WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Modeling the Number of Public-School Teachers in Junior High School: Trend and Predictions

Elvira L. Baliag [a]

[a] *Saint Mary's University, Bayombong 3700, Nueva Vizcaya Philippines E-mail address: elvirabaliag@gmail.com*
DOI: https://doi.org/10.55248/gengpi.4.823.51740

A B S T R A C T

This study provides an understanding of the effects of the factors determining the demand for secondary school teachers and its implication to the various sectors of the government related to the Department of Education. It established the trend in the number of public junior high school teachers in Cordillera Administrative Region, Philippines, sought if it has a linear relationship with the enrollment data, and explored the different time series models to find the best–fit model to predict the possible number of junior high school teachers for 3 consecutive years. The data used was downloaded from the Department of Education (DepEd) Website. This study revealed an increasing trend in the number of public-school teachers in junior high schools in the Cordillera Administrative Region from the school year 2010 – 2011 to 2020 – 2021. It also found that there exists a linear relationship between the number of public-school teachers and the number of enrollments in both male and female students in the junior high school in the Cordilleras. The best-fit model is the quintic function model. Using this model, the forecasted number of teachers in junior high school in CAR will increase to 5,711 for the school year 2021-2022, 6, 566 for S.Y 2022-2023 and 7, 627 for S.Y 2023 – 2024.

Keywords: Public junior high school teachers, Cordillera Administrative Region, Mathematical Modelling, Trend, Time Series Model, Prediction

1. Introduction

The secondary school teacher labor market faces many challenges including teacher shortages that occur alongside teacher surpluses, inadequate teacher distribution, and inefficient teacher utilization. Therefore, it is important to understand the effects of the factors determining demand for secondary school teachers and determine their implication to relative sectors. According to Wakumuru's (2016) study, the factors affecting the need for secondary school teachers in Kenya include the number of teachers on duty, the enrollment in secondary schools, class size, and the number of newly hired teachers each year. Additionally, they concluded that factors like the pupil-to-teacher ratio (PTR), the number of classes, the number of employed instructors, and teachers who lack the necessary policy controls and intervention procedures would raise the probability of a teacher shortage.

The number of students enrolled in a school is important because the curriculum revolves around the students. In their study, Daniel and Adair (2004) noted that a complex web of variables, including school quality, financial restrictions, and student preparation, affect enrollment trends in the school among other things. According to Mwirigi and Muthaa's (2015) study, trends toward high enrollment in primary schools contributed to overworked staff members, subpar teaching and learning environments, subpar sanitation infrastructure, and subpar classrooms. The improved enrollment has a significant impact on the standard of instruction in public primary schools. According to the study's conclusions, it is advised that the government take action to make facilities available that correspond to the enrollment of students.

According to Maligalig et al. (2010), classrooms and teachers are the most fundamental school resources, which are normally the basic inputs in education. While class size is typically correlated with the number of students per teacher, it is generally accepted that smaller classes promote better teaching and learning (Koc & Celik, 2015).

In the Philippines, the Cordillera Administrative Region is one of the regions with the lowest number of teachers in junior high school (DepEd Data Bits, 2022). This study aims to establish the trend of the number of public junior high school teachers in the Cordillera Administrative Region (CAR). The researcher also explores the relationship between the number of enrollment and the number of teachers and determines the best–fit model to predict the number of teachers. Specifically, this study seeks to:

1. Determine the trend of the number of public junior high school teachers in the Cordillera Administrative Region from school years 2010 – 2011 to 2020 – 2021.

2. Find if the number of teachers has a significant relationship with the total number of enrollments and according to the number of enrollees by gender and determine whether enrollees by gender is a significant predictor of the number of JHS teachers.

3. Construct a time series model to predict the number of teachers in JHS for the school years 2021 – 2022 and 2023 – 2024.

4. Determine the best-fit model and predict the number of teachers in JHS for the school years 2021 – 2022 and 2023 – 2024.

2. Methodology

The study is explorative-predictive and employs a quantitative approach to accomplish its objectives. The data used in the study was downloaded from the DepEd Website (*link: https://www.deped.gov.ph/alternative-learning-system/resources/facts-and-figures/datasets/*).

For the data analysis, a scatter plot was used to illustrate the trend of the number of public junior high school teachers while the linear relationship of the variables was analyzed using Linear Regression Analysis. Autocorrelation was measured using the Durbin-Watson Statistic. To construct the time series models, the school years were coded using simple numerical data while the actual number of teachers was reduced. The school years are represented by numbers starting from 1 to 11 as shown in Table 1 while the actual number of teachers was divided by 100.

Table 1. Coded Data

School Year (S.Y)	Year	Actual number of Teachers	Reduced Data
2010 – 2011	1	2,979	29.67
2011 – 2012	2	2,992	30.44
2012 – 2013	3	3,388	33.01
2013 – 2014	4	3,875	39.51
2014 – 2015	5	4,283	42.39
2015 – 2016	6	4,539	45.39
2016 – 2017	7	4,645	47.28
2017 – 2018	8	4,662	45.64
2018 – 2019	9	4,680	47.33
2019 – 2020	10	4,804	48.08
2020 – 2021	11	5,126	51.28

3. Results

Objective 1

Determine the trend of the number of public junior high school teachers in the Cordillera Administrative Region from school years 2010 – 2011 to 2020 – 2021.

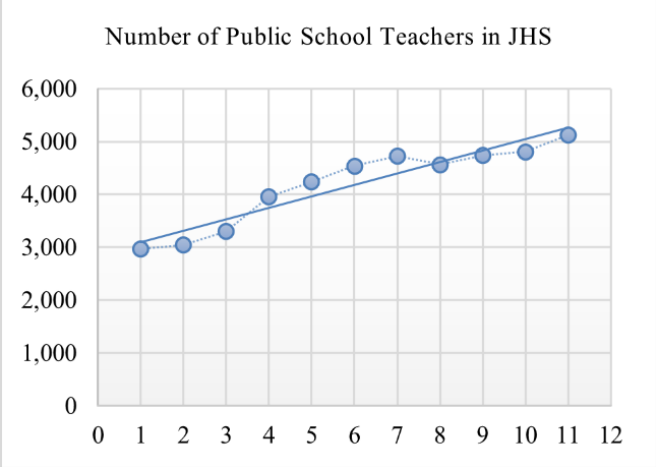

Figure 1. The Trend of the Number of Public Junior High School Teachers

It can be seen in Figure 1 that the number of public junior high school teachers in the Cordillera Administrative Region follows an increasing pattern from 2010 until 2021. The pattern suggests that throughout the following years, the number of public-school teachers may continue to increase.

The result entails a lot of possible occurrences such as an increase in enrollment to professional education courses due to higher demand of teachers in the public schools and additional classrooms or schools. The results of Wakumuru's (2016) study showed that the demand for teachers was significantly influenced by the number of teachers in the workforce. A rise in enrolment, for example, may also indicate an increase in other contributing elements, such as the number of teachers. Pupil Teacher Ratio (PTR), number of classes, number of streams, teacher workload, and government policy all had an impact on secondary school teacher demand collectively, but not significantly on it individually.

Objective 2

Find if the number of teachers has a significant relationship with the total number of enrollments and according to the number of enrollees by gender and determine whether enrollees by gender is a significant predictor of the number of JHS teachers.

Table 2. Regression Analysis of the Relationship Between the Number of Teachers and Male Enrollees

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-3923.57	1378.53	-2.8462	0.0192
Male	0.1728	0.0293	5.8985	0.0002

r = 0.891, F (1) = 34.7920, r^2 = 0.7945, p-value = 0.0002

Table 2 shows that there is a very strong correlation between the number of male enrollees and the number of teachers (*r = 0.8913*). There is also a significant linear relationship between the variables since p = 0.0002, p<0.01 at F (1) = 34.79. This suggests that the number of male enrollees significantly influences the number of teachers. The regression model, number of teachers = 0.1728*(number of male enrollees) – 3923.57, states that the number of teachers increases by 0.1728 in every unit increase in male enrollees, noting that 79.45% of the variances can be explained by the model.

Using the simple linear regression analysis, the results revealed that as the number of male enrollees increases or decreases, the number of teachers also increases or decreases, respectively. When the number of male enrollees is 52,000, the number of teachers is 5,062 whereas if the number of male enrollees is lowered to 43,000, the number of teachers is approximately down to 3,507. The change in the number of male enrollees helps teachers to prepare for their lessons considering the difference between the behaviors and characteristics of boys and girls in the classroom.

Table 3. Regression Analysis of the Relationship Between the Number of Teachers and Female Enrollees

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-8166.1300	1419.6689	-5.7521	0.0003
Female	0.2589	0.02972	8.7112	1.11395E-05

r = 0.9455, F (1) = 75.8859, r^2 = 0.8940, p-value = 0.0000

In Table 3, it is presented that there is a very strong correlation between the variables (*r = 0.95).* It is also shown that a linear relationship exists, p<0.01 (*p = 0.000, F (1) = 75.89),* between the number of female enrollees and the number of teachers. The regression model, number of teachers = 0.2589*(number of female enrollees) -8166.133, suggests that in every unit increase in the number of female enrollees, there is an increase of 0.2589 in the number of teachers. The 89.40% of the variance can be explained by the model.

Based on the simple linear regression analysis result as shown in Table 4, the number of teachers in junior high schools in CAR increases when there is an increase in female enrollees. When the number of female enrollees decreases, the number of teachers decreases. For example, when the number of female enrollees is 45, 000 which is within the range of values in the data, the number of teachers is around 3,484 while if the number of female enrollees increases to 53, 000 the number of teachers also increases to 5,556.

Table 4. Regression Analysis on the Relationship Between the Total Number of Enrollments and the Number of Teachers

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-5724.6363	1427.9484	-4.0090	0.0031
Total no. of enrollment	0.1047	0.0151	6.9533	0.0001

r= 0.9182, F (1) = 48.3480, r^2 = 0.8431, p-value = 0.000

Table 4 shows that there is a strong correlation, *r = 0.92*, between the total number of enrollments and the number of teachers. The p-value, *p = 0.000<0.01*, suggests that there is a linear relationship between the variables which is also demonstrated in the simple linear regression model, number of teachers = 0.1047*(number of enrollments) – 5724. 64. The model explains that in every unit increase in the number of enrollments, the number of teachers increases by 0.1047, of which 84.31% of the variance is explained by the model.

The study of Duah et al. (2022) stated that along with the increase in enrollment is the demand for more teachers; otherwise, the employed teachers are more likely to handle more than the standard class size. Challenges will surely emerge when this happens. The study further revealed that schools in Ghana experienced congestion in classrooms and dining halls, inadequate teaching and learning materials, inadequate hostel infrastructures, and high student-teacher ratio among others after the increase in enrollment in senior high school due to the Free SHS policy of their government.

Table 5. Multiple Regression Analysis Result

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-11551.3142	2195.5462	-5.2612	0.000763347
Male	-0.1769	0.0942	-1.8786	0.097114064
Female	0.5038	0.1330	3.7879	0.005328018

r = 0.9625, r^2 = 0.9080, F (2) = 50.37, p=0.0000

As seen in Table 5, the number of male enrollees (*p=0.0971*) is not a significant predictor of the independent variable; on the other hand, the number of female enrollees (*p=0.005*) is a predictor. The table further reveals that there is a linear relationship between the variables, p = 0.000. However, the number of male enrollees is not a significant predictor of the number of teachers since p=0.097 which is greater than the significance level, p=0.05 but the number of female enrollees is a significant predictor of the number of teachers since p=0.005, p<0.05. Moreover, the regression model, number of teachers = 0.5038*(number of female enrollees) – 0.1769*(number of male enrollees) – 1151.31, shows that the number of female enrollees positively influences the number of teachers while the number of male enrollees negatively influences the number of teachers. The adjusted r^2, 0.9080, indicates that 90.80% of the variances can be explained by the model.

The findings of the study reveal that when the number of female enrollees increases, the number of teachers also increases. The number of male enrollees does not predict the number of teachers. The researcher was not able to find other studies that determine whether the number of enrollments by gender is a significant predictor of the number of teachers.

Objective 3

Construct a time series model to predict the number of teachers in JHS for the school years 2021 – 2022 and 2023 – 2024.

Table 7. Time Series Model

Model	**Equation**	**R^2**	**Standard Error**
Linear	$y = 2.1702x + 28.799$	0.8985	2.5501
Exponential	$y = 29.585e^{0.0549x}$	0.8595	2.9998
Logarithmic	$y = 9.7837\ln(x) + 26.253$	0.9217	2.2401
Quadratic	$y = -0.1944x^2 + 4.503x + 23.744$	0.9547	1.7029
Cubic	$y = 0.0035x^3 - 0.2572x^2 + 4.8179x + 23.363$	0.9549	1.7005
Quartic	$y = 0.0228x^4 - 0.5448x^3 + 4.1065x^2 - 8.0677 + 34.055$	0.9921	0.7265
Quintic	$y = -0.0018x^5 + 0.0769x^4 - 1.1368x^3 + 6.9731x^2 - 13.928x + 37.805$	0.9936	0.6427
Sextic	$y = -0.0004x^6 + 0.0132x^5 - 0.1327x^4 + 0.2885x^3 + 2.1174x^2 - 6.3458x + 33.78$	0.994	3.6767
Power	$y = 27.531x^{0.2524}$	0.9389	1.9783
First Auto regression	$y_i = 660.2173 + 0.8913(y_{i-1})$	0.9068	207.1179
Second auto regression	$y_i = 1061.7028 + 0.866(y_{i-1}) - 0.0664(y_{i-2})$	0.8684	197.8246
Third auto regression	$y_i = 2026.4732 + 0.3838(y_{i-1}) + 0.1981(y_{i-2}) + 0.0172(y_{i-3})$	0.7529	179.3422
Fourth auto regression	$y_i = 1904.2068 + 0.4334(y_{i-1}) + 0.2577(y_{i-2}) - 0.1(y_{i-3}) + 0.2532(y_{i-4})$	0.2918	230.4483
Moving Average			116.2029
Exponential Smoothing			118.4441

Table 7 presents all the possible models that can be used to predict the number of public teachers in the junior high school in the Cordillera Administrative Region. The values of r^2 represent the percentage of variance while the Standard Error measures the discrepancy that can be expected in a sample estimate compared to the true value in the population. The higher the r^2 and the lower the standard error, the better the model.

Objective 4

Determine the best-fit model and predict the number of teachers in JHS for the school years 2021 – 2022 and 2023 – 2024.

From the models presented in the previous table, the least model to be used in forecasting the main variable is the Fourth autoregression as it has the lowest value of r^2 while having the highest value of standard error; on the other hand, the best-fit model is the quintic model (*r^2 = 0.9936, SE = 0.6427).*

Table 8. Forecast of the number of Teachers using the Quintic Model

$y = -0.0018x^5 + 0.0769x^4 - 1.1368x^3 + 6.9731x^2 - 13.928x + 37.805$	**Forecasted Value** ***Let y be the number of teachers and x be the year being predicted.***
(Year 12) 2021 – 2022	Let x = 12, $y = -0.0018(12^5) + 0.0769(12^4) - 1.1368(12^3) + 6.9731(12^2) - 13.928(12) + 37.805$ *=57. 11*100 =**5,711***
(Year 13) 2022 – 2023	Let x = 13, $y = -0.0018(13^5) + 0.0769(13^4) - 1.1368(13^3) + 6.9731(13^2) - 13.928(13) + 37.805$ *=65.66*100 = **6,566***
(Year 14) 2023 - 2024	Let x = 14, $y = -0.0018(14^5) + 0.0769(14^4) - 1.1368(14^3) + 6.9731(14^2) - 13.928(14) + 37.805$ *=76.27*100 = **7,627***

****The answer is multiplied by 100 as the data was divided by 100 when it was encoded for the construction of the time series model.*

Figure 2 presents the trend of the number of teachers from 2010 until the predicted value of the number of teachers in junior high school for the school years 2021 – 2022 to 2023 – 2024 using the quintic model *(see Table 8).*

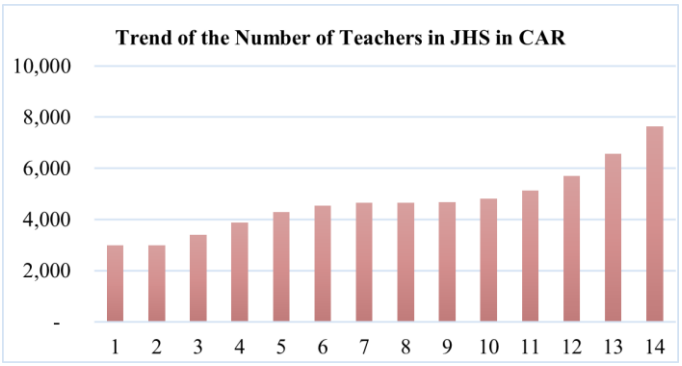

Figure 2. Trend of the Number of Teachers from 2010 – 2024 as Predicted Using the Quintic Model

Figure 2 shows a continuously increasing number of teachers from the school year 2010-2011 including the predicted values from school years 2021-2022 to 2023-2024. This contrasts with the study of Yang et al (2020) in Taiwan where the number of students and teachers decreased annually except in private primary schools from 1991 to 2018.

The number of enrollments is one of the major factors that may be considered in the increasing number of teachers. The rapid growth of secondary education, however, along with the dearth of suitable teaching and learning facilities, presents significant obstacles to effective teaching and learning in the classroom, which could have a significant impact on the standard of education provided (Duah et al, 2022).

4. Summary of Findings

Providing quality education entails a vast range of considerations. Among these is one of the major stakeholders in education, the teachers. Predictions can signal potential teacher shortages in advance, allowing policymakers and education authorities to take early intervention measures. Predicting the number of teachers is essential for efficient resource allocation, improved academic outcomes, and overall effectiveness in providing quality education to students. It aids in fostering a conducive learning environment and supporting the professional growth of educators.

After data analysis, the following are the findings of the study.

- The trend of the number of public junior high school teachers in the Cordillera Administrative Region follows an increasing pattern from the school year 2010 – 2011 to 2020 – 2021.
- There exists a linear relationship between the number of public junior high school teachers and the number of enrollments in both male and female students in the junior high school in the Cordilleras.
- The time series models of the number of public junior high school teachers from 2010 to 2021 are:

Linear	$\boldsymbol{y = 2.1702x + 28.799}$
Exponential	$y = 29.585e^{0.0549x}$
Logarithmic	$y = 9.7837\ln(x) + 26.253$
Quadratic	$y = -0.1944x^2 + 4.503x + 23.744$
Cubic	$y = 0.0035x^3 - 0.2572x^2 + 4.8179x + 23.363$
Quartic	$y = 0.0228x^4 - 0.5448x^3 + 4.1065x^2 - 8.0677 + 34.055$
Quintic	$y = -0.0018x^5 + 0.0769x^4 - 1.1368x^3 + 6.9731x^2 - 13.928x + 37.805$
Sextic	$y = -0.0004x^6 + 0.0132x^5 - 0.1327x^4 + 0.2885x^3 + 2.1174x^2 - 6.3458x + 33.78$
Power	$y = 27.531x^{0.2524}$
First Autoregression	$y_i = 660.2173 + 0.8913(y_{i-1})$
Second autoregression	$y_i = 1061.7028 + 0.866(y_{i-1}) - 0.0664(y_{i-2})$
Third autoregression	$y_i = 2026.4732 + 0.3838(y_{i-1}) + 0.1981(y_{i-2}) + 0.0172(y_{i-3})$
Fourth autoregression	$y_i = 1904.2068 + 0.4334(y_{i-1}) + 0.2577(y_{i-2}) - 0.1(y_{i-3}) + 0.2532(y_{i-4})$

- The best-fit model is the quintic function model. Using this model, the predicted number of teachers in junior high school in CAR will increase to 5,711 for the school year 2021-2022, 6, 566 for S.Y 2022-2023 and will reach 7,627 by S.Y 2023 – 2024.

5. Conclusions

As the trend of the number of public-school teachers continues to increase, all concerned stakeholders should take into consideration the factors to maintain and improve the quality of education in the different areas in the region without sacrificing and demanding so much from the teachers. Since there is a significant linear relationship between the variables, it is important to note that when the number of enrollments increases, impending results must be anticipated. The quintic model can be used to forecast data using the same historical data. However, the model might not be applicable for longer range forecasting.

6. Recommendations

Based on the findings of the study, the following recommendations were made:

- The concerned agencies must continue to conduct interventions to achieve the ideal class size and teacher-student ratio in public schools nationwide to provide students and teachers with environment conducive to learning.
- Allocate appropriate budgets and resources for hiring and training teachers. It helps ensure that schools have sufficient staff to meet the educational needs of students without overspending or understaffing.
- The Department of Education must ensure that they have enough teachers with specific subject expertise to cover the required subjects.

Further studies may be conducted to measure the accuracy of the predictions made in this study. The predictions may be compared with the actual number of teachers when the data is available. Several other factors may be considered in determining the possible predictors of the number of teachers and provide clearer explanation of its implications.

Acknowledgments

This research was made possible through the invaluable support and resources provided by the Department of Science and Technology through the DOST-SEI (CBPSME) Graduate Scholarship.

References

Daniels, M. & Adair, L. (2004). Growth in young filipino children predicts schooling trajectories through high school. *The Journal of Nutrition*. *134*(6),1439–1446.

DepEd Data Bits (2022). Retrieved from https://www.deped.gov.ph/wp-content/uploads/2022/08/4-Data-Bits-Public-School-Teachers-Apr.pdf

Department of Education Datasets. Retrieved from https://www.deped.gov.ph/alternative-learning-system/resources/facts-and-figures/datasets/

Duah, R., Gyabaah, K. Mensah, B., & Poku, A. (2022). Effects of increasing student enrollment on teaching and learning in senior high schools in Ghana: The free senior high school policy in retrospection. *Research Square.*

Engberg, M. E., & Wolniak, G. C. (2009). Examining the effects of high school contexts on postsecondary enrollment. *Research in Higher Education, 51*(2), 132–153.

Koc, N., & Celik, B. (2015). The impact of number of students per teacher on student achievement. *Procedia - Social and Behavioral Sciences, 177*, 65–70.

Maligalig, D. S., Caoli-Rodriguez, R. B., Martinez, A., & Cuevas, S. (2010). Education outcomes in the Philippines. *Asian Development Bank Economics Working Paper Series. 199*.

Wakumuru, D. K. (2016). Modelling the effects of teacher demand factors on teacher understaffing in public secondary schools in Kenya. *Journal of Education and Practice. 17*(3).

Yang, S., Chen, H., Chen W., & Yang, C. (2020). Student enrollment and teacher statistics forecasting based on time-series analysis. *Hindawi Computational Intelligence and Neuroscience, 2020,* 15 pages.