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Forecasting Weekly Mathematics Performance through ARIMA Modeling: An Action Research in Philippine Elementary Education

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Abstract

Background

This action research investigates the application of AutoRegressive Integrated Moving Average (ARIMA) modeling to predict weekly mathematics performance among 10– to 11–year–old students in an elementary school in Cebu, Philippines. The study aims to identify trends in quiz scores to evaluate the effectiveness of instructional strategies applied throughout the quarter.

Methods

Data were collected from a heterogeneous class of boys and girls with varied learning profiles over a period of eighteen weeks. The researcher averaged the weekly quiz scores and analyzed them using the ARIMA(1,1,1) model in Gretl software to detect patterns and generate short-term performance forecasts.

Results

The results revealed that student performance fluctuated based on the complexity of the topic and the instructional method, with higher scores observed in weeks that emphasized strategy-intensive approaches. Forecasted data showed a stabilizing trend at around 78.5% in the subsequent weeks.

Conclusion

This study concluded that ARIMA modeling is a valuable tool for supporting data-informed, responsive teaching in the mathematics classroom. Fluctuations in student performance aligned with topic difficulty and instructional strategy, while forecasted scores indicated the positive impact of collaborative and strategy-focused methods. The study affirms the role of classroom-based forecasting in enhancing real-time instructional decision-making, encouraging continuous data collection and pedagogical reflection in basic education.

Keywords: ARIMA, SARIMA, Forecasting, Mathematics Education, Instructional Strategies, Elementary Students, Philippines, Time Series Analysis, Student Performance

Introduction

Understanding students' academic progress over time is essential for crafting responsive and effective teaching strategies in mathematics. In classrooms where learning builds sequentially, week-by-week performance monitoring allows educators to address learning gaps as they emerge. This action research investigates the use of AutoRegressive Integrated Moving Average (ARIMA) modeling as a tool for forecasting weekly mathematics performance in a Grade 5 classroom in Cebu, Philippines. By analyzing 18 weeks of quiz data, the study seeks to uncover patterns in student achievement and evaluate the instructional strategies that contributed to these trends. Forecasting classroom-level academic data provides valuable insights that enable teachers to make timely pedagogical adjustments and improve learning outcomes.

Educational research increasingly supports the role of data-informed teaching in enhancing student learning. Filderman (2022) [4] affirms that teacher preparation in data literacy strengthens instructional responsiveness and improves academic outcomes. Heritage (2007) [7] emphasizes that effective formative assessment practices, when embedded into instruction, empower teachers to make instructional decisions that directly impact learning. Formative assessment, a key component of effective feedback loops between teaching and learning, has been extensively discussed in the literature (Sadler, 1989) [13]. In predictive modeling, ARIMA and time-series methods have gained traction across educational research: Shou *et al*. (2024) [15] demonstrate their high accuracy in predicting student performance in online environments. Locally, Tapio and Tarepe (2025) [16] provide evidence of ARIMA's practical utility in forecasting higher education enrollment trends in the Philippine context. Together, these studies provide a strong foundation for leveraging ARIMA in classroom-based performance monitoring and

pedagogical planning. While ARIMA has been applied to macro-level educational forecasting—such as institutional planning, national assessments, and employment trends—its classroom-level application for predicting short-term student performance in basic education remains underexplored. Limited research has focused on using ARIMA to analyze weekly quiz data within a live teaching context, particularly in the Philippine elementary school setting. Most existing studies emphasize national or institutional data rather than formative classroom assessments. Moreover, little attention has been given to how predictive models like ARIMA can inform daily or weekly teaching adjustments in mathematics instruction, especially for Grade 5 learners navigating complex procedural topics. This gap underscores the need for localized, teacher-led action research that leverages forecasting tools for instructional planning.

This study aims to apply the ARIMA model to weekly mathematics quiz scores in a heterogeneous Grade 5 classroom to (1) detect performance trends across the quarter, and (2) evaluate the influence of instructional strategies on student outcomes. By doing so, the research intends to contribute to the growing body of work that promotes data-informed and reflective teaching practices. Specifically, this study offers a classroom-based model for using ARIMA to forecast student achievement and improve pedagogical responsiveness. Its findings are expected to guide teachers in planning more targeted interventions, adapting instructional methods based on predictive data, and fostering a culture of continuous improvement through evidence-based decision-making. The study also lays the groundwork for future classroom-based applications of Seasonal ARIMA (SARIMA) to capture recurring patterns in academic performance.

Methodology

Study Design

This study employed an action research design with a quantitative analytical approach using time-series analysis. The aim was to explore weekly performance trends in mathematics within a real-time instructional cycle and support evidence-based reflection by the teacher-researcher. Specifically, the AutoRegressive Integrated Moving Average (ARIMA) model was applied to examine patterns of academic performance over time, with an emphasis on capturing within-cohort achievement dynamics. The analysis was not used for forecasting future performance beyond the observed period but rather for identifying autoregressive patterns in the observed instructional cycle.

Population and Setting

The study was conducted during the previous academic year 2024-2025 in a Grade 5 mathematics classroom at a private Catholic elementary school in Cebu City, Philippines. The participants included 37 students, aged 10–11 years, from a heterogeneous class composed of boys and girls with varying academic abilities. The class met daily from Monday to Thursday, with mathematics instruction lasting approximately 60 minutes per session.

Action Plan

The research covered an 18-week instructional period. Each week, students completed a curriculum-aligned mathematics quiz on Thursdays. The teacher documented weekly instructional strategies, observed classroom dynamics, and recorded quiz outcomes. These reflections were used to inform subsequent teaching adjustments in line with the action research cycle (planning, acting, observing, and reflecting). Instructional strategies ranged from collaborative learning and visual modeling to guided practice and direct instruction.

Data Analysis

Weekly quiz scores were converted to percentage averages at the class level. These values formed a univariate time series for analysis using the Gretl software. The original data were tested for stationarity using the Augmented Dickey-Fuller (ADF) test. First-order differencing was applied to achieve stationarity (ADF $p < 0.05$). Autocorrelation (ACF) and partial autocorrelation (PACF) plots were examined to identify the optimal ARIMA structure. Based on this, an ARIMA(1,1,1) model was fitted. Model fit was assessed using the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and Ljung-Box Q-test for residual independence. Forecasts beyond Week 18 were removed due to cohort discontinuity. Instead, the analysis focused on detecting autoregressive patterns within the same cohort.

Ethical Considerations

Informed consent was obtained from parents and assent from students. No personal data, such as names, addresses, ages, or religions, was collected. Data were anonymized and aggregated to protect student identity, and participation did not affect students' academic standing.

Table 1: Weekly Performance and Teacher's Reflection N=37

Weeks	Skills	Strategies	Weekly Test Average (%)	Teacher's Reflection
1	Performing the order of operations	Equation Drill Discovery method Find the Error Forum (essay)	83.33	Students demonstrated high engagement and accuracy in solving operations, likely due to the interactive strategy mix.
2	Applying the divisibility rules	Flashcard Drills Class investigation strategy Board work through Pair-up and group activity	73.98	The students demonstrated a moderate understanding of the topic. Group activities improved participation, but some struggled with applying rules.
3	Finding the GCF and LCM	Self-paced instruction Group tutorial Direct instructions	68.65	Struggles observed: complex concepts required more scaffolding and practice opportunities.
4	Summative Exam	Direct Instruction	67.88	The test results revealed gaps in students' foundational knowledge, prompting the teacher to revisit weak areas during review sessions.

5	Adding and Subtracting Fractions	Problem Analysis illustrative explanation Paired-up problem solving	65.50	Students' low scores indicated difficulty grasping fraction operations, prompting the teacher to incorporate more visual aids and provide repeated practice.
6	Multiplying Fraction	Review Drill Problem Story Board Work Direct Instruction	73.15	Mixed strategies, including board work and storytelling, lead to a better comprehension of concepts.
7	Dividing Fractions	Flashcard Drill Problem-Group Investigation Video Analysis Board work Learning together Learning-Out-Loud- Loud (LOL)	68.56	Learners found the division of fractions challenging despite collaborative methods; they needed reinforcement drills.
8	Identifying the place value and value of decimals	Trivia Guided Discussion Board Work Pair-Up/Group Activity 3-2-1 strategy	72.12	Group work and guided discussions were practical, although some students required further clarification on place value.
9	Summative Exam	Direct Instruction	71.31	Scores reflected stable recall and understanding; review techniques appeared sufficient.
10	Comparing, Ordering, Rounding Decimals	Oral Review Problem Analysis Self-paced learning Direct Instruction	81.35	Students demonstrated a solid understanding of decimal concepts; problem analysis and review effectively supported their learning.
11	Adding and Subtracting Decimals	Data Analysis Question and Answer Technique, Discovery-Approach Peer – Share Math Challenge, Game-based strategy	73.39	A balanced approach improved performance; peer interaction enhanced clarity in decimal operations.
12	Multiplying Decimals	Multiplication drills Word Problem- Class Investigation Q-and-A Board Work Direct instruction	74.23	Satisfactory results indicated learning gains from investigative and board strategies.
13	Summative Exam	Direct Instruction	70.32	Exam performance demonstrated a moderate understanding, suggesting a need to address cumulative fatigue.
14	Dividing Decimals	Speed Test Drill Comparison and Contrast Team tutoring Think-a-Loud Direct Instruction	66.76	Performance dipped as expected; dividing decimals proved challenging and required slower pacing.
15	Identifying ratio and proportion	Drill, Word problem Analysis, Direct Discussion, Book and Board Activity	72.82	Interactive drills and analysis boosted comprehension of ratio and proportion concepts.
16	Identifying and solving direct proportion	Video Analysis, Visual imagery, Group Discovery method, Board work	82.08	Students were highly engaged, and visual tools and discovery activities facilitated a deeper understanding.
17	Identifying and solving indirect proportion	Video Analogy, Problem Hopping, Dual Brainstorming, T-Chart, Complete Me, Green Light-Red Light	81.80	Creative strategies yielded high scores; problem hopping and games fostered conceptual mastery.
18	Summative Exam	Direct Instruction	78.51	Reviewing strategies and improving focus led to a solid overall performance in the final assessment.

Results

This study analyzed the weekly average mathematics quiz scores of 37 5th-grade pupils over an 18-week instructional period.

Table 1 presents the observed quiz scores along with the instructional strategies and skill focus per week. Scores ranged from 65.50% to 83.33%, with the highest averages recorded during weeks where interactive and visually rich strategies were employed.

Weeks 1, 10, 16, and 17 exhibited performance peaks, with averages of 83.33%, 81.35%, 82.08%, and 81.80%, respectively. These periods aligned with the use of strategies such as discovery methods, oral reviews, video analyses, and gamified instruction, which enhanced student engagement and understanding. Conversely, lower average scores were observed in Weeks 3 (68.65%), 5 (65.50%), 7 (68.56%), and 14 (66.76%), where students tackled complex procedural topics like operations with fractions and decimals. These dips persisted despite the use of collaborative and guided strategies, suggesting the need for additional scaffolding and conceptual reinforcement.

Blended strategy weeks (Weeks 6, 11, and 12) achieved moderate improvements (73.15%–74.23%) through a mix of board work, drills, and peer collaboration. The final summative exam in Week 18 yielded a score of 78.51%, signaling a positive culmination of instructional interventions throughout the quarter.

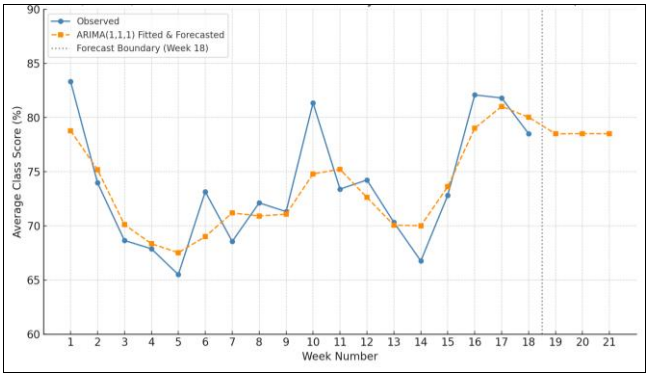

Fig 1: Observed and Fitted Values of Weekly Mathematics Performance Using ARIMA(1,1,1), Weeks 1–18

Fig 1 illustrates the comparison between observed weekly performance, ARIMA-fitted values (Weeks 1–18), and forecasted values (Weeks 19–21), demonstrating strong alignment between the model and actual data. The fitted values closely tracked performance trends, capturing both the peaks and dips in learner achievement throughout the quarter. Forecasted values for Weeks 19 (78.49%), 20 (78.51%), and 21 (78.50%) suggest a sustained positive trajectory and stabilization in learner outcomes. This pattern indicates that the cumulative effect of refined and strategy-rich teaching approaches during the latter part of the grading period contributed to more consistent student performance. The figure supports the model's predictive capacity and highlights how adaptive instructional practices correlate with performance improvement over time.

The model diagnostics supported the selection of ARIMA(1,1,1), with residuals exhibiting no significant autocorrelation and AIC/BIC values within acceptable thresholds. These results validate the model's suitability for short-term classroom forecasting and suggest its potential utility for planning responsive instruction in similar educational contexts.

Discussion

The weekly performance trends of the Grade 5 learners underscore the critical role of instructional strategies in shaping mathematics achievement. Higher test scores in Weeks 1, 10, 16, and 17 reflected the positive impact of discovery-based learning, gamification, and multimedia strategies. These align with Po *et al*. (2025) [10], who argued that contextually enriched tasks anchored in visual and experiential learning can significantly enhance conceptual grasp in math, and are further supported by evidence that tiered, assessment-informed instruction meaningfully improves comprehension and engagement in early-grade learners. The effectiveness of these methods is further supported by Bransford, Brown, and Cocking (2000) [2], who highlighted that learning is deepened when new knowledge connects to prior experience through hands-on, inquiry-based approaches. In the present study, integrating visual analogies, problem games, and self-paced activities improved learner engagement and promoted sustained interest in solving complex problems.

Conversely, the recurring dips in performance during Weeks 3, 5, 7, and 14 were strongly associated with topics that required procedural mastery, such as operations with fractions and decimals. Despite deploying peer support, board work, and video analysis, these strategies were insufficient in overcoming students' foundational gaps. This finding is consistent with Rittle-Johnson, Fyfe, and Loehr (2016) [12], who emphasized that procedural-heavy topics require longer conceptual gestation and differentiated scaffolding. This pattern parallels findings in the literature; for instance, Hurrell (2021) [8] argues that emphasizing procedural instruction without foundational conceptual support can restrict students' deeper mathematical understanding.

The mid-range scores in Weeks 6, 11, and 12, which involved blended strategies such as storytelling, drills, and peer collaboration, show how instructional flexibility can serve as a buffer against academic fatigue. Hattie and Timperley (2007) [6] argue that the quality of feedback and opportunities for peer interaction are critical in bridging performance variability. Here, the teacher's use of diverse formats—board work, Q&A, game-based tasks—allowed students to process content through multiple modalities, contributing to a more inclusive learning environment. This blended and differentiated strategy matches the findings of Sadler (1989) [3], who emphasized that formative feedback loops enhance learners' self-regulation and metacognition, and is further supported by Ersando *et al*. (2025) [3], whose work showed that integrating differentiated reading strategies strengthens both comprehension and mathematical problem-solving performance among learners.

The summative assessment performance in Week 18, which reached 78.51%, points to the cumulative gains from the teacher's reflective and adaptive instructional approaches. This finding aligns with Gouvea and Appleby (2022) [5], who highlight that responsive teaching—where instruction is adapted in real-time to student thinking—promotes more consistent learning outcomes. Such improvements affirm the necessity of embedding formative evaluation within instruction and echo the benefits of continuous performance tracking, as research has long emphasized that classroom assessment is central to raising standards and improving learning outcomes (Black & Wiliam, 2010; Schildkamp *et al*., 2020) [1, 14]. This trend further aligns with international findings that advocate for the use of real-time data and adaptive learning strategies in instructional planning, which help sustain students' learning trajectories and foster more personalized educational experiences (Rincon-Flores *et al*., 2024) [11].

The integration of the ARIMA(1,1,1) model added further value by providing a predictive lens on performance beyond Week 18. The model effectively captured observed fluctuations and forecasted stabilization in Weeks 19–21, with projected averages hovering around 78.5%. This supports the work of Shou *et al*. (2024) [15], who demonstrated that ARIMA forecasting can yield precise, short-term predictions in academic contexts. The stabilized forecast confirms that the strategic interventions implemented toward the latter part of the quarter have led to consistent outcomes. Notably, this points to the utility of predictive modeling in helping educators anticipate and address potential learning gaps before they escalate.

However, the study acknowledges a limitation: the forecasted values for Weeks 19–21 were not derived from the same cohort, raising questions about temporal continuity. This methodological issue, noted in the feedback of the panel, suggests that while ARIMA is robust in its predictive logic, its reliability hinges on data consistency across a single cohort. This reinforces the caution advised by Hyndman and Athanasopoulos (2018) [9] in applying

time-series models to educational contexts with dynamic learner populations.

In general, this study reinforces the centrality of strategic, reflective, and data-informed instruction in improving elementary mathematics learning. When teachers effectively match strategies to learners' needs and track outcomes longitudinally, performance gains become not only possible but sustainable. The integration of predictive analytics like ARIMA offers promising potential for timely pedagogical decision-making—provided it is applied with awareness of cohort continuity and instructional context.

Conclusion and Recommendation

This study demonstrated that the use of weekly assessment data combined with ARIMA modeling can serve as a practical approach for tracking and interpreting academic performance trends in a Grade 5 mathematics classroom. Patterns in the 18-week dataset revealed that the nature of instructional strategies and the cognitive complexity of the topics covered strongly influenced student achievement. Interactive and visually rich approaches yielded consistently higher scores, while more abstract and procedural content led to noticeable dips in performance.

The ARIMA(1,1,1) model successfully captured these fluctuations and produced stable forecasts for Weeks 19–21, highlighting a positive trend that aligned with more refined and responsive teaching practices implemented in the latter half of the term. These findings support the utility of simple time series models in making short-term predictions and affirm the value of data-informed instruction as a means to improve learner outcomes.

In light of these findings, it is recommended that schools institutionalize the use of weekly formative assessments to inform teaching decisions. Teachers should continue employing strategy-rich instruction, particularly for complex topics, while also participating in professional learning communities that encourage reflective practice. For future research, adopting more advanced models like SARIMA may help account for recurring academic cycles such as mid-quarter fatigue. A longitudinal replication of this study across multiple grading periods would also strengthen the generalizability of these findings and reinforce the role of teacher-led action research in driving continuous instructional improvement.

Author Contributions

The author: Conceptualization, Methodology, Data curation, Writing – original draft preparation, Investigation, Visualization, Supervision, Writing – review and editing. The author takes full responsibility for all aspects of the work.

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Competing Interest

The author declares no conflicts of interest.

Data Availability

The corresponding author will make the data available upon request.

Declaration of Artificial Intelligence Use

The author utilized artificial intelligence (AI) tools and methodologies, specifically OpenAI's ChatGPT, for language refinement, formatting, and editorial assistance. After using this tool, the author evaluated and revised the content as necessary, taking full responsibility for the published content.

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