-19 in higher education institutions in Poland. The study showed that enjoyment and self-efficacy were positive predictors of student acceptance. Mabrook and Mabrook [25] investigated the impact of shifting to distance learning for English as a foreign language (EFL) students. They suggested implementing attractive and motivating virtual classes. For teachers, the study revealed the necessity of implementing critical thinking questions in writing and using multiple choice questions to avoid copying references directly. Onyema et al. [26] investigated the impact of the pandemic on education by including teachers, students, parents, and policymakers from different countries. The study revealed that the negative effects on education included disruptions, inaccessibility to education and research resources, and financial impacts. During the pandemic, Almaghaslah and Alsayari assessed the high satisfaction of education staff with turning to online education instead of face-to-face education [27]. Although the findings showed that continuing education and administrative work were effective and smooth in a virtual environment, the scientific and practical meetings were negatively impacted by the suspension of face-to-face education. However, the consequences for student performance were not assessed.

Alshehri et al. [28] highlighted the experience of Yanbu College, a mid-size college in Saudi Arabia, during the pandemic. The study summarized lessons learned during the crisis period to the end of the semester in which it occurred. Importantly, the authors presented challenges associated with shifting to an online environment and how the institute was able to deliver and complete the second half of the semester. Furthermore, Abdelhadi [29] showed that the pandemic impacted the accreditation process. In fact, institutions had additional adjustments and requirements to meet the accreditation requirements during the pandemic period. In addition, Osman [30] presented an analytical study on the experience and lessons learned from the impact of the pandemic at Sultan Qaboos University. The study highlighted a bright side to this circumstance, noting that it promoted a rapid adoption of e-learning and overcame resistance to change.

Roman and Plopeanu [31] compared traditional, online, and hybrid learning methods to determine which was preferred by Romanian economics majors. Psychological concerns and issues like internet access caused negative impacts on learning effectiveness; thus, students preferred traditional education rather than online learning. Khalil et al. [32] investigated medical students' perceptions about the effectiveness of synchronized online learning during the pandemic, revealing that students felt positive about this method. In particular, pre-clinical students preferred synchronized online learning for upcoming academic years. In addition, students found that online learning was more engaging because it increased interactions between instructors and students. However, the study did not address students' performance in other scientific fields. Tuma et al. [33] demonstrated critical technical difficulties with online learning related to poor audiovisuals and decreased student engagement.

Blankenberger and Williams [34] used Gaus' ecological approach to investigate the impact of the pandemic on higher education. The study highlighted that systems of higher education would persevere during difficult times, seek financial support, ensure the equivalent level of education of students, encourage students to enroll under new circumstances, and inspire society to play a role in education. In their study, Balhareth et al. [35] conducted an e-survey among residents and fellows. They found that the training of residents and fellows was impacted due to direct contact with COVID-19 patients, insufficient training in the proper use of personal protective equipment (PPE), and being infected by the virus.

Madhesh [36] revealed that deaf students in Saudi Arabia were challenged by the lack of alternative educational approaches. Inefficient reactions from teachers and lack of educational provisions for these students require further investigation. Ali et al. [37] studied the impact of the pandemic on the perspective of Saudi pharmacy students and their learning. The study showed that the students' education was affected during lockdown when compared with face-to-face education. This, therefore, requires improved preparation to meet academic and accreditation standards.

Abdulrahim and Mabrouk [38] tried to explain how the fourth industrial revolution technologies (4IRT) could reduce the effects of the pandemic on higher education. The study showed that digital learning improves students' learning outcomes compared to traditional learning. Additionally, 4IRT improved productivity and developed the work environment during these uncertain circumstances. Dhanalakshmi et al. [39] showed that COVID-19 caused challenges in the Indian education sector. However, the virus also caused positive impacts like new e-learning skills for instructors and students. The study indicated invisible damages and losses that require more efforts to analyze the effects and solutions to recover losses. Damsa et al. [40] examined how the duration

of the COVID-19 curfew prompted the digitalization of education in Norwegian higher education institutions. The study revealed that higher education institutions must promote instructors' digital competence and educational digitalization, as well as highlight the efforts as a shared responsibility. Arif and Ahmad [4] showed the importance of the integration of soft skills into the higher education curriculum in all academic majors, especially Saudi Arabia, to provide better job opportunities for graduates in competitive Saudi business organizations. Zawacki-Richter [41] studied whether the pandemic would promote the digitalization of teaching and learning in higher education in Germany. The authors found that the pandemic had a positive effect on the digitalization of education, creating innovative digital teaching skills due to teachers' commitment and the pressure to move online. Aristovnik et al. [42] presented the perceptions of the students about the impacts of the first COVID-19 wave in several countries. Their work revealed that students were satisfied with the support provided by universities and their teaching staff. However, a lack of computer skills and adjusting to the heavy workload affected students' performance.

During the pandemic, Azmi and Khoshaim [43] compared auto-graded online exams with manually graded exams in two courses, both taught in a private university in Saudi Arabia. The study showed a statistically significant difference in students' mean scores caused by technical errors related to the mathematical ability of the platform. McManus et al. [44] assessed the expected consequences on the grades of students in medical schools due to the pandemic. The study used a data set for predicted and actual grades provided by the United Kingdom Medical Education Database to show the reduced predictive validity of predicted A-level grades compared to actual A-level grades. The results showed that around 44.7% of the cases were over predicted. The authors indicated the probable demand for additional teaching and support to reach A-level grades and maintain standards. The study suggested that such problems can be improved by using different measures to complement the calculated grades. Furthermore, Glesias-Pradas et al. [45] analyzed the transition from emergency online teaching and the impact of organizational aspects related to unplanned change due to the pandemic. Comparing the academic results of students during the pandemic with students in previous years demonstrated an increase in student academic performance during the online shift. This indicates that organizational factors can contribute to the success of remote emergency teaching. El Said [46] presented a comparison of grades between face-to-face students and fully online students. The study also assessed the effect of gender, credit hours, age, and CGPA, which did not show statistically significant differences in student grades. Furthermore, Gonzalez et al. [47] assessed two groups, including face-to-face students (2017/2018 and 2018/2019, control group) and online students (2019/2020, experimental group). The study showed positive results

in terms of improving student learning strategies and efficiency. This resulted in improved learning performance and higher grades.

Researchers have addressed students' and teachers' acceptance of distance education, the limited comparisons between student performance and the psychological, social, and financial effects of online learning. However, few studies examine the pandemic's impact on grades and efforts to reduce grade inflation. Additionally, there is a lack of work on how each country handled problems related to student performance and CGPA. In Saudi Arabia, efforts were made to navigate these challenges, including the call by the MoE to maintain the CGPA. Universities were left to apply an appropriate approach to address their teaching, courses, and technical and academic capabilities. Therefore, there is a need to investigate the impact of the approaches implemented by Saudi universities to maintain student GPAs.

III. METHOD

This research uses empirical evidence by applying three approaches to real data. These approaches were described, designed, implemented, tested, and evaluated. The procedures to conduct the study are described in the following subsections.

A. Approaches

The revolved approach uses CGPA to reach the same level or slightly higher average. Simply, the approach increases the impact of a lower CGPA by excluding courses with fewer hours and lower grades from the semester's GPA calculation. This approach was implemented by Imam Abdulrahman Bin Faisal University's student information system (SIS). The involved approach uses the CGPA to compare the student's grades. If the grade is less than the CGPA, the grade will be changed to nongraded. The evolved approach uses the current semester's GPA and changes all courses whose grades are less than 'B' (equivalent to 4.00 out of 5.00) to non-graded. The evolved approach uses the current semester's GPA and changes all courses whose grades are less than B (equivalent to 4.00 out of 5.00) to non-graded. Although those approaches were implemented differently, they agreed on using non-graded classifications like NP for a non-graded pass and NF for non-graded fail. Using non-graded grades raises eligible GPAs by omitting the grades that caused GPA decreases. Some definitions and abbreviations in this study are shown in Table I. The grading system calculates the grades using points equivalent to the final score of 100. Grades are expressed with alphabetical letters [48].

The CGPA computation includes determined stages using the following equations:

1) Calculating the earned points:

$$EPTS = \sum_{n=1}^{n} PTs \times CRTs \quad ,\text{n = number of courses}$$

TABLE I
SUMMARY OF RELATED ACADEMIC DEFINITIONS OF FREQUENTLY USED NOTATIONS AND THEIR ABBREVIATIONS.

Term	Notation	Definition
Grade	GRD	Letter grade: A+, A, B+, B, C+, C, D+, D
Score	SCR	Equivalent numeric grade to letter grade between 2.00 and 5.00.
Credits	CRTs	Class credit hours
Non-graded pass	NP	Non-graded pass grade, which is not considered in the GPA, and the course is not required to be taken again
Non-graded fail	NF	Non-graded fail grade, which is not considered in the GPA, but the course is required to be studied again
Points	PTs	The equivalent numeric points for the letter grade
Last Term	LTRM	The term before COVID-19 occurred
COVID19 Term	CTRM	The term when COVID-19 occurred
Enrollment	Enr	A transactional process relating a student and class, which results the number of students in a class
Grade Point Average	GPA	Grade point average for a semester
Cumulative grade point average	CGPA	Cumulative grade point average for all achieved semesters
Earned Points	EPTs	Points student earns for a passed course and becomes included in the GPA
Earned Credits	ECRTs	Credit hours student earns for a passed course and becomes included in the GPA

2) Summing the earned credit hours:

$$ECRTs = \sum_{k=1}^{k} CRTs \quad ,\text{k = number of courses}$$

3) Calculating the grade point average:

$$GPA = \frac{EPTS}{ECRTs}$$

4) Producing the cumulative grade point average:

$$CGPA = \sum_{j=1}^{j} \frac{GPA}{j} \quad ,\text{j = number of enrolled semesters}$$

B. Algorithms

The **revolved approach** initially changes any failure grade (F) to a non-graded failure (NF) for each student. Then, it recalculates the new GPA before comparing the GPA with the CGPA of the previous semester. If the new GPA is higher than the CGPA, the process stops and continues to the next student. Otherwise, the lowest points are chosen and assigned NP grades. The new GPA is recalculated. Choosing the lowest points impacts the lowest course in terms of score and credit hours. If turning the selected course into NP improves the GPA to be equal to or higher than the CGPA, the process quits. If the process still does not reach the target CGPA, it loops and incrementally selects courses. Algorithm 1 shows the implementation of this approach.

The **involved approach** directly compares each grade with the CGPA. Then, it turns each score that is below the CGPA into non-graded pass (NP) regardless of the new GPA. Additionally, it changes any failure grade (F) into a non-graded failure (NF). This approach produces GPAs that are higher than or equal to the previous CGPA. Recalculating the new GPA takes place at the end of the process. Algorithm 2 simplifies the implementation of this approach.

The **evolved approach** uses a straightforward process, converting any grade less than B+ into NP (regardless of the new GPA). Like the involved approach, this approach

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Algorithm 1 Pseudo-code of the revolved approach

Require: STD, list students
1: $LTRM(CGPA) \leftarrow$ Previous CGPA
2: **for each** STD **do**
3:     **for each** $grade$ **do**
4:         **if** $grade =$"F" **then**
5:             $grade \leftarrow$ "NF"
6:         **end if**
7:     **end for**
8: **end for**
9: $CTRM(GPA) \leftarrow$ calculate(GPA)
10: **repeat**
11:     $Course \leftarrow Course$ (Lowest PTs)
12:     $Grade(Course) =$"NP"
13:     $CTRM(GPA) \leftarrow calculate(GPA)$
14: **until** $LTRM(CGPA) \geq CTRM(GPA)$ *OR Null*

Algorithm 2 Pseudo-code of the involved approach

Require: STD, list students
1: $LTRM(CGPA) \leftarrow$ Previous CGPA
2: **for each** STD **do**
3:     **for each** $grade$ **do**
4:         **if** $grade =$"F" **then**
5:             $grade \leftarrow$ "NF"
6:         **else if** $grade < LTRM(CGPA)$ **then**
7:             $grade \leftarrow$ "NP"
8:         **end if**
9:     **end for**
10: **end for**

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changes any failure grade (F) into NF. It then recalculates the new GPA at the end of the process. The pseudocode in Algorithm 3 clarifies the implementation of this approach.

C. Data Sample

This study was conducted at Imam Abdulrahman Bin Faisal University by relying on real data from the university's SIS. The retrieved dataset was in its original form before maintaining the GPAs. It includes 111,085

Algorithm 3 Pseudo-code of the evolved approach

Require: *grade*, list grades
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 1: for each grade do
 2:     if grade ="F" then
 3:         grade ← "NF"
 4:     else if grade < "B+" then
 5:         grade ← "NP"
 6:     end if
 7: end for
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enrollments for 20,247 students enrolled, with a total of 4,316 classes for 102 academic programs.

D. Implementation and Experiment

A server-side script was developed using the hypertext preprocessor (PHP) programming language and MySQL to test the approaches on the data sample. A database was built and loaded with the essential data (i.e., students' masked identification badges, college, course, grade, and credited units). Initially, the described approaches were applied to the exact data. The results were then produced and extracted for analysis. Some results were randomly selected and validated to generate the expected results. Each approach completed multiple performance tests on a local using a dedicated virtual server with four 3.20GHz virtual processors, 64-bit Linux OS, 8GB memory, and Apache Host. Functionality and productivity experiments were executed to collect performance statistics.

IV. EVALUATION AND RESULTS

This section reports the findings and evaluates the results produced by the approaches used to maintain CGPA. Table II summarizes the results before and after applying each approach. It also indicates their optimal indicators. Grades and statistics of students after applying the approaches to the data sample are included. It shows the total number of graded and non-graded grades. In addition, the table indicates the number of GPAs that were counted, uncounted, changed, unchanged, exceeded, and decreased compared to the basis GPAs. It also shows the number of students who received warnings due to low GPAs. Furthermore, the table shows the total number of GPAs that became null after processing the data. A null GPA results from converting all the grades for a student into NF or NP after unsuccessful attempts to maintain the GPA by altering the grades to non-graded. The following subsections describe the results of the research questions and measurements.

A. Effectiveness

In this study, an effective approach is defined as having the ability to produce a desired outcome. Yielding valid computable functions of the approaches is key to achieving desired results. In terms of producing non-graded grades, the revolved approach showed fewer non-graded grades. Both the involved and evolved approaches

produced unnecessarily non-graded grades during the GPA maintaining processes. The results also indicated that the revolved approach maintained GPAs with the highest counted GPAs, where each GPA has at least one graded grade. On the contrary, the evolved and involved approaches produced more null GPAs. In fact, a null GPA has NP or NF grades generated by the GPA maintaining processes.

The three approaches are intended to improve the dropped GPAs, aiming to reach the exact level of the last CGPA or higher. However, producing GPAs that exceed the last CGPA is not preferred. Hence, the revolved approach performed better compared to the other approaches. In fact, it produced a smaller number of GPAs that were higher than their last CGPAs.

The academic probation warning, an important aspect that universities and their students consider at the end of each semester, is defined as performance dropping below the minimum pass threshold (usually 2/5 or 1.5/4). This study analyzed the improvement of academic warnings among the three approaches. The results revealed that the revolved and evolved approaches showed the most successful improvements of probation. Thus, the produced GPA exceeded 2.00 as the minimum level. Table II compares the approaches of the number of GPAs that were successfully increased or equal to the warning level and the number of GPAs that were not successfully improved due to complete NP/NF alterations. All approaches lifted 293 probations by raising GPAs or excluding null GPAs from the entire CGPA.

The measure of effectiveness is generally based on maintaining GPAs lower than the previous CGPA. This could not be the exact case in all approaches. For example, if there is a drop in a GPA (4.5) compared to the last CGPA (4.6), the revolved and involved approaches maintain the GPA to reach the CGPA or higher. If all scores are 4.00 or higher, the evolved approach will not turn any B+ (or above) score into NP. Thus, GPA maintenance for the evolved approach would not be achieved.

B. Precision

In this study, precision refers to the achievement of the purpose of these approaches with optimal results compared to baseline results (grades and GPAs before the process). Table III shows the comparisons between the range of GPAs before and after applying each approach. The results revealed that the revolved approach yields the closest results to the actual (before) GPA ranges compared to the other approaches.

An important factor is the difference between each actual GPA and new GPA. Differences that are near zero are considered the best because they produce the least inflation or deflation. As a result, the revolved approach indicated the least negative impact compared to the other approaches. Moreover, the involved approach produced highly negative differences (e.g., -4), especially in deflated GPAs. As shown in Table IV, for example, the revolved

TABLE II
SUMMARY OF RESULTS BEFORE AND AFTER IMPLEMENTING THREE APPROACHES ON THE DATA SAMPLE (N/A = NON-APPLICABLE MEASUREMENT).

Approach	Before	Revolved	Involved	Evolved	Ideal Indicator
Graded Grades	111,085	106,333	67,601	83,537	Higher
Non-Graded Grades	0	4,752	43,484	27,548	Lower
Total Counted GPA	20,247	19,937	16,482	19,380	Higher
Unchanged GPAs	20,247	17,665	6,248	8,886	Higher
Changed GPAs	N/A	2,582	13,999	11,361	Lower
Exceeded GPAs	N/A	2,377	10,358	10,618	Lower
GPA Average	4.39	4.49	4.66	4.78	Lower
Null GPA	0	310	3,765	867	Lower
Probation GPA (< 2)	293	0	0	0	Lower
Improved Probation	N/A	170	130	61	Higher
Uncounted Probation	N/A	123	163	232	Lower

TABLE III
GPA RANGES AND FREQUENCY AMONG ALL APPROACHES.

GPA Level	Before	Revolved	Involved	Evolved
0	124	0	0	0
0<1	50	0	0	0
1< To 2	152	9	12	0
2< To 3	492	232	125	0
3< To 4	3,018	2,848	1,049	0
4< To 5	16,411	16,848	15,296	19,380

TABLE IV
GPA DISTRIBUTIONS ACCORDING TO THE DIFFERENCES BETWEEN THE ORIGINAL AND NEW GPA AFTER APPLYING THE APPROACHES.

GPA Difference	Revolved	Involved	Evolved
5	1	1	2
4	15	23	40
3	47	120	178
2	215	966	1,315
1	2,099	9,248	9,083
0	17,701	6,264	8,922
-1	29	23	72
-2	42	54	206
-3	53	184	372
-4	45	2,690	57
-5	0	674	0

Fig. 1. Number of GPAs distributed based on the increased or decreased differences after applying the approaches.

C. Impact

The real impact of the process of maintaining student GPA is when course points are not calculated because they are turned into NP or NF. This means that regardless of the earned credit hours and points, they have no weight in the CGPA. Passing many courses with ungraded grades is a negative indicator in this study. Therefore, Figure 2 shows the different impacts that occurred on the points earned from the students after applying the three approaches compared to the actual points earned before the processes are run. Obviously, the revolved approach has less impact on the earned points than both the involved and evolved approaches. For example, the total number of students who earned 80 points before applying the three approaches was 2,904. The results showed that the revolved, evolved, and involved approaches yielded 2,749, 1,724, and 879 students, respectively, where higher is better.

Comparing the frequency of the achieved grades before and after applying the three approaches shows that the revolved approach produced the closest distribution of the number of students per grade. Both the involved and evolved approaches might produce undesirable non-graded grades for courses with higher credit hours and points. Table V shows the total grade frequencies among the grading letters. Grade B, for example, was 11,732 before running the process. Consequently, the revolved approach was able to maintain GPAs while

approach was highly resistant to 17,701 GPAs. Both the evolved and involved approaches were resistant to 8,922 and 6,264, respectively. The results showed an increase in GPAs within a one-point range as a clear inflation of approximately 50% of the GPAs by applying the involved and evolved approaches. Otherwise, the increase in the revolved approach was less than 10% of the GPA.

Finally, the results in Figure 1 show that the averages of the GPAs of the students between the revolved, involved, and evolved approaches were 4.49, 4.66, and 4.78, respectively. Compared to the original average of 4.39, the revolved approach appeared to produce the closest GPAs with the lowest inflation rate (2%+). However, the involved approach resulted in a negative increase in GPA. Furthermore, the involved approach caused irrational inflation to GPAs on average. Figure 1 demonstrates students' new average GPA after applying the approaches compared to the original average.
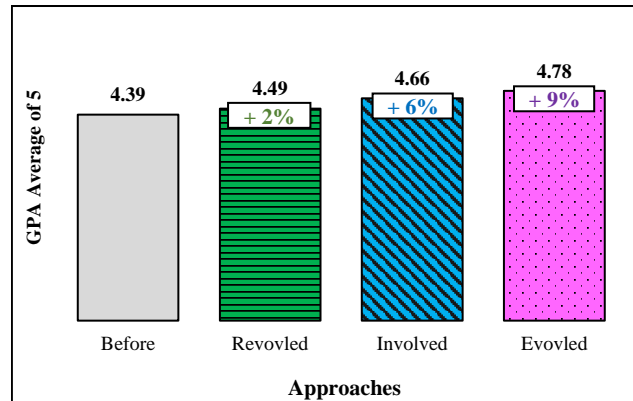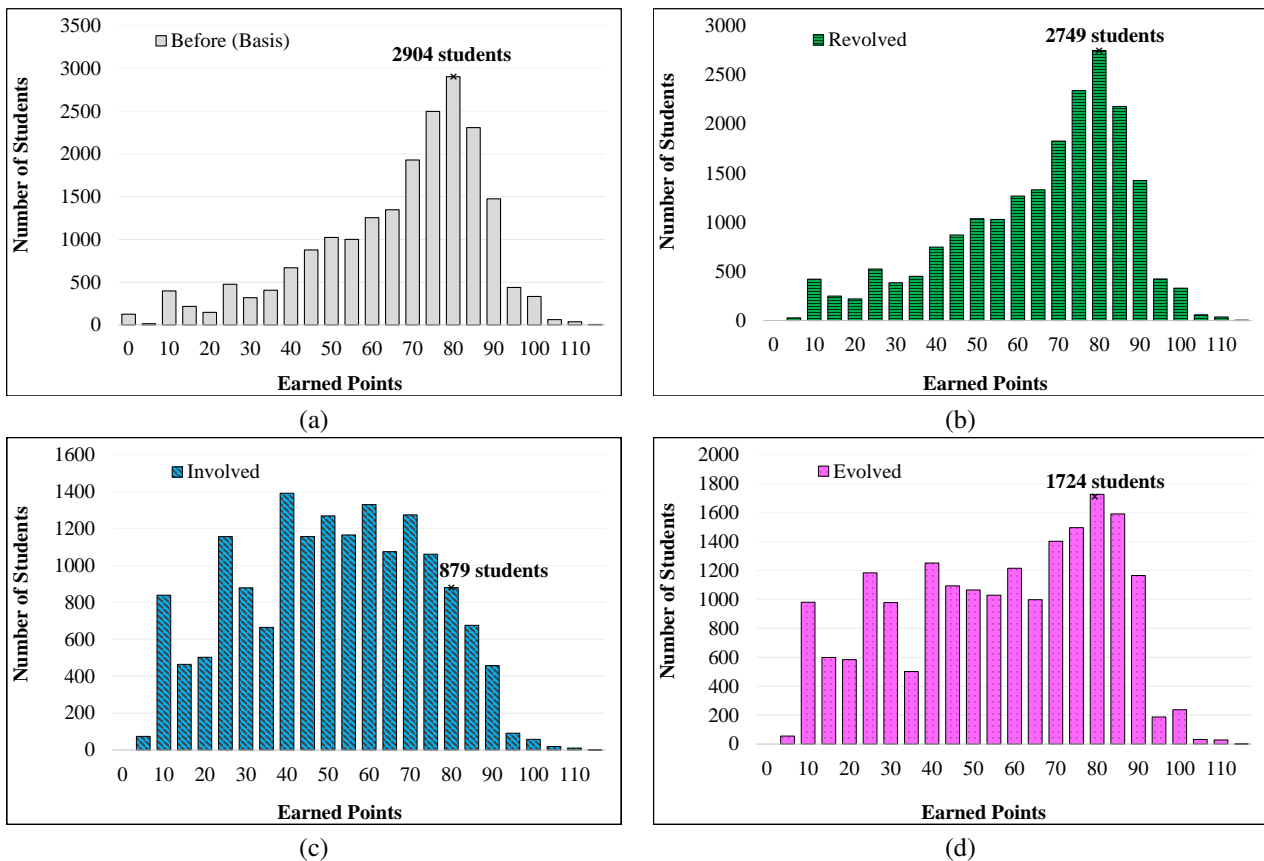
Fig. 2. Total students distributed based on the total of earned credits before and after applying the approaches: (a) earned points before; (b) revolved approach earned points; (c) involved approach earned points, and (d) evolved approach earned points.

maintaining 93% (10,958) of B grades. However, the involved approach turned 58% into NP. Also, the evolved approach severely turned the B, C+, C, D+, and D grades into NP, which caused an extreme loss of points. Figure 3 demonstrates the pattern of grade distributions between all cases, indicating that the revolved approach gave a very close approximation to the actual distribution in the "before" case. On the other hand, the involved and evolved approaches produced an incomparable pattern of grade distribution with the actual "before" case.

TABLE V
GRADE FREQUENCIES AMONG GRADING LETTERS BEFORE AND AFTER APPLYING THE APPROACHES.

Grade	Before	Revolved	Involved	Evolved
A+	37,583	37,582	26,846	37,583
A	27,598	27,355	21,812	27,598
B+	18,356	17,886	10,786	18,356
B	11,732	10,958	4,874	0
C+	6,782	6,163	1,633	0
C	4,103	3,510	1,286	0
D+	2,090	1,688	321	0
D	1,507	1,131	43	0
F	1,334	0	0	0
NF	0	1,334	1,334	1,334
NP	0	3,479	42,150	26,214

Another perspective of this measure is the negative and positive impact of the processes. A negative impact occurs when a GPA becomes lower in terms of the total earned points, such as null GPAs resulting in a decrease in GPA. The positive impact, on the other hand, occurs when a GPA becomes higher, causing an unreasonable inflation of the GPA. According to Table II mentioned above, the revolved approach had the best indicators, maintaining the GPA with the highest number of existing GPAs. However, the involved and evolved approaches caused inflation because they caused most GPAs to increase. Figure 4 shows the comparison between the impact of the three approaches in which dropping is negative, increasing is positively undesirable, and persisting is desirable.

Figure 5 indicates fluctuations in the earned points before and after applying the approaches. Undoubtedly, the revolved approach maintained the GPAs without a significant impact on earned points. This is demonstrated by the highest, lowest, average, and median results before and after applying the revolved approach. Additionally, Figure 5 shows that the involved and evolved approaches had a negative impact on the earned points (although it was intended to maintain the GPAs).

The alteration of some grades in some courses into non-graded NP aimed to improve student GPA. However, this study was keen to address a downside related to the impact on the earned credit units for the students. In fact, approaches did not let students decide if they wanted any grades changed to non-graded. Thus, they had to determine if it would be beneficial. Table VI shows the courses in which the students enrolled based on credit
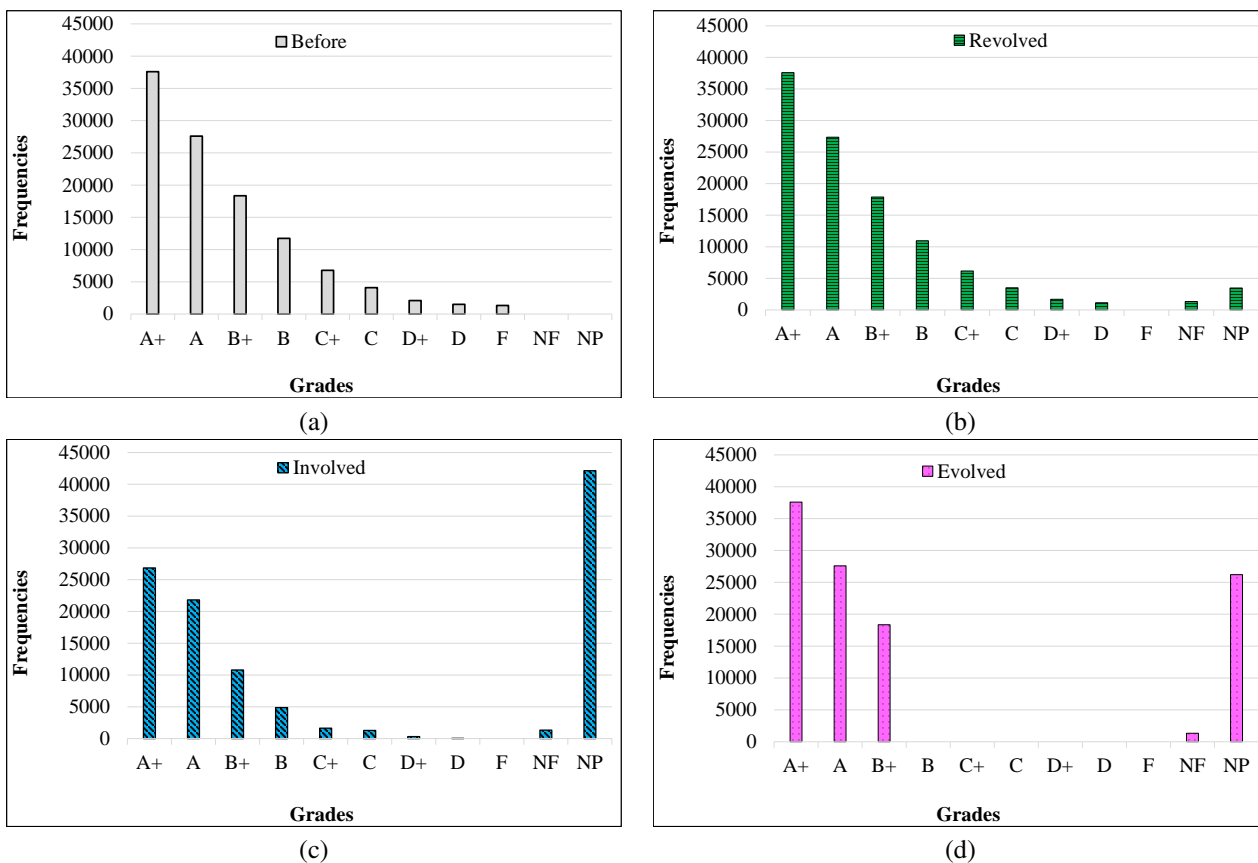
Fig. 3. Grade frequencies before and after applying the approaches: (a) grade frequencies before; (b) revolved approach grade frequencies; (c) involved approach grade frequencies; and (d) evolved approach grade frequencies.

TABLE VI
NUMBER OF ENROLLMENTS REMAINING GRADED DISTRIBUTED BY
COURSE UNITS.

Units	Enrollments	Revolved	Involved	Evolved
1	3,388	3,193	662	1,465
2	47,095	45,814	9,218	14,137
3	51,846	49,301	13,339	21,810
4	5,276	4,788	1,896	2,957
5	987	887	264	572
6	474	454	75	174
7	1,396	1,230	752	892
8	336	336	3	36
9	281	269	4	106

hours (classified as enrollments). The table shows the total number of enrollments that changed to NP per their credit units. The revolved approach had a tangible impact on enrollments with different credit units. On the other hand, the involved and evolved approaches had a significant impact, which deferentially allowed many students to lose credit units passed in their GPA. NP alterations in each approach are considered to have a negative impact because course units of any NP grade would not be included in the GPA calculation.

D. Academic Disciplines

In terms of academic disciplines, the results in Table VII indicate that the engineering and architecture disciplines were the most affected by the academic consequences of the COVID-19 pandemic. Here, it is 13%, 60%, and 43% of the grades that become NP in all three approaches, revolved, involved, and evolved, respectively. This shows that engineering students' GPAs severely degraded in the semester when the pandemic hit. The medical and health disciplines were second affected as 6% of the students' grades turned to NP by the revolved approach, 52% grades turned to NP by the involved approach, and 21% grades turned to NP by the evolved approach. Basic Sciences, Information Technology, Business Administration, and Human Studies were the least affected, respectively.

In terms of academic disciplines, the results in Table VII indicate that the engineering and architecture disciplines were most affected by the academic consequences of the pandemic. Here, 13%, 60%, and 43% of the grades were turned to NP in all three approaches (revolved, involved, and evolved, respectively). This shows that engineering students' GPAs severely degraded in the semester the pandemic hit. The medical and health disciplines were second, as 6% of the students' grades turned to NP by the revolved approach, 52% turned to NP by the involved approach, and 21% turned to NP by the evolved approach. Basic sciences, information technology, business administration, and human studies were the least affected, respectively.

In general, the involved approach depleted many grades to raise students' GPAs. This could have been remedied
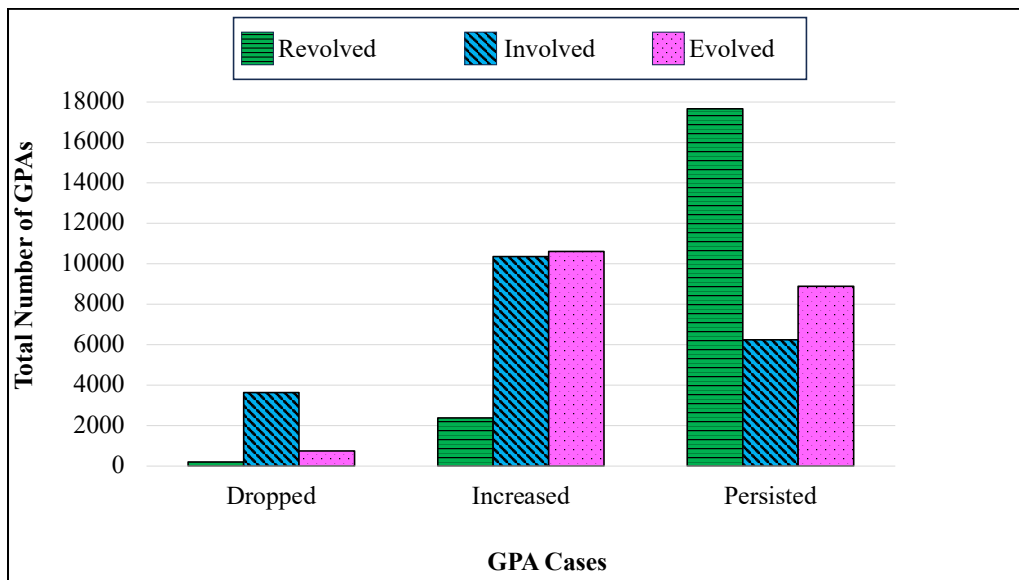
Fig. 4.   Comparison of approaches in terms of produced GPAs.

TABLE VII
STATISTICS OF THE IMPACT OF COVID-19 ON STUDENTS' GRADES AFTER APPLYING THE THREE APPROACHES BASED ON THE ACADEMIC DISCIPLINES AND STUDENTS' GENDER. N/A INDICATES THE ACADEMIC DISCIPLINES OFFERED TO FEMALES ONLY.

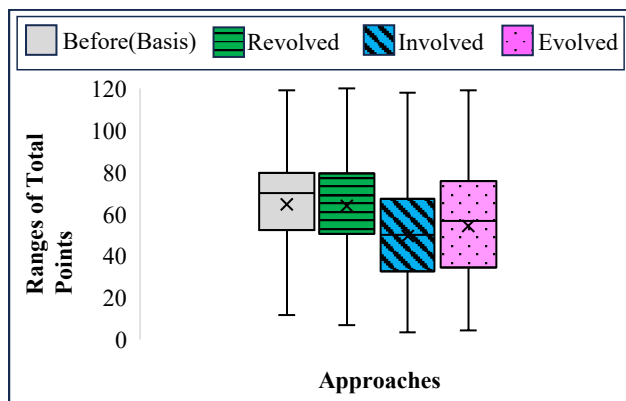| Approach	Revolved			Involved			Evolved		
Academic Discipline	**Male**	**Female**	**Overall**	**Male**	**Female**	**Overall**	**Male**	**Female**	**Overall**
Basic Sciences	N/A	1%	1%	N/A	23%	23%	N/A	18%	18%
Business Administration	3%	2%	2%	27%	47%	42%	24%	18%	20%
Engineering & Architecture	7%	22%	13%	47%	79%	60%	48%	36%	43%
Human Studies	N/A	1%	1%	N/A	30%	30%	N/A	24%	24%
Information Technology	4%	5%	5%	34%	39%	38%	41%	26%	29%
Medicine & Health	5%	7%	76%	43%	58%	52%	28%	17%	21%
Grand Total	4%	3%	3%	37%	38%	38%	33%	22%	24%

Fig. 5.   Ranges of points before and after applying the approaches.

by using the revolved approach. The evolved approach comes in second place for excluding grades from being calculated in the GPAs; however, it did not raise all GPAs for some cases. Figure 6 shows the contrast between the percentage of courses that were altered to NP to achieve the goal of preserving student GPAs.

E. Student Gender Effect

Surprisingly, the results demonstrate the effect of student gender on the results. In fact, a large percentage of female students in some disciplines were academically affected by the pandemic. Figure 7 shows that 22% of the engineering and architecture female students' grades were turned into NP to preserve their GPAs. On the contrary, 7% of the male students' grades were affected by applying the revolved approach, which is considered the best case. The involved approach demonstrated the worst scenario by turning 47% of the grades of male students and 79% of the grades of female students. The disciplines of medicine and health, business administration, and information technology show a considerable impact in the case of applying the revolved approach. Still, they were severely affected by both the involved and evolved approaches, as shown in Figure 7.

More comprehensively, there is an effect on the grades of both genders. However, the effect was not due to the academic level of one type of gender. Instead, the applied approach influences the results, as shown in Figure 8.

F. Efficiency

Efficiency demonstrates the most important aspects of algorithm complexity, including differences in software performance. The following three performance aspects were addressed in the implementation of the approaches: (1) central processing unit (CPU); (2) memory; and (3)
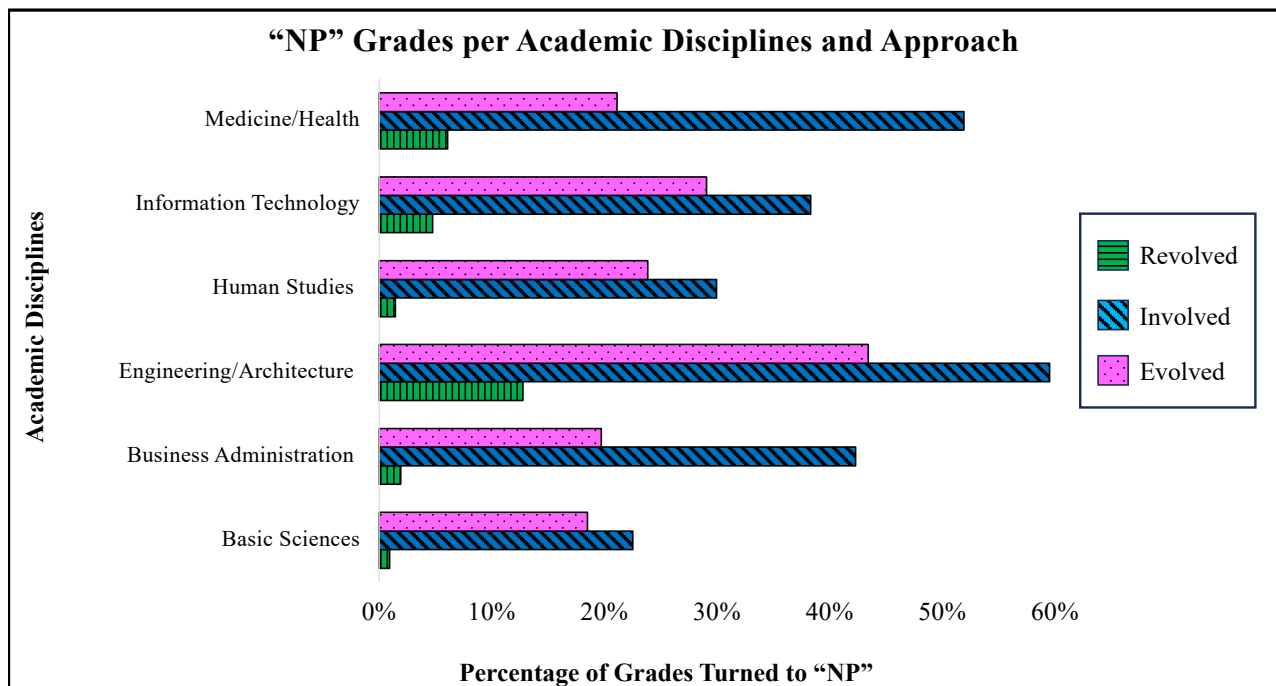
Fig. 6.   Effect of applying the three approaches on academic disciplines resulted in turning passing grades to NP.

time usage. Furthermore, this study considers the three complexity cases as best, average, and worst. Table VIII summarizes the averages of CPU utilization, memory usage, and execution time.

The results of the processor utilization tests showed very slight differences among the three approaches. The revolved approach utilized higher processing compared to the involved and evolved approaches. In terms of memory usage, the experiments showed no substantial difference in memory consumption. The revolved approach remains the most consuming however, the difference is slight compared to the other approaches. In all tests, the revolved approach demonstrated a longer execution time. While it needed an average of 57.5 minutes to complete its process, the other two approaches needed an average of 41.5 minutes.

V. Discussion

In response to RQ1, the results show that the revolved approach effectively maintained GPAs and yielded the highest number of counted GPAs. In terms of deflated and inflated GPAs, the revolved approach indicated the least impact compared to the other two approaches. That is, the revolved approach produced the fewest increased or decreased GPAs. It maintained GPAs as needed, which responds to RQ2 and RQ3. Moreover, the revolved approach produced a smaller number of null GPAs, which fulfills RQ4. On the other hand, the evolved and involved approaches produced more null GPAs. The results imply a significant effect on the academic disciplines offered by the university, including medicine and health, architecture and engineering, basic sciences, information technology, business administration, and human studies. This responds

to RQ5. Furthermore, this study showed that student gender makes a significant difference in the results, which responds to RQ6. In terms of the complexity of the approach, the three approaches consumed a similar percentage of processor and memory consumption; however, the revolved approach had a longer execution time compared to the evolved and involved approaches. This confirms RQ7. The algorithms in subsection B of the Methods section illustrate the reason that the revolved approach had the most complex procedure. First, the additional loop that performs as many attempts as the GPA maintenance is achieved or all courses are turned into NP. This, in turn, produces a null GPA. Second, the revolved approach performs a prior process to convert the F grades into NF to mitigate the impact on the current GPA. Third, there are recurrent calculations to the GPA each time a course grade is turned into NP. Both the evolved and involved approaches performed straightforward steps and specific operations for each student, which reduced their complexity.

The properties of the study on the three approaches are summarized as follows. First, the revolved approach uses a conic method that revolves around courses from the lowest to the highest in terms of points. This contributed to maintaining the GPA of the students without a drop or increase. Therefore, it ensures that all GPAs are maintained only if they are less than their CGPAs from the previous semester. Another property is that it does not raise GPAs undesirably. If a course is required to convert into an NP grade, the algorithm for this approach targets the lower-ranked course in terms of earned points and credit units. It is characterized by accurately preserving most earned points and avoiding
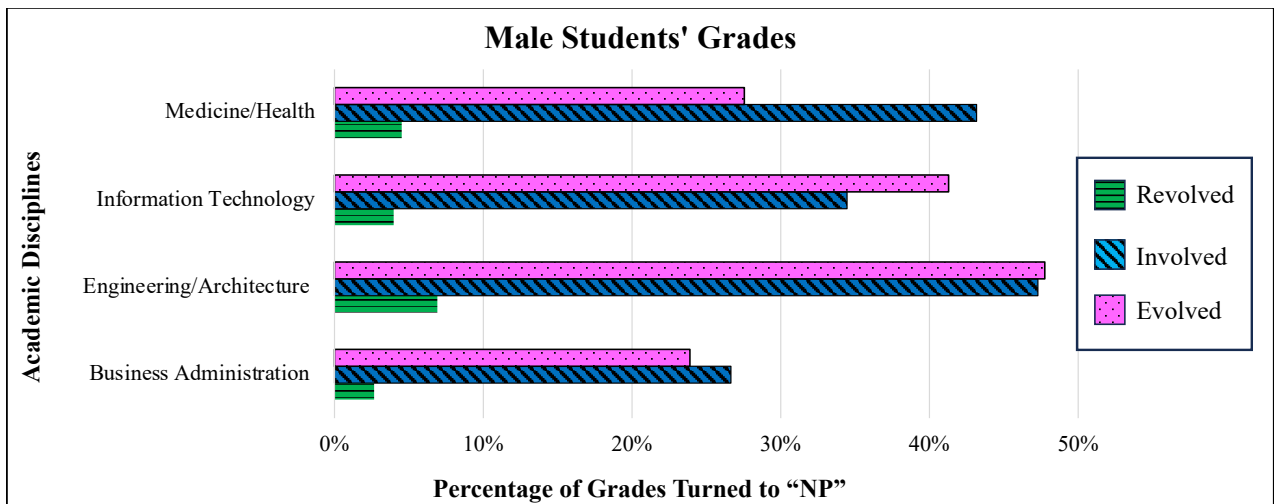
(a)
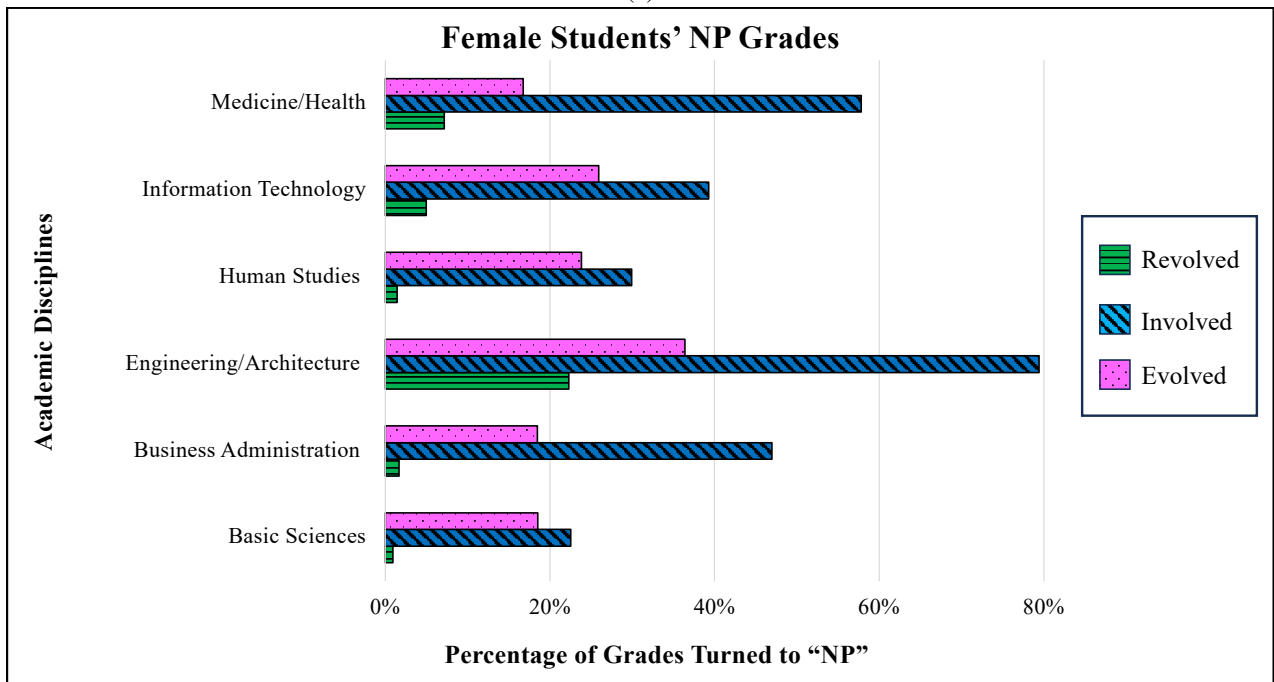
(b)

Fig. 7.   Effect of applying the three approaches on academic disciplines resulted in turning passing grades to NP for (a) male students and (b) female students. Note that no academic disciplines are offered for male students.

GPA inflation. However, its only drawback is that it needed additional time to perform the process compared to the other two approaches. Second, the involved approach uses the previous CGPA in the process and guarantees that all GPAs are maintained; however, it is vulnerable to increasing some GPAs unnecessarily although they are higher than the CGPA of the previous semester before the process. The algorithm for this approach targets any course grade lower than the previous CGPA regardless of the need for GPA maintenance. Therefore, it has less accuracy. A considerable number of earned points may become null, causing undesirable inflation and negative effects by excluding a considerable number of earned points from the GPA calculation. Lastly, the evolved approach addresses the GPA of students at the level

of the course grades to maintain many GPAs; however, some GPAs might be increased and not maintained. Furthermore, it might increase some GPAs undesirably even if they are higher than the CGPA of the previous semester before the process. The algorithm for this approach only targets low course grades regardless of the GPA maintenance status. Therefore, it is the least accurate because many earned points may become null and cause undesirable inflation.

VI. CONCLUSION

This study presented three approaches to maintaining students' GPAs in Saudi universities for those whose academic performance was affected by the on-set of COVID-19. The Saudi MoE established rules to maintain

TABLE VIII
SUMMARY OF CPU, MEMORY, AND CONSUMPTION TIME (IN MINUTE) AMONG APPROACHES.

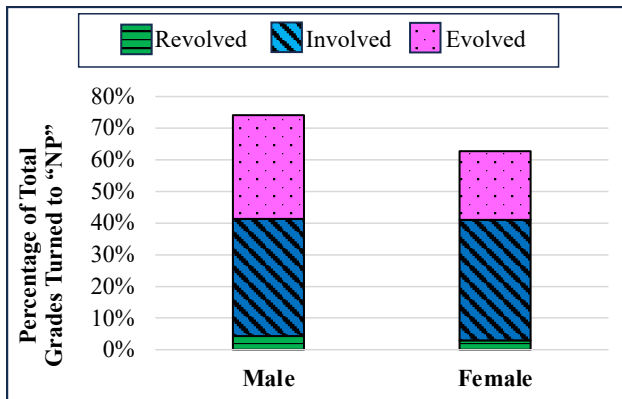| Approach	Revolved			Involved			Evolved		
Measure	CPU	Memory	Time	CPU	Memory	Time	CPU	Memory	Time
Average	0.67%	0.18%	57.52	0.56%	0.16%	41.55	0.57%	0.17%	41.54
Best Case	0.51%	0.15%	56.85	0.47%	0.14%	40.87	0.46%	0.12%	41.23
Worst Case	0.83%	0.22%	58.55	0.67%	0.24%	43.00	0.64%	0.21%	43.08

Fig. 8. Comparison of the overall effect of applying the three approaches resulted in turning passing grades to NP based on student gender.

students' GPAs. For example, each university would identify and implement the appropriate method that fits its system. As a result, three approaches were implemented. First, the revolved approach focuses on the weakest grades to raise the GPA. Second, the involved approach involves the last semester's CGPA when making a decision about grades. Third, the evolved approach raises GPAs at a steady pace regardless of factors. The approaches were implemented and tested using real data provided by Imam Abdulrahman Bin Faisal University. The results showed that the revolved approach was the most effective and accurate. It also had the lowest inflation rate (+2%). Additionally, the revolved approach maintained all GPAs with the least negative impact compared to the other two approaches. This had an undesirable impact on the results. On the other hand, the revolved approach was the most complex. It required more execution time to accomplish the process. In the end, this study clarified the consequences of applying each approach, allowing decision makers the ability to use the appropriate approach according to the criterion. Furthermore, future work can investigate the possibility of implementing a hybrid approach.

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