Effects of Survey Weights on the Ordinal Logistic Regression Modeling of Perceived Difficulty in Reading Comprehension From PISA 2018

Ronald Gerbaud Gucyam*, Flynt Razal, Mark Lenard Tan and Rechel Arcilla

Department of Mathematics and Statistics, De La Salle University 2401 Taft Avenue, Malate, Manila, Philippines, 1004
*Corresponding Author: ronald_gucyam@dlsu.edu.ph

Abstract: Recent literacy statistics reveal that Filipino students have poor reading comprehension. Perceived difficulty, typically impacted by teacher input and peer comparison, influences their motivation which may produce inadequate reading outcomes. This study employed a Proportional Odds (PO) Ordinal Logistic Regression analysis in identifying significant factors that affect the perceived difficulty of 15-year-old Filipino students in reading comprehension using the Programme for International Student Assessment (PISA) 2018 data. However, PISA employed a complex sampling design, and ignoring it would lead to misleading inferences. Thus, the effects of survey weights in PO modeling were also investigated. Results showed that coefficients and standard errors were overestimated when weights were ignored, and the significant predictors differ between the unweighted and weighted models. For both models, predictors that were found to be not significant were the support shown by the teacher in test language lessons and teacher-directed instructions. Meanwhile, the attitude of the students towards school learning activities, their exposure to bullying, their sense of belongingness in school, the interest being displayed by the teacher. In addition, the way of stimulating reading engagement by the teacher was found to be significant only for the weighted model.

Keywords: Ordinal Logistic Regression, Proportional Odds Model, Survey Weights, Reading Comprehension, PISA 2018

1. INTRODUCTION

The 2019 statistics from the Philippine Statistics Authority (PSA, 2020) and the United Nations Educational, Scientific and Cultural Organization Institute of Statistics (UNESCO, 2021) revealed exceptional results in literacy (95.0% and 98.4%, respectively). However, most students across various studies are still at frustration level regarding reading

skills (Camocamo & Ong, 2021; Tomas et al., 2021), implying poor reading comprehension among Filipinos. Reading outcomes have been underwhelming across various large-scale learning assessment programs. Most notably, the 2018 Program for International Student Assessment (PISA) (Organisation for Economic Co-operation and Development, 2019) ranked Filipinos the least among participating countries in terms of overall reading literacy, where merely 1 out of 5 students (19.4%) reached the baseline level of reading proficiency.

An abundance of PISA studies (Orbeta et al., 2020; Koyuncu & Firat, 2021; Bernardo et al., 2021) have discussed factors affecting the reading performance of students using plausible values in assessing the scholastic achievement of students. These studies considered reading self-concept, particularly the perception of difficulty as an affective influence contributing to the stunted reading outcomes. Identifying factors that influence the perceived reading comprehension difficulty among 15-year-old students can help address the issue of reading comprehension among Filipino students.

The perceived difficulty in reading comprehension of students is measured in PISA 2018 using ST161Q08HA (I find it difficult to answer questions about a text). Modeling such variable often employ Ordinal Logistic Regression (OLR). However, PISA 2018 used a two-stage stratified sampling design with probability proportional to size for schools and equal probability for Filipino students. The sample was implicitly divided into 17 strata corresponding to the Philippine regions. Hence, it is inappropriate to conduct OLR analysis without incorporating survey weights.

Thus, the objective of this study was to investigate the effect of ignoring survey weights on the OLR model for ST161Q08HA, along with identifying significant factors that influence the difficulty perception in reading comprehension of 15-year-old Filipino students. This is in congruence with improving the quality of education (Sustainable Development Goal 4) since the results can support educational sectors in their policy formulation along with teachers, parents, and other stakeholders in implementing strategies that can help address issues in reading comprehension among Filipino students.

2. METHODOLOGY

2.1 Data

This study utilized PISA 2018 data set containing student questionnaire responses across 79 countries which was filtered to only contain data from the Philippines. It contains information on student profiles, perceptions, and learning outcomes in reading, science, and mathematics among 15-year-old student.

The ordinal response variable of interest, ST161Q08HA, is a 4 point Likert scale question with responses Strongly Disagree, Disagree, Agree, Strongly Agree. Meanwhile, the explanatory continuous variables are indices which are standardized Likert scale responses, also known as Warm's likelihood estimates. These variables utilized in this study are listed in Table 1. Data cleaning was conducted since missing values were present. From the 7,233 original student respondents, data had been reduced to 5,897 respondents and was used in the analysis.

Table 1. PISA Variables Used in PO Modeling

Variable	Description
ST161Q08HA	Perceived difficulty in reading comprehension
ATTLNACT	Index on Attitude towards school: learning activities
BEINGBULLIED	Index on Students' experience of being bullied
BELONG	Index on Subjective well-being: Sense of belonging to school
TEACHSUP	Index on Teacher support in test language lessons
TEACHINT	Index on Students' perception on the teacher's interest in teaching
DIRINS	Index on Teacher-directed instruction
STIMREAD	Index on Students' perception on teacher's stimulation of reading engagement

2.2 Ordinal Logistic Regression

In identifying the factors that influence the difficulty perception of reading comprehension among 15-year-old students in the Philippines, OLR was used. Specifically, the Proportional Odds (PO) model was assessed without the involvement of interaction effects due to the complexity of analyzing an increased number of parameters.

Two PO models were fitted to demonstrate the effect of survey weights: the unweighted model and the weighted model. The backward selection procedure was used in identifying the predictors for OLR modeling since some studies say that the use of stepwise selection procedure may introduce bias in parameter estimation and result in inconsistencies among model selection algorithms (Whittingham et al., 2006).

In OLR modeling, the multicollinearity and PO assumptions were investigated, and the significance of each predictor was evaluated. Model fit statistics such as Likelihood Ratio statistic, Akaike Information Criterion (AIC), and Schwarz Bayesian Criterion (SBC) were calculated in assessing the adequacy of the PO models. All statistical computations were performed using SAS 9.4 with a 5% level of significance.

3. RESULTS AND DISCUSSION

Tables 2 and 3 present the results after employing the backward elimination procedure in PO Ordinal Logistic Regression analysis. Both unweighted and weighted models found TEACHSUP and DIRINS to be not significant in predicting Filipino students' perceived level of difficulty in reading comprehension while the predictors ATTLNACT, BEINGBULLIED, BELONG, and TEACHINT, were found to be significant. A different result was observed for the predictor STIMREAD where it was found to be not significant under the unweighted model but is considered significant under the weighted model.

Table 2. Maximum Likelihood Estimates for Reduced Unweighted PO model

Variable	PO Model-Unweighted		
	b (se)	Odds Ratio	p-value
1-SD	- 1.9522		<.0001*
2- D	0.3866		<.0001*
3- A	3.3344		<.0001*
ATTLNACT	0.0799 (0.0262)	1.083	0.0023*
BEINGBULLIED	- 0.3237 (0.0226)	0.723	<.0001*
BELONG	0.2869 (0.0354)	1.332	<.0001*
TEACHINT	- 0.1516 (0.0353)	0.859	<.0001*
STIMREAD	0.0555 (0.0296)	1.057	0.0612

*significant at $\alpha=0.05$

Table 3. Maximum Likelihood Estimates for Reduced Weighted PO Model

Variable	PO Model-Weighted		
	b(se)	Odds Ratio	p-value
1-SD	- 1.9226		<.0001*
2- D	0.4119		<.0001*
3- A	3.3240		<.0001*
ATTLNACT	0.0780 (0.015)	1.081	0.0052*
BEINGBULLIED	- 0.3253 (0.0109)	0.722	<.0001*

BELONG	0.2779 (0.0209)	1.320	<.0001*
TEACHINT	- 0.1604 (0.0184)	0.852	<.0001*
STIMREAD	0.0486 (0.0142)	1.050	0.001*

*significant at α =0.05

Furthermore, the logit coefficients and their corresponding standard errors decreased when weights were applied. The estimated logit regression coefficient for ATTLNACT decreased by 2.38%, and its corresponding standard error decreased by 42.75%, BEINGBULLIED by 0.49% and 51.77%, respectively, BELONG by 3.14% and 40.96%, TEACHINT by 5.8% and 47.88% respectively, and STIMREAD by 12.43% and 52.03%.

With the reduced weighted model, the estimated cumulative probability of difficulty perception among the reading comprehension of students can be exhibited through the odds equation model. This model can be used to calculate the odds of observing a level of difficulty perception of the students in their reading comprehension at level j or below. The equation is as follows:

$$\frac{P(Y \leq j)}{1 - P(Y \leq j)} = exp\left[\beta_{0_j} + 0.078X_1 - 0.3253X_2\right.$$

$$\left. +0.2779X_3 - 0.1604X_4 + 0.0486X_5\right]$$

where X_1 is ATTLNACT, X_2 is BEINGBULLIED, X_3 is BELONG, X_4 is TEACHINT and X_5 is STIMREAD.

In estimating the cumulative odds of being at or below a certain perceived level of difficulty in the reading comprehension of Filipino students, it is necessary to substitute the values of the estimated logit coefficients into the equation. Considering the first predictor, ATTLNACT, while holding the other variables constant, $e^{0.078} = 1.081$. The odds of being at or below a particular level of the perceived difficulty of the student's reading comprehension increases multiplicatively by a factor of 1.081 with a one-unit increase in the value of the predictor variable, the attitude of the students towards learning activities,

holding others constant. In simpler terms, students were less likely to be in a higher level of the difficulty perception of the student's reading comprehension with the increased frequency in the predictor of interest. Similarly, the odds of being at or below a level of perceived difficulty with BELONG and STIMREAD have the same interpretation, with values $e^{0.2779} = 1.320$ and $e^{0.0486} = 1.0498$, respectively.

On the other hand, considering the predictors BEINGBULLIED and TEACHINT, the odds of being at or below a particular level of the perceived difficulty of the student's reading comprehension decreases multiplicatively by a factor of $e^{-0.3253} = 0.722$ and $e^{-0.1604} = 0.852$ respectively. This is in consideration of a one-unit increase in the value of the predictor variable. Given this, Filipino students are more likely to be at a higher level of the perceived difficulty in the student's reading comprehension with the increased frequency in the predictor of interest.

It was revealed in the reduced weighted PO Model that the attitude of the students towards school learning activities (ATTLNACT), the sense of belongingness the students feel at school BELONG, and the experience of students in bullying (BEINGBULLIED), were found to be significant predictors. These results support the findings regarding the perception of difficulty in reading comprehension being influenced by the learning attitude (Nootens et al., 2019), bullying experience (Turunen et al., 2017), and sense of belongingness (Chang & Bangsari, 2020), which are deemed school experience factors. Similarly, factors relating to teacher influence, such as the interest shown by the teacher (TEACHINT) and the teacher's way of stimulating reading engagement (STIMREAD), were also found significant.

These are in congruence with the findings of Adebayo (2017) regarding teacher enthusiasm and Mohammend and Amponsah (2018) about teacher-stimulated engagement, both being influential teacher-related factors that affect the reading comprehension of students. However, the factors teacher support (TEACHSUP) and teacher-directed instructions (DIRINS) were found to be not significant in predicting Filipino students' perceived difficulty in reading comprehension. These findings contradict the claims about teachers expressing support (Jensen et

al., 2019) and on instructions given by teachers (Yan & Cai, 2021; Rupley et al., 2009) which have been claimed to positively affect the reading comprehension of students.

Despite the significant differences in AIC and SBC after weights are applied (Table 4), this does not imply that the unweighted model has a better fit than the weighted model since ignoring and including weights are two different methods that may produce two different results, which are incomparable.

Table 4. Summary Model Fit Statistics for Unweighted and Weighted PO Models

PO Model	Model	AIC	SBC
Unweighted	Null	13052.89	13072.94
	Full	12691.56	12758.38
	Reduced	12689.66	12736.43
Weighted	Null	2534376.9	2534412.7
	Full	2462505.5	2462625.0
	Reduced	2462543.9	2462639.5

4. CONCLUSIONS

This study demonstrated the effect when survey weights are ignored when dealing with datasets that have a complex sampling design. In particular, it explicated the difference between ignoring and incorporating survey weights in OLR modeling using PISA 2018, an extensive assessment dataset with a complex sampling design. The estimated unweighted and weighted PO models revealed that both coefficients and standard errors were overestimated when the weights were ignored. These confirmed the findings of the study by Liu and Koirala (2013).

Furthermore, both models had a different number of significant factors identified that influence the difficulty perception in reading comprehension. In addition to the attitude of the students toward school learning activities, their exposure to bullying, their sense of belongingness in school, and the interest being displayed by the teacher towards teaching, the weighted PO model identified another significant predictor which is the way of stimulating reading engagement by the teacher.

5. REFERENCES

Adebayo, O. (2017). The impact of mother tongue on students' achievement in English language in Junior Secondary Certificate Examination in western Nigeria. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/09718923.2008.11892632

Bernardo, A., Cordel II, M., Lucas, R., Teves, J., Yap, S., & Chua, U. (2021). *Using Machine Learning Approaches to Explore Non-Cognitive Variables Influencing Reading Proficiency in English among Filipino Learners.* Retrieved from https://www.mdpi.com/2227-7102/11/10/628/html

Camocamo, C., & Ong, C. (2021). *DEVELOPING A READING PROGRAM FOR JUNIOR HIGH SCHOOL.* Global Scientific Journals, 9(4), 584. Retrieved from https://www.globalscientificjournal.com/researchpaper/DEVELOPING_A_READING_PROGRAM_FOR_JUNIOR_HIGH_SCHOOL.pdf

Chang, Y., & Bangsri, A. (2020). Thai Students' Perceived Teacher Support on Their Reading Ability: Mediating Effects of Self-Efficacy and Sense of School Belonging. Retrieved from https://files.eric.ed.gov/fulltext/EJ1254856.pdf

Jensen, M., Solheim, O., & Idsøe, E. (2019). Do you read me? Associations between perceived teacher emotional support, reader self-concept, and reading achievement. OECDSocial Psychology of Education, 22(2), 247–266. Retrieved from https://doi.org/10.1007/s11218-018-9475-5

Koyuncu, I. & Fırat, T. (2021). *Investigating Reading Literacy in PISA 2018 Assessment.* International Electronic Journal of Elementary Education,

13(2), 263–275. Retrieved from https://www.iejee.com/index.php/IEJEE/article/view/1137

Liu, X. & Koirala, H. (2013). *Fitting Proportional Odds Models to Educational Data with Complex Sampling Designs in Ordinal Logistic Regression.* Retrieved from: https://digitalcommons.wayne.edu/cgi/viewcontent.cgi?article=1025&context=jmasm

Mohammed, I., & Amponsah, O. (2018). Predominant factors contributing to low reading abilities of pupils at Elsie Lund Basic School in the Tamale Metropolis, Ghana. Retrieved from https://files.eric.ed.gov/fulltext/EJ1208309.pdf

Nootens, P., Morin, M., Alamargot, D., Gonçalves, C., Venet, M., & Labrecque, A. (2019). Differences in attitudes toward reading: A survey of pupils in grades 5 to 8. Frontiers in Psychology, 9. doi:10.3389/fpsyg.2018.02773

OECD. (2019). *Philippines - Country Note - PISA 2018 Results.* Retrieved from https://www.oecd.org/pisa/publications/PISA2018_CN_PHL.pdf

Orbeta, A., Melad, K., & Potestad, M. (2020). *Correlates of Test Performance of 15-year-old students in the Philippines: Evidence from PISA.* Retrieved from https://pidswebs.pids.gov.ph/CDN/PUBLICATIONS/pidsdps2057.pdf

Philippine Statistics Authority. (2020). *Functional Literacy Rate is Estimated at 91.6% in 2019.* Retrieved from https://psa.gov.ph/content/functional-literacy-rate-estimated-916-percent-2019

PISA. (2018). *Pisa 2018 technical report.* Retrieved from https://www.oecd.org/pisa/data/pisa2018technical report/

Tomas, M., Villaros, E. and Galman, S. (2021). *The Perceived Challenges in Reading of Learners: Basis for School Reading Programs.* Open Journal of Social Sciences, 9, 107-122. Retrieved from https://doi.org/10.4236/jss.2021.95009

Turunen, T., Poskiparta, E., & Salmivalli, C. (2017). Are reading difficulties associated with bullying involvement? Learning and Instruction, 52, 130–138. Retrieved from https://doi.org/10.1016/j.learninstruc.2017.05.007

UNESCO Institute for Statistics. (2021). *Philippines.* Retrieved from http://uis.unesco.org/en/country/ph

Whittingham, M., Stephens, P., Bradbury, R., & Freckleton, R. (2006). *Why do we still use stepwise modelling in ecology and behaviour?* Retrieved from https://eprints.ncl.ac.uk/file_store/production/56364/AE9762E1-23E2-4C9D-9518-5BCDAD47FAAB.pdf

Yan, J., & Cai, Y. (2021). Teachers' Instruction of Reading Strategies and Primary School Students' Reading Literacy: An Approach of Multilevel Structural Equation Modelling. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/10573569.2021.1923100