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Monte Carlo Method for Predicting Educational Service Revenue at Each Level of Education at PT. Kanaka Belajar

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ABSTRACT

The increasing demand for education services in Indonesia has significantly influenced the growth of private tutoring businesses. PT Kanaka Belajar is a company that provides private tutoring services, yet it continues to face challenges related to revenue uncertainty and fluctuating student enrollment, which can affect financial management and increase the risk of business bankruptcy. Therefore, a reliable and accurate revenue prediction system is necessary at each level of education to estimate income for the coming year. The Monte Carlo method is a computational algorithm that uses repeated random sampling to obtain numerical results. This study applied the Monte Carlo method to forecast revenue based on historical data from 2021 to 2023. This research aims to develop a web-based revenue prediction system for educational services at different levels by implementing the Monte Carlo simulation. The results demonstrated that the model provided high prediction accuracy for private tutoring income at the elementary school level in 2023, with an MAPE value of 1.57%. The system predicted 314 tutoring sessions, while the data showed 319 sessions, resulting in a minimal difference of 5 sessions. These findings suggest that the Monte Carlo method effectively forecasts educational service revenue, where smaller percentage error values indicate higher accuracy, while larger errors suggest lower forecast reliability.

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1. INTRODUCTION

Education development in Indonesia has experienced a rapid increase in recent years. This is characterized by an increase in the number of students pursuing education at the primary, secondary, and tertiary levels. This increase in the number of students certainly impacts the increasing demand for educational services, such as tutoring services and private lessons. Along with this trend, private tutoring institutions are expected to offer high-quality services and effective financial strategies to support operational sustainability.

However, many educational institutions still rely on conventional financial projections, which often fail to capture uncertainty and fluctuations in student participation.

PT Kanaka Belajar is a company engaged in education that provides private tutoring services for primary, secondary, and higher education levels. Currently, PT Kanaka Belajar is facing two interrelated problems. The uncertainty of revenue and acceptance of private tutoring students has had a negative impact on the financial management of PT Kanaka Belajar. This has resulted in difficulties in managing finances, incurring large losses, and increasing the risk of business bankruptcy. In addition, the absence of a revenue prediction system at PT Kanaka Belajar has made financial decision-making difficult. Without a proper prediction system, the company struggles to plan effective financial strategies, potentially hindering the company's growth in the long run. This condition underscores the urgency for data-driven forecasting tools that can provide reliable estimates and support the company’s decision-making process.

To overcome this problem, the prediction of education service revenue is very important for PT Kanaka Belajar. Prediction compares past data to be used as a guide for the future [1], and can be the basis for long-term planning in business processes [2]. The Monte Carlo method is widely used to solve problems, such as analyzing uncertainty in predicting or forecasting education service revenues at various levels of education [3]. Compared to traditional deterministic methods, Monte Carlo simulation offers advantages in modeling random variables, making it suitable for forecasting under conditions of uncertainty.

The Monte Carlo method is a computational algorithm that uses random samples repeatedly to obtain results [4]. This random number is a set of numbers whose chances of occurrence are equal, and the pattern of numbers that arise cannot be known [5]. This method can provide solutions in estimating education service revenue by testing probabilistic elements through random number samples [6]. Therefore, the Monte Carlo method can be a practical and flexible forecasting tool in the educational business, especially when dealing with limited historical data and variable market behavior.

Beni Mulyana Putra's research [6] discusses the prediction of advertising revenue levels at Van Advertising Printing with the Monte Carlo method so that forecast data can be used as a reference in determining revenue for the coming year. To generate random numbers, this study uses the Linear Congruential Generator (LCG) method to produce predictions of advertising revenue 2018 with an accuracy rate of 89.2%. Fikri Algifari's research [1] discusses the prediction of cellphone sales revenue with the Monte Carlo method, which aims to help predict sales revenue, which is used as a recommendation in developing management strategies. This study uses the Mixed Congruent Method formula to generate random numbers. The results of predicting cellphone sales revenue in 2019 have an accuracy rate of 97.18% with an income of Rp. 77,150,000. With a high level of accuracy in predicting, it is expected to help company leaders decide business strategies quickly and optimally in the following year. These studies provide a strong basis for applying similar methods at PT Kanaka Belajar, hoping to get optimal results in predicting education services revenue. However, most of these studies focus on commercial sectors such as advertising and retail, with limited application in the educational services domain.

Thus, there remains a research gap in applying Monte Carlo simulations specifically to educational revenue forecasting at varying education levels. Based on this gap, this study aims to implement the Monte Carlo method to develop a forecasting model for education service revenues at PT Kanaka Belajar, which can serve as a strategic tool for financial planning and risk mitigation.

2. METHOD

The research method used is quantitative. Quantitative research is commonly used to analyze numerical data statistically and objectively, especially when identifying patterns or relationships. Quantitative research is a process of finding knowledge that uses numerical data to analyze data [7]. The steps of quantitative research in general are formulating problems, determining the theoretical basis, formulating hypotheses, collecting data, analyzing data, and making conclusions based on analysis findings. This study used the quantitative approach to predict educational service revenues at PT Kanaka Belajar based on historical financial data from 2021 to 2023.

Monte Carlo simulation is a form of simulation where the solution of a given problem is based on randomization (random) and its probability value is calculated to obtain a good value based on the distribution of the data used [1]. It is a computational method that repeatedly generates random values to simulate possible outcomes and analyze uncertainty. The following are the stages of analyzing the Monte Carlo method:

a. Identifying revenue data.
b. Categorizing data and determining frequency.
c. Calculating the probability distribution.
   Determine the probability distribution for the important variables in the observed model by dividing the sum of the frequencies of each variable by the total sum of all variable frequencies with the formula shown in equation (1).
   $$PDF = \frac{F}{J} \quad (1)$$
d. Calculating the cumulative distribution.
   Converting the probability distribution into a cumulative distribution, i.e., summing each probability distribution number with the sum of the previous distributions, with the formula shown in equation (2).
   $$DPK = AK + JA \quad (2)$$
e. Determining the interval of random numbers.
   At this stage, determining the interval of random numbers is based on the cumulative distribution. The initial limit value for the first variable starts with a value of 1, and the final value of random numbers is obtained from multiplying the final cumulative probability by 100. The next initial limit value is obtained by adding the previous final value plus 1 [3].
f. Generating random numbers
   Random number generation is carried out using the Linear Congruential Generator (LCG) with the formula shown in equation (3):
   $$Z_{i+1} = ((a.Zi + c)\ mod\ m) \quad (3)$$

g. Data simulation
Testing is performed to determine the results of the Monte Carlo simulation by adjusting the previous random numbers and comparing the simulated data with actual historical data. This comparison allows researchers to observe the alignment between forecasted outcomes and real values.

h. Simulation results
The simulation results of Monte Carlo are analyzed from the level of accuracy between the actual data and the predicted data by determining the percentage of deviation or error. A high level of similarity between simulated and actual data indicates the robustness of the Monte Carlo method in forecasting educational service revenue.

i. Calculate the percentage error with MAPE.
MAPE (Mean Absolute Percentage Error) is a statistical measure of the accuracy of forecasts (predictions) in forecasting methods. The MAPE method can be calculated using the formula shown in equation (4):

$$\text{MAPE} = \left(\frac{(Original\ data - Predicted\ data)}{Original\ data}\right) \times 100\% \quad (4)$$

The smaller the percentage error value in MAPE, the more accurate the forecasting results. A MAPE value of less than 10% has a good prediction accuracy. The MAPE value between 10% and 20% has good prediction accuracy. The MAPE value between 20% and 50% has a fair level of prediction accuracy, while the MAPE value of more than 50% has a poor level of prediction accuracy [8]. Therefore, MAPE serves as a key validation metric for evaluating the accuracy and reliability of the simulation model used in this study.

3. RESULTS AND DISCUSSION

3.1. Results

Based on the stages of applying the Monte Carlo method for simulating annual income, the process was carried out in accordance with the research method described previously. The simulation focused on forecasting the number of private tutoring sessions and the corresponding income at various education levels. The data used to predict education service revenue included the number of private tutoring meetings and the pricing structure. For example, the following is the private tutoring meeting data for the elementary school level in 2020, as shown in Table 1.

Table 1. Data of Elementary Private Tutoring Meetings in 2020

Number	Months of the year	Frequency
1	January	24
2	February	23
3	March	33
4	April	30
5	Mey	25
6	June	26
7	July	22
8	August	27
9	September	20
10	October	28
11	November	29
12	December	32
	Total	319

The next step involved establishing the probability distribution for each variable in the dataset. This was done to determine how likely each monthly frequency value was to occur. The calculation was performed by dividing the number of meetings each month by the total number of meetings in the year, as shown in Table 2. This distribution is the basis for generating random samples in the Monte Carlo simulation.

Table 2. Frequency Probability Distribution

Number	Months of the year	Frequency	Probability Distribution
1	January	24	0,08
2	February	23	0,07
3	Maret	33	0,10
4	April	30	0,09
5	May	25	0,08
6	Juny	26	0,08
7	July	22	0,07
8	August	27	0,08
9	September	20	0,06
10	October	28	0,09
11	November	29	0,09
12	December	32	0,10
	Total	319	1,00

Once the probability distribution was established, it was converted into a cumulative distribution. This process involved summing each probability value with all preceding values to generate cumulative probabilities, as shown in Table 3. The cumulative distribution is essential for determining random number intervals and mapping those numbers to specific months.

Table 3. Cumulative Distribution

Number	Months of the year	Frequency	Probability Distribution	Cumulative Distribution
1	January	24	0,08	0,08
2	February	23	0,07	0,15
3	Maret	33	0,10	0,25
4	April	30	0,09	0,34
5	May	25	0,08	0,42
6	Juny	26	0,08	0,50
7	July	22	0,07	0,57
8	August	27	0,08	0,66
9	September	20	0,06	0,72
10	October	28	0,09	0,81
11	November	29	0,09	0,90
12	December	32	0,10	1,00
	Total	319	1,00	

Following the cumulative distribution, the next step was determining the interval range for random numbers based on the cumulative probabilities. The initial value for the first interval begins at 1, and each subsequent range was defined by multiplying the cumulative distribution by 100 and incrementing accordingly. These ranges are displayed in Table 4. These intervals are a reference for assigning generated random numbers to corresponding frequency categories.

Table 4. Interval Numbers

Moon	Frequency Number of Encounters	Probability Distribution	Cumulative Distribution	Initial Interval	Final Interval
January	24	0,08	0,08	1	8
February	23	0,07	0,15	9	15
Maret	33	0,10	0,25	16	25
April	30	0,09	0,34	26	34
May	25	0,08	0,42	35	42
Juny	26	0,08	0,50	43	50
July	22	0,07	0,57	51	57
August	27	0,08	0,66	58	66
September	20	0,06	0,72	67	72
October	28	0,09	0,81	73	81
November	29	0,09	0,90	82	90
December	32	0,10	1,00	91	100
Total	319	1,00			

The next step was to generate random numbers for the simulation. These random numbers were generated using the Linear Congruential Generator (LCG) formula with parameters a = 11, Z_0 = 29, c = 47, and m = 83. The process is summarized in Table 5. These random values simulate variability in monthly tutoring frequency while maintaining a probabilistic alignment with historical data.

Table 5. Calculation of Random Numbers

i	**a**	**z_i**	**$(a \times z_i)$**	**c**	**$(a \times Z_i) + c$**	**m**	**Z_{i+1}**
0	11	29	319	47	366	83	34
1	11	34	374	47	421	83	6
2	11	6	66	47	113	83	30
3	11	30	330	47	377	83	45
4	11	45	495	47	542	83	44
5	11	44	484	47	531	83	33
6	11	33	363	47	410	83	78
7	11	78	858	47	905	83	75
8	11	75	825	47	872	83	42
9	11	42	462	47	509	83	11
10	11	11	121	47	168	83	2
11	11	2	22	47	69	83	69

The generated random numbers were then used to simulate predicted values for tutoring sessions in 2024. The predicted number of meetings for each month was determined by mapping the random numbers to their respective intervals. These values were multiplied by the tutoring price at the elementary school level to estimate monthly revenues. The simulation results, including comparisons to 2023 actual data, are shown in Table 6. The simulation resulted in 314 predicted meetings for 2024, compared to 319 meetings in 2023.

Table 6. Prediction Simulation Results for the Year 2024

Moon	random numbers	Frequency Number of Meetings 2023	Private tutoring price (elementary school)	Revenue Year 2023	Simulation Results for Year 2024	Revenue Year 2024
January	34	24	Rp105.500	Rp2.532.000	30	Rp3.165.000
February	6	23		Rp2.426.500	24	Rp2.532.000
Maret	30	33		Rp3.481.500	30	Rp3.165.000
April	45	30		Rp3.165.000	26	Rp2.743.000
May	44	25		Rp2.637.500	26	Rp2.743.000
Juny	33	26		Rp2.743.000	30	Rp3.165.000
July	78	22		Rp2.321.000	28	Rp2.954.000
August	75	27		Rp2.848.500	28	Rp2.954.000
September	42	20		Rp2.110.000	25	Rp2.637.500
October	11	28		Rp2.954.000	23	Rp2.426.500
November	2	29		Rp3.059.500	24	Rp2.532.000
December	69	32		Rp3.376.000	20	Rp2.110.000
Total	-	319		Rp33.654.500	314	Rp33.127.000

After obtaining the predicted and actual values, the Mean Absolute Percentage Error (MAPE) was calculated to assess the accuracy of the prediction. The MAPE formula is as follows:

MAPE = ((Original data – Predicted data) / Original data) × 100%

Applying this formula using 319 as the actual number of meetings and 314 as the predicted value yields:

MAPE = ((319 – 314) / 319) × 100% = 1.57%

This indicates a very high level of prediction accuracy, as the error is below the 10% threshold.

Table 7. Conclusion of Prediction for Year 2024

No	Categorical Name	Education Level	Private Tutoring Price	In 2024				MAPE
				Actual	Revenue 2023	Prediction	Revenue 2024	
1	Number of Meetings	SD	Rp105.500	319	Rp33.654.500	314	Rp33.127.000	1,57%
2		SMP	Rp112.500	489	Rp55.012.500	482	Rp54.225.000	1,43%
3		SMA	Rp157.400	992	Rp156.140.800	966	Rp152.048.400	2,62%
4	Number of Students	SD	-	74	-	70	-	5,41%
5		SMP	-	78	-	77	-	1,28%
6		SMA	-	175	-	169	-	3,43%

A complete summary of the simulation results for 2024 across different education levels is provided in Table 7. In addition to meeting frequencies, the table also includes projected revenue and student numbers for elementary, junior high (SMP), and senior high school (SMA) levels. The MAPE values confirm that the Monte Carlo simulation produced highly accurate results across all categories.

3.2. Discussion

The findings of this study demonstrate that the Monte Carlo method can be effectively applied to predict revenue in private educational services, particularly at PT Kanaka Belajar. With an MAPE (Mean Absolute Percentage Error) of 1.57% for the elementary school level, the simulation provides highly accurate forecasting results. This low error rate indicates that the model closely mirrors real-world conditions and can be used to support financial planning decisions. The results affirm that when processed with a probabilistic simulation model like Monte Carlo, historical meeting data can serve as a reliable basis for forecasting income in education-based enterprises.

Compared to traditional deterministic forecasting methods, Monte Carlo simulation provides flexibility by incorporating randomness and uncertainty inherent in the education service sector. This is especially useful in the case of PT Kanaka Belajar, where student enrollment and tutoring frequency may fluctuate due to academic calendars, policy changes, or economic factors. Studies by Putra [6] and Algifari [1] similarly found that Monte Carlo simulations could deliver high prediction accuracy for advertising and retail revenue, with MAPE values below 10% [1], [6]. These parallels strengthen the argument that Monte Carlo is a robust tool for revenue forecasting in various business sectors, including education.

The accuracy achieved in this study is also supported by previous works such as Syaputra (2023), who applied Monte Carlo in forecasting snack product sales, achieving a strong match between predicted and actual values [3]. Moreover, the simplicity and adaptability of the Monte Carlo method make it suitable for small to medium-sized enterprises that may not yet be ready to adopt more complex machine learning algorithms. The simulation in this study not only predicts monthly revenue but also assists in identifying months with potential financial instability, thus enabling more proactive budgeting and marketing strategies.

Despite the promising results, this study has limitations. The most notable is the limited scope of historical data, which only spans from 2021 to 2023. As PT Kanaka Belajar is a relatively new company, the available dataset may not capture broader trends or anomalies that could emerge over a longer timeframe. In addition, the prediction model was based primarily on the frequency of meetings without incorporating external variables such as promotional campaigns, changes in tutoring prices, or seasonal fluctuations. These factors, if integrated, could further refine the prediction model.

The findings from this study suggest that educational institutions, especially private tutoring companies, can benefit from adopting data-driven forecasting methods. Monte Carlo simulations can be integrated into financial planning systems to improve resource allocation, monitor cash flow, and support long-term sustainability. In a competitive industry where financial mismanagement can lead to early business failure, a reliable forecasting tool is not merely beneficial but essential. As shown by Nurani et al. [8], prediction models that use stochastic simulation can significantly improve the accuracy of financial decision-making processes in service-based businesses.

Future research should expand the dataset to include at least five years of historical data and consider incorporating additional variables such as pricing dynamics, student

retention rates, and macroeconomic indicators. Furthermore, comparing Monte Carlo simulations with more advanced predictive models such as ARIMA, Prophet, or machine learning algorithms (e.g., Random Forest, XGBoost) may provide deeper insights into model efficiency and performance. These comparative studies will enrich the academic understanding of forecasting in the education sector and help practitioners choose the most appropriate model based on scale, data availability, and organizational capability..

4. CONCLUSION

This study concludes that implementing the Monte Carlo method provides a highly accurate prediction model for estimating educational service revenue, particularly at the elementary school level. In the 2023 case study, the model successfully predicted 314 tutoring sessions with an estimated income of Rp33,127,000, while the actual data recorded 319 sessions and a total revenue of Rp33,654,500. This results in a small deviation of only five sessions, or Rp527,500 in income, yielding a MAPE value of 1.57%, indicating a very high forecasting accuracy level.

The results demonstrate that the Monte Carlo method effectively forecasts across different education levels. The accuracy of the prediction model is inversely related to the MAPE value: the smaller the MAPE, the higher the reliability of the forecast; conversely, a high MAPE indicates lower prediction accuracy. In this study, all tested education levels yielded MAPE values below 5%, confirming the robustness of the simulation approach.

The application of this model can assist PT Kanaka Belajar in projecting revenue more reliably, thus supporting better financial management and strategic planning. By incorporating historical meeting data and probabilistic modeling, the company is better equipped to anticipate future trends and allocate resources effectively.

In conclusion, the Monte Carlo simulation is a practical and reliable method for forecasting educational revenue, especially for small to medium-sized private tutoring institutions. Future implementations of this model may also benefit other educational providers seeking to improve their financial forecasting capabilities and operational efficiency.

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