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Analysis of Students' Academic Performance in the Department of Mathematics Based on Semester GPA Dynamics: A Case Study of the 2017–2024 Cohorts

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ABSTRACT

This quantitative exploratory study investigates changes in students' Semester Grade Point Average (GPA) and their relationship with graduation status and study duration. It uses academic records from the Department of Mathematics at a public university in Indonesia for cohorts from 2017 to 2024. The study addresses concerns raised after the COVID-19 pandemic, which may have disrupted academic progression and altered the predictive power of initial GPA on graduation outcomes a gap not sufficiently explored in existing literature. Data were collected directly from the university's academic database, ensuring accuracy and consistency without relying on self-reported surveys. Descriptive statistical methods and visual analytics (e.g., line charts, boxplots, and scatter plots) were applied to uncover trends and patterns. Results show that earlier cohorts (2017–2020) have high graduation rates (82.7%–94.4%), while the 2019 cohort recorded the highest dropout rate (11.1%). Newer cohorts (2021–2024) predominantly consist of students still enrolled, though some early graduations and dropouts occurred. A positive correlation was found between first-semester GPA and graduation success, yet the pandemic likely introduced new variables that affect academic outcomes. These findings provide actionable insights for academic policy and support the development of early detection systems to identify students at academic risk.

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A. INTRODUCTION

Indications of declining academic performance among students have become a concern for educational institutions, particularly in understanding how Semester Grade Point Average (GPA) dynamics reflect overall academic success. Fluctuations or stability in GPAs mirror individual performance and indicate the learning process dynamics within higher education institutions (Jannah, 2023). Studies by (Atti et al., 2021; Cheung et al., 2021) have shown that a student's initial GPA can indicate graduation success; however, further analysis is required to understand the relationship between academic performance, graduation rates, and study duration.

The shift in learning systems over the past few years due to the COVID-19 pandemic has raised concerns regarding students' competency, especially in fundamental mathematics courses. Several studies Di Pietro (2023); Lalin et al. (2024); Ren & Du (2024); Schriek et al. (2024); Soto-Ferrari et al. (2024); Zhao & Akhter (2023) indicate that the pandemic had a significant impact on students' academic performance, as reflected in GPA trends, and has

become a crucial factor in analyzing post-pandemic academic success. The transition from online learning back to face-to-face instruction has also posed challenges, affecting students' academic adaptation, particularly during their first year in university. Beyond the pandemic, various other factors contribute to students' academic performance. While sleep quality is often associated with academic achievement, a study by Khaled et al. (2025) found no significant correlation between the two. Conversely, factors such as the learning environment, teaching quality, and students' creativity have been proven to influence academic outcomes beyond the impact of GPA and personality traits (Kapoor et al., 2025; Tran et al., 2025), highlighting the importance of further investigation into intrinsic academic factors contributing to student success.

Variations in GPA provide insight into the challenges and potential students face throughout their academic journey, where some experience a significant decline in early semesters while others manage to maintain or improve their GPA over time (Pöysä et al., 2020; Yelfera et al., 2022). Factors such as student characteristics (Binelli et al., 2024), engagement in the learning process (Alghamdi et al., 2024), and technical challenges in e-learning (Bravo-Agapito et al., 2021) influence these dynamics. GPA fluctuations reflect students' academic challenges, which can impact their overall academic success (Wahyuning et al., 2024). Therefore, analyzing GPA trends is essential to identifying academic obstacles, evaluating the effectiveness of the learning system, and anticipating barriers that may hinder timely graduation.

Monitoring changes in students' Grade Point Average (GPA) is vital for evaluating the effectiveness of higher education systems, as it offers measurable insights into students' academic development over time. Trends in GPA can reflect the strengths and weaknesses of instructional methods, curriculum structure, and institutional support systems (Papamitsiou & Economides, 2014; Romero & Ventura, 2020; Tran et al., 2025). Furthermore, fluctuations or stability in GPA across semesters often indicate students' academic adaptation and resilience, serving as early signals of potential academic risks or progress. Understanding these trends provides institutions with evidence-based insights that are crucial for designing targeted interventions, academic advising, and student support strategies that align with real-time academic needs (Alghamdi et al., 2024; Kapoor et al., 2025; Pöysä et al., 2020).

Beyond GPA analysis, academic success can be measured through graduation status, dropout frequency, and study duration key indicators of both student progression and institutional performance. Evaluating these outcomes helps identify systemic challenges such as delayed graduation, academic disengagement, and structural barriers that hinder timely completion (Cheung et al., 2021; Delogu et al., 2024; Yelfera et al., 2022). These academic trajectories provide deeper insight into student development, informing the formulation of responsive policies aimed at improving graduation rates, minimizing dropouts, and fostering an inclusive academic environment that supports diverse student needs (Amalita et al., 2020; Sinval et al., 2024; Wahyuning et al., 2024).

In the era of big data, academic analysis can be strengthened using data exploration techniques based on educational data mining, which uncover hidden patterns in large-scale student records. This study applies such methods to analyze GPA trends of student cohorts from 2017 to 2024. Through visual and descriptive analyses, this research examines GPA dynamics. It links them to graduation distribution, aiming to support the development of more

adaptive academic policies responsive to post-pandemic challenges in Indonesian higher education.

This study specifically contributes to the context of undergraduate mathematics education in Indonesia, where post-pandemic academic disruptions have raised concerns regarding timely graduation and learning consistency. By focusing on GPA dynamics and graduation outcomes, the research seeks to identify early indicators of academic success and inform institutional strategies for academic support.

B. METHODS

This research adopts an exploratory quantitative approach grounded in Educational Data Mining (EDM). Unlike predictive or inferential models, exploratory EDM focuses on identifying patterns, anomalies, and trends from educational datasets without constructing predictive algorithms or testing statistical hypotheses (Papamitsiou & Economides, 2014; Romero & Ventura, 2020). The aim is to gain a deeper understanding of GPA dynamics and their relation to academic success indicators such as graduation rates and study duration.

The dataset consists of semester-based academic records from 586 undergraduate students in the Department of Mathematics at a public university in Indonesia, spanning the 2017–2024 cohorts. Data were collected directly from the university's official academic archives, which serve as the institutional record for internal evaluations. These archives are integrated into the university's Academic Information System (SIAKAD), ensuring reliability and consistency of the data. The dataset includes GPA values for each semester, study duration (in semesters), and graduation status (Graduated, Active, or Dropped Out).

Data inclusion criteria encompassed all students enrolled in the 2017–2024 cohorts, including those who had graduated, were still active, or had dropped out. This comprehensive inclusion was intended to reflect the full spectrum of academic progression across different cohorts. The range of semesters analyzed spans from Semester 1 to Semester 12, though later semesters (9–12) were only applicable to earlier cohorts (e.g., 2017–2019) that had reached those stages, as shown in Figure 1.

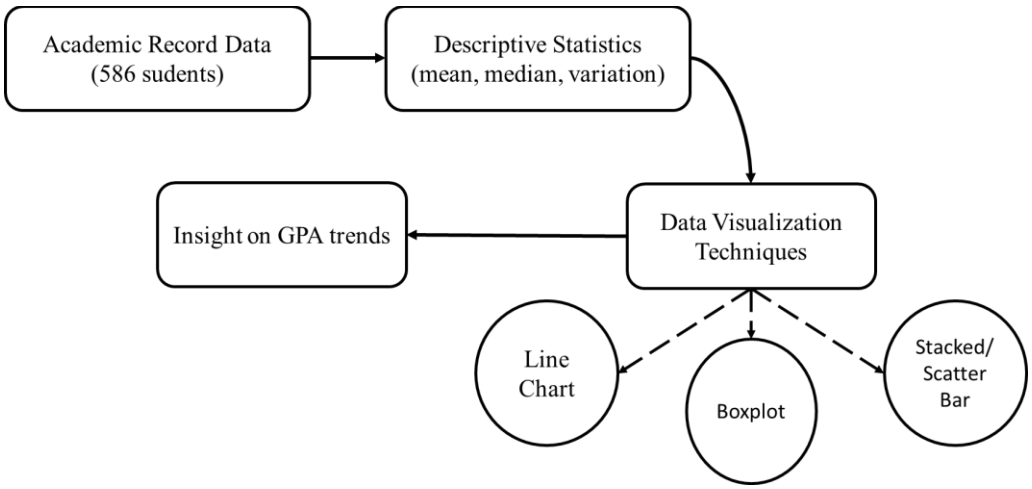

Figure 1. Analytical Framework

$$\bar{x} = \frac{1}{n}\Sigma_{i=1}^{n} x_i \quad (1)$$

$$Me = \frac{x_{\frac{n}{2}} + x_{\frac{n}{2}+1}}{2} \quad (2)$$

$$\sigma = \sqrt{\frac{1}{n}\Sigma_{i=1}^{n}(x_i - \bar{x})^2} \quad (3)$$

This study applies descriptive statistical analysis using standard formulas for mean, median, and standard deviation to examine patterns in students' academic performance. The mean (1) indicates the average GPA across semesters, the median (2) shows the central tendency, and the standard deviation (3) measures the variability of student achievement over time. These measures were selected to capture the central tendency and variability of student performance across semesters. Additionally, visualization techniques were used to facilitate pattern recognition and cohort comparison:

Table 1. Type of Charts

Chart Type	Purpose	Data Used	Insight Expected
Stacked Bar Chart	To compare and display the distribution of total graduates, dropouts, and ongoing students by cohort	Graduation status per cohort	Understanding graduation trends and identifying cohorts with high dropout rates
Line Chart	To observe the progression of average GPA from Semester 1 to Semester 12	Average GPA per semester for each cohort	Identifying GPA trends over time and detecting potential periods of academic difficulty
Boxplot	To identify the distribution and variation of GPA in each semester	Average GPA values for each semester	Revealing GPA variability and detecting outliers or patterns of academic consistency
Scatter Plot	To explore the relationship between initial GPA and the number of graduates in each cohort	Initial GPA and graduation status per student	Evaluating whether initial academic performance predicts graduation success

C. RESULT AND DISCUSSION

Analysis of students' GPA data across multiple cohorts reveals notable patterns in academic development. By exploring GPA trends from the early semesters to graduation, this study identifies variations in academic performance between cohorts and the distribution of students' graduation statuses. Through data visualization, differences in GPA trends and shifts in academic patterns from year to year can be interpreted more clearly. This section provides an in-depth discussion of how GPA evolves and how students' academic statuses whether graduated, still active, or dropped out can offer valuable insights into the dynamics of higher education. Furthermore, identifying periods of academic decline or improvement can inform

institutional strategies for academic support. Such insights are essential for enhancing curriculum planning, early intervention, and student retention policies, as shown in Figure 2.

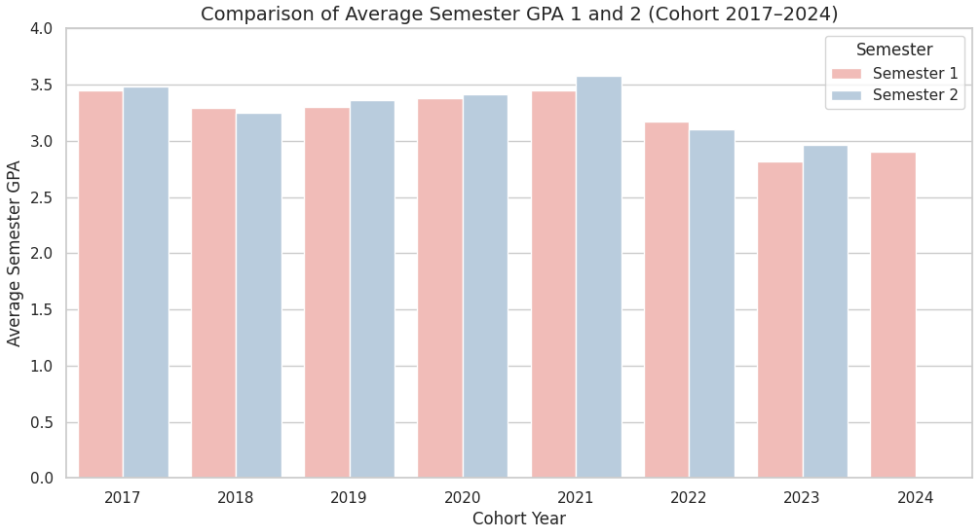

Figure 2. Comparison of Average Semester GPA 1 and 2

Figure 2 compares students' average Semester Grade Point Average in the first semester (GPA1) and second semester (GPA2) for cohorts from 2017 to 2024. The GPA1 and GPA2 trends generally remained relatively stable for the 2017 to 2021 cohorts, with averages between 3.25 and 3.58. However, a noticeable decline occurred in the 2022 and 2023 cohorts, where the average GPA1 and GPA2 fell below 3.20. For the 2024 cohort, GPA2 is explicitly set to zero, as the data is unavailable, and students have not yet reached the second semester. The differences between GPA1 and GPA2 in the figure indicate that, in general, students experienced slight improvements or maintained stability in their academic performance from the first to the second semester, as shown in Fogure 3.

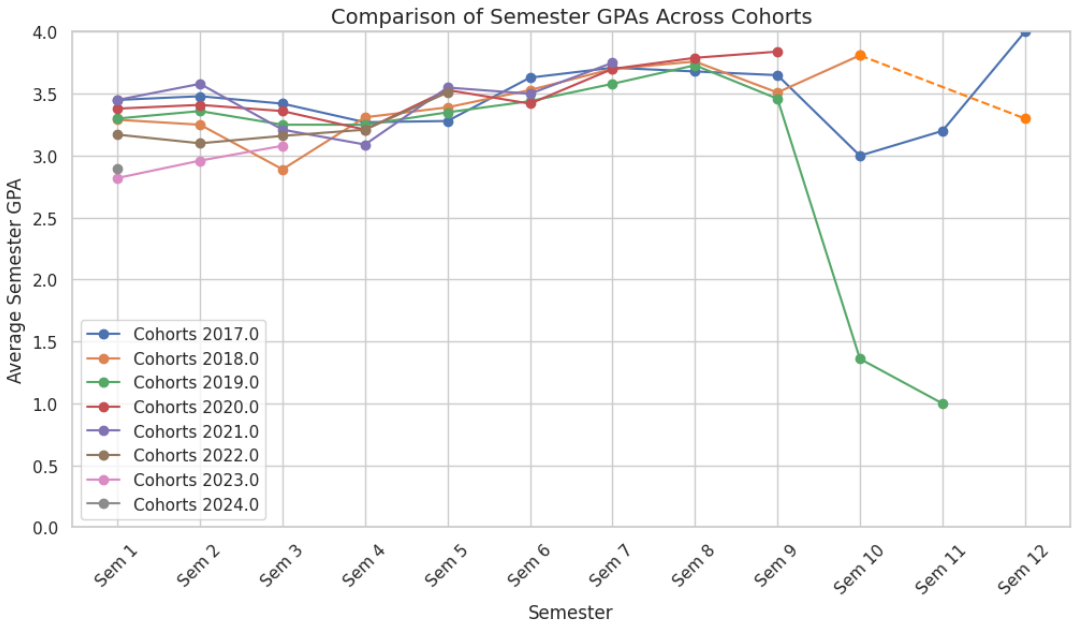

Figure 3. Comparison of Semester GPAs Across Cohorts

Figure 3 illustrates the average GPA trends across various student cohorts from the first to the twelfth semester. In the early semesters (GPA1 to GPA8), the average GPA remains stable, ranging between 3.00 and 3.50 without significant fluctuations. Each cohort exhibits relatively similar patterns, with slight variations from year to year. Additionally, some more recent cohorts, such as those from 2022 and 2024, only have data available for the early semesters, reflecting the unavailability of GPA information for the later semesters. In the final semesters (GPA9 to GPA12), a noticeable decline is observed in several cohorts, particularly in the 2018 and 2019 cohorts. This is attributed to the decreasing number of students in the later semesters due to graduation, resulting in greater variability in the average GPA. In contrast, the 2017 cohort shows a more stable pattern through to GPA12, indicating that a larger number of students continued their studies until the end of their academic period.

The fluctuations in GPA patterns across cohorts reveal intriguing academic dynamics. Some semesters show significant improvement, which may be due to lighter course loads or more effective learning strategies developed after facing earlier academic challenges. Conversely, certain semesters experience sharp declines, which could be associated with increased academic demands, higher course difficulty levels, or more stringent evaluation systems. Depression, anxiety, and stress can reduce students' academic engagement and increase the risk of dropout, contributing to the shifting GPA dynamics throughout their studies (Sinval et al., 2024). If these patterns persist across cohorts, it may indicate the presence of systemic factors affecting students' academic achievement, such as curriculum changes or difficulties in adapting to specific courses. Therefore, further evaluation is necessary to assess the learning system's effectiveness and develop strategies to support improved student academic success, as shown in Figure 4.

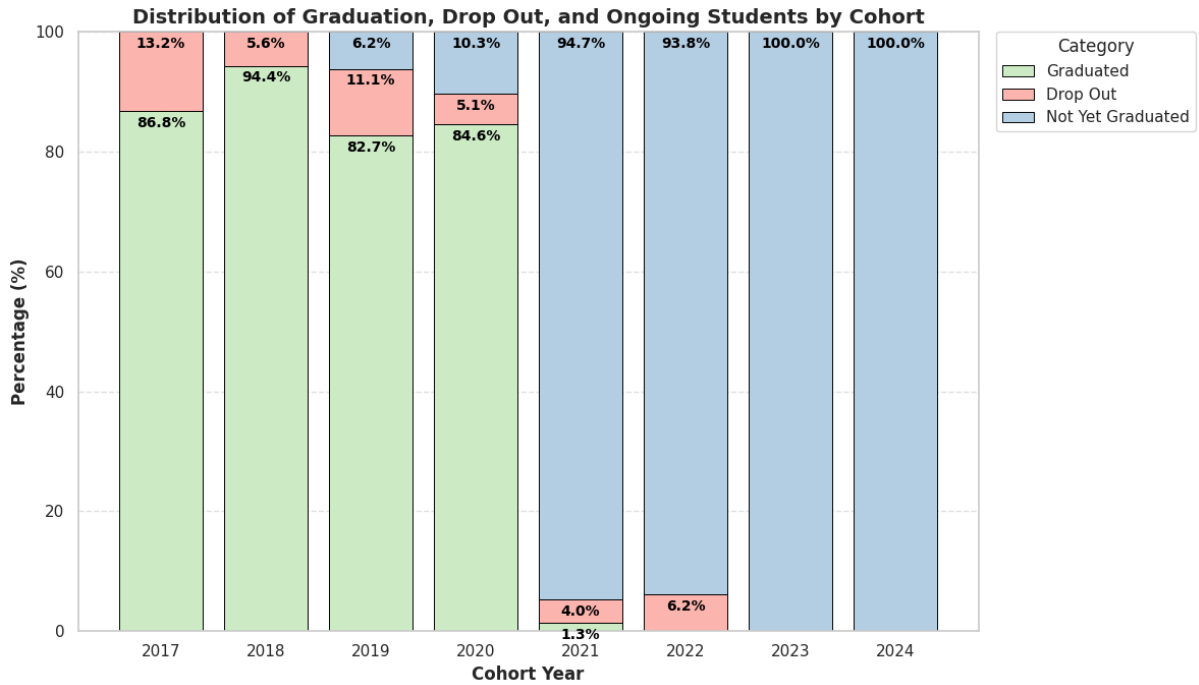

Figure 4. Students' Distribution by Cohort

Figure 4 displays the distribution of the percentage of students who have graduated, dropped out, and are still enrolled, categorized by cohort. The older cohorts, such as those from 2017 to 2020, generally show a high graduation rate, ranging from 82.7% to 94.4%. Meanwhile, the dropout rate varies across cohorts, with the highest recorded in the 2019 cohort at 11.1%. This trend indicates that most students can complete their studies within a reasonable time frame, although a portion do not complete their education. For more recent cohorts, such as those from 2021 to 2024, the percentage of students who have not yet graduated remains dominant, reaching 100% in the 2023 and 2024 cohorts. This is expected, as these students are still studying and have not reached the typical graduation period. However, in the 2021 cohort, some students have already graduated (1.3%) or dropped out (4.0%), indicating that some completed their studies early, while others discontinued their education.

This pattern suggests that early academic performance may serve as one indicator of graduation success. However, other factors such as the learning system, academic policies, or student characteristics also play a significant role. Some cohorts with similar initial GPA levels show different graduation outcomes, indicating that GPA alone is not the sole determinant of academic success. It must be considered with other factors, such as perseverance and a supportive academic environment, as shown in Figure 5.

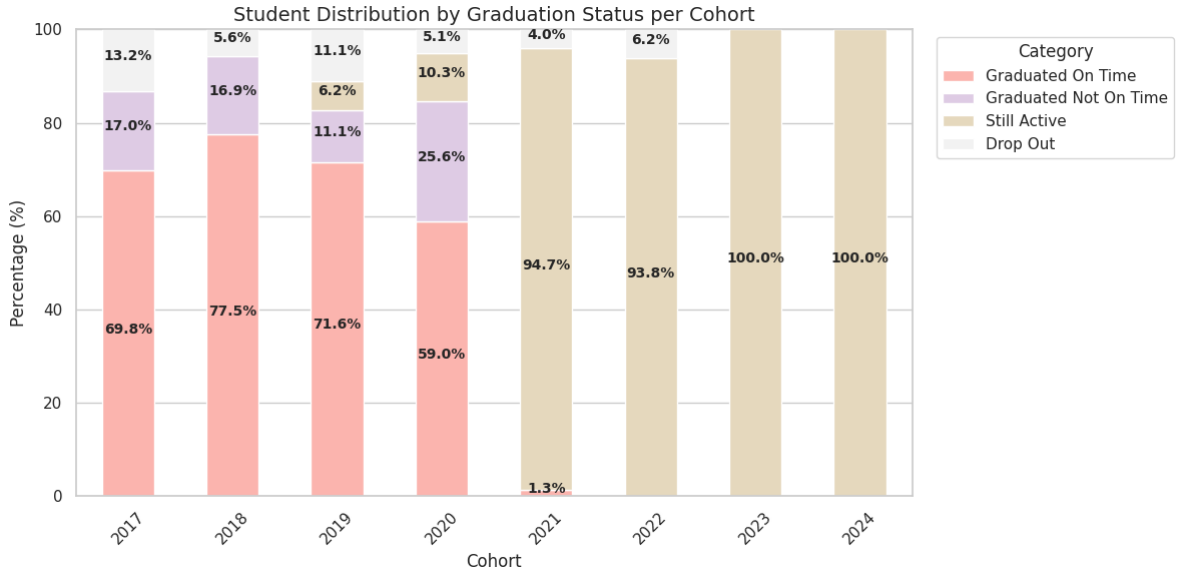

Figure 5. Student Distribution by Graduation Status per Cohort

Figure 5 illustrates the distribution of students' graduation status by cohort using a stacked bar chart. Four categories are presented: students who graduated on time (≤8 semesters), graduated late (>8 semesters), are still active, and dropped out. Older cohorts, such as those from 2017 to 2020, show a significant proportion of students who have graduated, either on time or late, with varying percentages. In contrast, more recent cohorts, such as those from 2021 to 2024, are predominantly composed of active students, as they have not yet reached the standard graduation timeframe.

Additionally, a small proportion of dropouts is observed in several cohorts, with the highest rates occurring in the 2017 and 2020 cohorts. Supported by (Delogu et al., 2024), predictive analyses of student dropout indicate that early academic performance can predict academic

success, aligning with the importance of GPA pattern analysis in understanding academic risk. These trends reflect the graduation and study continuation patterns of each cohort, which can serve as an important basis for evaluating the effectiveness of the implemented educational system, as shown in Figure 6.

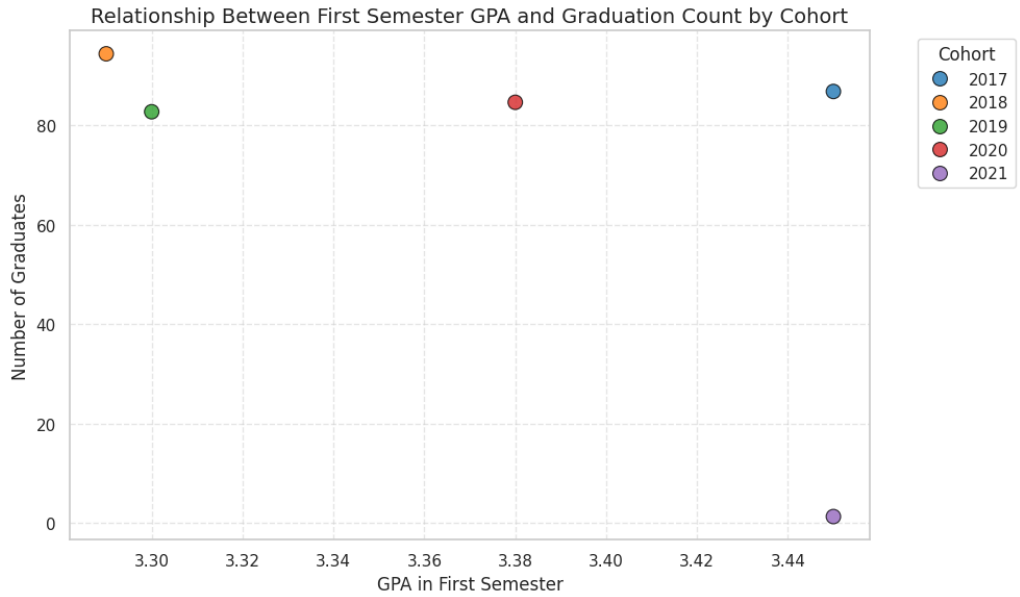

Figure 6. Relationship Between First Semester GPA and Graduation Count by Cohort

Figure 6 illustrates the relationship between students' first-semester GPA and the number of graduates in each cohort. In general, cohorts with higher initial GPAs tend to have more graduates, as seen in the 2017 and 2018 cohorts, which had an average initial GPA of around 3.3–3.4 and recorded a high graduation count. Conversely, the very low number of graduates in the 2021 cohort is most likely because students from this cohort have not yet completed their study period.

Although there is a positive trend, the differences in graduation numbers among cohorts with similar initial GPAs indicate that GPA alone is not the sole determinant of academic success. Other factors, such as learning motivation, instructional systems, and academic support environments, also play a significant role. (Amalita et al., 2020) Note that a student's GPA is influenced not only by academic factors but also by family environment, learning motivation, and instructors' perceptions, all of which can contribute to GPA fluctuations throughout the study. In addition, institutional policies, such as curriculum updates or changes in assessment methods, may also impact student performance and graduation rates. For instance, the presence of academic mentoring programs or flexible learning systems could significantly support students with lower initial GPAs to achieve successful graduation. It is also important to consider external factors, including socioeconomic conditions and access to learning resources, which may vary across cohorts and affect academic outcomes differently. The 2022, 2023, and 2024 cohorts were excluded from the visualization, as most students from these cohorts are still enrolled in their studies, and graduation data is not yet available. Therefore, to maintain the accuracy and relevance of the analysis, Figure 6 only includes cohorts that have completed their studies and for whom graduation data are available.

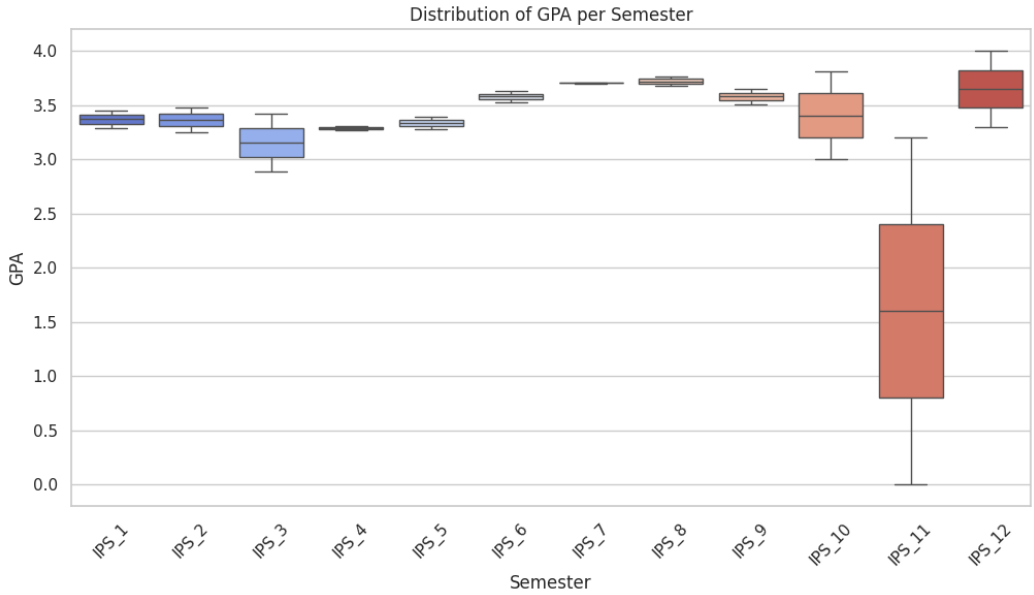

Figure 7. Distribution of GPA per Semester

The boxplot of GPA distribution per semester in Figure 7 shows that students' GPA tends to remain stable during the early semesters, with median values ranging from 3.3 to 3.5. However, in certain semesters such as the third semester there is an increase in variation, indicated by students with significantly lower GPAs than most of their peers. Over time, the interquartile range widens, suggesting growing differences in academic performance among students.

An interesting phenomenon appears in the final semesters (10–12), where GPA distribution becomes significantly more varied, and outliers increase, indicating a wide range of academic performance. The high variation in the later semesters is likely because many remaining students are focused on completing their final projects or theses. At the same time, most of their peers have already graduated within eight semesters. This group includes students facing academic challenges or administrative delays that affect their GPA. Since they are no longer enrolled in multiple regular courses, their GPA is heavily influenced by the outcome of their final projects. Some students may achieve high grades due to concentrated effort on their theses, while others may experience a decline due to difficulties in completing their research. This explains the broader GPA distribution and the presence of noticeable outliers in the final semesters.

The analysis of students' GPA data across multiple cohorts reveals distinct patterns in academic development. Figure 2**,** which compares average GPA between the first and second semesters, shows initial academic performance trends. Stable or slightly improving GPA in early semesters (2017–2021) may reflect students' adaptation success during the first year. However, the sharp decline in GPA for the 2022 and 2023 cohorts likely reflects the lingering academic impact of post-pandemic transition challenges, such as shifting learning modalities and decreased engagement. These early GPA patterns are expanded in Figure 3, which traces GPA evolution across semesters. This broader trajectory shows that most cohorts maintain relatively stable academic performance through Semester 8. However, greater variability in the later semesters (particularly GPA9–GPA12) among cohorts like 2018 and 2019 suggests divergence in students' academic resilience. The drop in average GPA for some cohorts during

final semesters may be tied to the pressure of thesis work or reduced academic support near graduation.

To contextualize these GPA patterns, Figures 4 and Figures 5 present the graduation status and study duration distribution across cohorts. Older cohorts (2017–2020) show high graduation rates with timely completion, while newer cohorts (2021–2024) remain largely active. Interestingly, despite similar GPA trends in earlier semesters, dropout rates vary, highlighting the influence of non-academic factors. For example, the high dropout in the 2019 cohort (11.1%) aligns with prior findings that stress, burnout, and lack of institutional support contribute significantly to academic attrition (Sinval et al., 2024; Bravo-Agapito et al., 2021).

Figure 6 further emphasizes that while initial GPA is positively associated with graduation, it is not a deterministic factor. Cohorts with comparable average first-semester GPA (e.g., 2017 vs. 2019) exhibit different graduation outcomes, indicating that intrinsic motivation, academic support systems, and mental well-being may mediate long-term academic success (Amalita et al., 2020; Alghamdi et al., 2024). Finally, Figure 7 shows that GPA distributions tighten in early semesters but become widely dispersed in the final semesters. This confirms that although academic performance is stable during structured coursework, variability increases during the thesis and independent research phases. These findings resonate with earlier studies highlighting how reduced structure, combined with psychological stress, disproportionately affects performance near graduation (Schriek et al., 2024; Delogu et al., 2024).

The study finds that students' academic performance tends to be stable in the early semesters but becomes more varied in later stages, indicating diverse academic pathways (Romero & Ventura, 2020). While initial GPA may suggest future success, factors such as motivation, institutional support, and learning environment also significantly influence academic outcomes (Amalita et al., 2020; Delogu et al., 2024). Increased GPA variation in final semesters reflects academic and administrative challenges during thesis completion, highlighting the need for continued academic support (Sinval et al., 2024). Patterns of dropout and delayed graduation further underscore the complexity of academic progression shaped by both personal and structural factors (Santos & Henriques, 2023). Thus, early academic monitoring and adaptive education policies are essential to enhance student success (Shukor et al., 2015).

D. CONCLUSION AND SUGGESTIONS

This study concludes that the academic performance of students, as reflected in GPA trends from 2017 to 2024 cohorts, tends to be stable in the early semesters but becomes increasingly varied in later stages, particularly beyond the eighth semester. The use of an exploratory approach enables the identification of subtle patterns in academic trajectories, including critical periods in Semester 3 and the final semesters, where fluctuations and academic vulnerability become more apparent. This methodological approach provides a fresh perspective by allowing the data to reveal trends without predefined assumptions, offering a clearer view of how academic outcomes evolve.

The findings suggest that early GPA can serve as an initial indicator of graduation success, though it is not a definitive predictor. Variations across cohorts highlight the importance of institutional support and academic engagement throughout the study period. Therefore, the

study recommends that higher education institutions enhance early academic monitoring based on first-semester performance and provide structured support, particularly during thesis or final project stages. These insights are valuable for designing more responsive academic strategies and policies that align with students' actual academic journeys, especially in adapting to post-pandemic challenges.

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