Ordered Logistic Regression Model on How Logical and Rewarding is Learning Statistics Online

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Abstract

Statistics education amid the new normal faced a lot of challenges and barriers where students cannot seriously experience the logical and rewarding nature of statistics. This research article aimed to describe the logical and rewarding nature of statistics experienced by students in the new normal and elucidate the causal determinants. The study dealt with secondary and cross-sectional data from the current study in the literature. Standard descriptive measures, frequency table, and chi-square test were calculated to summarize the selected variables, and ordered logistic regression was employed to capture the influencing factors of how logical and rewarding learning statistics is. Results showed that, on average, statistics learning during distance education is both logical and rewarding. The regression models revealed that the predictors of the logical nature of statistics are younger students, male students, money for the internet, and a conducive place for learning. Meanwhile, the predictors of the rewarding nature of statistics are male students, household assets, physical health, money for the internet, and a conducive place for learning. Conclusively, students with more resources and a comfortable place for learning are likely to perform better and satisfied with learning. Hence, students in distance education must be provided with suitable tools for learning, and a healthy and conducive environment for studying.

Keywords: Statistics Education, Logical and Rewarding, Influencing Determinants, Ordered Logistic Regression, College Students

INTRODUCTION

The COVID-19 pandemic has changed the way of learning statistics into a difficult and unprecedented educational platform so-called new normal (Pham & Ho, 2020). Students are struggling to grasp the lessons, especially the formulas and equations since the statistics teacher cannot monitor their learning progress (Casinillo, 2022a). According to Kanneganti et al. (2020), academic institution has to adopt the online learning setup to continue serving the students in their education journey despite the challenges due to health protocols. In that case, statistics teachers have to continue teaching without any proper training in online learning and hence, they found statistics difficult to teach online (Casinillo, 2022b). In fact, formulas, symbols, and equations are hard to explain from an online perspective. Plus, teachers cannot monitor their students concerning their understanding and learning progress (Ní Fhloinn & Fitzmaurice, 2021). In the study of Rafique et al. (2021), it is depicted that most teachers are not ready and prepared to teach online learning environments during the pandemic. As a result, teachers cannot make their students think logically about statistics concepts, and learning the subject is not that satisfying or rewarding for them. So, it is sufficient to investigate the logical and rewarding aspect of statistics from students' view to formulate a teaching strategy that is suitable for the new normal.

On the students' side, they are also dealing with a difficult situation in understanding statistics lessons because of distractions in their learning environment. Students are distracted by technology features like online games, social media, and other video channels (Dontre, 2021). In addition, they are not able to concentrate on the technical aspect of the subject and at the same time they are experiencing anxiety because of health and financial crises (Dubey & Pandey, 2020). According to Hebebci et al. (2020), students and teachers are struggling to cope with distance education because of a lack of resources and even opportunities. In that case, both of them cannot maximize their ability in the teaching-learning process due to the limitations. In fact, statistics course is complex and technical that needs analytical thinking (Casinillo & Miñoza, 2020). Hence, teachers must make the learning process logical and creative so that students' cognitive ideas will be enhanced. However, students are challenged in acquiring a good internet signal to join the discussion in class online and working on their activities that need access to the internet (Irfan, 2020). In the face fit, according to Islam et al. (2020), students are dealing with anxiety in learning and depression in which they cannot focus on thinking about their lessons and are discontented with the situation. As a result, the logical nature of learning statistics is getting low, and students' satisfaction and performance are as well. Whence, investigating the logical and rewarding nature of statistics education at a distance is a way to get an idea of how to enhance the teaching strategies to become efficient and effective.

Statistics at distance education is well-studied and several articles in the body of literature deal with learning statistics online, however, assessing its logical and rewarding nature is very scarce. Moreover, modeling how logical and rewarding learning statistics online has never been studied especially in rural areas. Hence, this study is immediately performed. Generally, this article aimed to investigate the logical level and rewarding level of learning statistics at a distance from the student's point of view. Plus, the study captured the causal determinants (socio-demographic and learning profile) that govern how they perceived statistics in regard to how logical and rewarding it is amid the new normal. The purpose of this study is to develop an argument that improves the existing policies in distance education, especially in the field of statistics. In addition, the findings of this study may give detailed suggestions that the performance of both statistics students and teachers might improve and be efficient despite the challenges of distance learning. Moreover, the results and methodology of this article may serve as a piece of baseline information for many statistics educators and researchers to fill in the body of literature in the field of statistics education.

CONCEPTUAL FRAMEWORK

Statistics is a branch of applied mathematics that involved technical terms and mathematical knowledge, hence, it is overwhelming in regard to time. Miñoza and Casinillo (2022) portrayed that statistics course is a challenging task to learn and it requires good problem-solving skills, a logical mind, and creative thinking. In addition, since statistics is a course that has gotten a reputation that it is one of the difficult mathematics subjects, then surviving statistics class is considered rewarding. According to Garfield and Chance (2000), teaching statistics has issues and challenges that need to be addressed especially regarding the teacher's qualification and educational attainment in statistics. It is worth noting that teachers are a great factor in how statistics lessons must be learned by students. The challenge has intensified during the pandemic since teaching statistics has shifted from face-to-face to online learning. In the article by Coman et al. (2020), it is depicted that college teachers are not prepared to teach their courses because they lack resources and experience.

Plus, Junus et al. (2021) stated that lecturers during the new need proper training and workshop seminars to enhance their teaching strategies in online education. In that case, Chirinda et al. (2021) pictured that college teaching is quite challenging at a distance, especially for technical subjects like mathematics and statistics. Meanwhile, students also had their struggle with online learning due to a lack of focus (Suprianto et al., 2020), barriers and limitations (Casinillo, 2022a, 2022b), difficulty in adjusting to the new learning setup (Pham & Ho, 2020), technology distractions (Dontre, 2021), internet connection problem (Irfan et al., 2020), responsibilities at home (Suprianto et al., 2020), and lack of skills in devices (Islam et al., 2020), among others. In this regard, statistics learning is quite difficult during the new normal amid the health crisis where students are most likely to feel unsatisfied. Hence, to accomplish the objectives of this study, the conceptual framework considered the socio-demographic and learning profile of students as predictors of how logical and rewarding learning statistics online is.

METHODS

A descriptive-correlational research design was used in this article to capture the influencing factors of how logical and rewarding learning statistics online is amid the pandemic. The study employed cross-sectional and secondary data from the study of Casinillo (2022a) titled "Modeling Determinants of Challenge in Learning Statistics in Time of the COVID-19 Pandemic." The study focuses on the level of challenge in learning statistics at a distance and captured the governing determinants using a statistical model. However, the study did not focus on the perspective of the logical level and the rewarding level of students' experience in learning statistics at distance education. The study dealt with 129 participants (engineering students of Visayas State University (VSU)) using availability sampling by way of a Google form survey since the study was conducted during the lockdown of the university.

The data has undergone a clearing operation in which the extreme response and outliers were excluded from the data set. Plus, the study also excludes students with age above 25 years old and family income of above 100 thousand pesos (PHP) to make the data more or less homogeneous. Hence, this current study used 120 students as respondents. The independent variable considered in this study is the following: (1) the socio-demographic profile of students, and (2) the learning profile in statistics. For socio-demographic profile, it dealt with age, sex, home residence, family members, household assets, monthly family income, monthly household expenses, number of hours studying statistics lessons in a week, physical and mental health (1 to 10 scaling), leisure time (1 to 10 scaling). And for learning profile, dealt with the number of hours studying statistics lessons in a week, money spent on the internet in a week (PHP), internet access (1 to 10 scaling), possessing of laptop for online learning (yes or no), how conducive is the learning environment at home (1 to 10 scaling), and statistical anxiety (1 to 10 scaling).

Moreover, the dependent variable of this study is the following: (1) how logical is learning statistics online (1 to 10 scaling), and (2) how rewarding is learning statistics online (1 to 10 scaling)? The reliability coefficient of this 2-item question is 0.85 and it can be interpreted as reliable using the alpha coefficient by Cronbach (1951). Table 1 shows the mean possible perception, overall response of students, the equivalent verbal description, and coding for an ordered response.

Table 1. Students' perception scores and their corresponding verbal description

Perception Score	Response	Verbal Description	Code
1.00 - 2.80	Strongly disagree	Not logical/rewarding	0
2.81 - 4.60	Disagree	Slightly logical/rewarding	1
4.61 - 6.40	Neutral	Moderately logical/rewarding	2
6.41 - 8.20	Agree	Logical/rewarding	3
8.21 - 10.00	Strongly agree	Very logical/rewarding	4

In summarizing the selected data, standard statistical measures were computed that include mean average, standard deviation, and minimum and maximum observation. In addition, a cross-tabulation and chi-square test was used to determine the association between how logical and rewarding learning statistics is at distance education. Moreover, to capture the statistically significant factors on the logical and rewarding level in learning statistics, an ordered regression model was constructed using the code in Table 1. Assumption check and diagnostic tests (in the form of ordinary least square (OLS) method) were done to validate the regression results and all computations were through using STATA software.

RESULTS AND DISCUSSION

Profile of Students

The socio-demographic and statistical learning profiles of engineering students are presented in Table 2. It is revealed that the mean average age of students is close to 19.94 (SD=0.88) and with the youngest of 18 years old and the oldest being 23 years old. About 39% of these engineering students are male and 61% of them are female. On average, there are 76% of these students are living in urban places and

about 24% of them are living in rural areas where internet connectivity is sometimes a problem. The mean number of family members of these students is close to 6 (SD=1.89) with a minimum of 2 and a maximum of 13. The family member of 2 implies that a student is raised by a single parent/guardian. The mean average household assets, family monthly income, and monthly household expenses are PHP 181,892.90 (SD=PHP 337,106.10), PHP 20,728.33 (SD=PHP 15,295.85), and PHP 13,349.17 (SD=PHP 8,292.96), respectively.

On a scale of 1 to 10 scaling, on average, students' physical and mental health are 6.10 and 4.83, respectively (Table 2). They also have a leisure time of 6.65 (Scale of 1 to 10). Approximately, students are studying and review their statistics lesson for about 6.52 hours (SD=8.69 hours) within a week. They are spending PHP 232.48 (SD=PHP 205.81) per week for their internet load and they rated their internet connectivity as 5.43 (SD=1.98) on a scale of 1 to 10. About 83% of these students are using the laptop for their online learning activities and 17% of them are just using mobile phones for their distance education. Furthermore, these students rated their statistical anxiety as 7.13 (SD=1.91) and rated their learning environment at home as 5.68 (SD=2.29) on a scale of 1 to 10.

Table 2. Summary of students' profile

Students' profile	Mean	Std. dev.	min	max
Age of students in years	19.94	0.88	18	23
Dummy variable: Male	0.39	0.49	0	1
Dummy variable: Rural	0.76	0.43	0	1
Household size (counts)	5.64	1.89	2	13
Household assets (in Peso (PHP))	181,892.90	337,106.10	3,000	2,000,000
Family monthly income (in Peso (PHP))	20,728.33	15,295.85	1,000	80,000
Monthly household expenses (in Peso (PHP))	13,349.17	8,292.96	800	50,000
Physical health[s]	6.10	2.27	1	10
Mental health[s]	4.83	2.31	1	10
Leisure activities[s]	6.65	2.47	1	10
Number of hours studying statistics in a week	6.52	8.69	1	70
Internet connectivity rating[s]	5.43	1.98	1	10
Money spent for internet load (in Peso (PHP))	232.48	205.81	20	1,400
Statistical online anxiety[s]	7.13	1.91	1	10
Dummy variable: Availability of laptop for online learning	0.83	0.38	0	1
How conducive learning at home rating[s]	5.68	2.29	1	10

Note: s - Scale 1 to 10.

Logical and Rewarding Nature in Learning Statistics

On average, learning statistics online during the COVID-19 pandemic is considered "logical" and "rewarding" with mean perception scores close to 7.26 (SD=2.19) and 6.95 (SD=2.05), respectively. This implies that students are experiencing analytic questions and problems in learning statistics. Students are using reasoning and cognitive thinking in dealing with their statistical problems. According to Lai and Yang (2011), it is very important to develop the logical reasoning abilities of students to be good problem solvers. In the book of Dietz and Kalof (2009), statistics is a course that needs an analytical mind and a good logical foundation that makes reasoning a cogent fashion. On the other hand, students are contented with their experience in learning statistics during the pandemic which they found rewarding.

Moawad (2020) portrayed that learning online is interesting due to the suitable and convenient platform in which students can easily search for the information they need on the internet and this makes them rewarded at the same time. Plus, Rahiem (2021) depicted that students are still motivated in learning despite the limitations because they are influenced by their social friends and family, and they also like the learning atmosphere and setup. In that case, students are moving forward and driven to learn their lessons which makes it rewarding and satisfying. The chi-square test revealed that there is

an association (X^2=124.99, p-value<0.001) between how logical and how rewarding learning a statistics course in an online setup during the health crisis (Table 3).

This result is statistically significant at a 1% level showing that the association between the two variables is strong. In Table 3, it was revealed that most of the students who found statistics learning to be logical also experience that it is rewarding. Hence, this implies that as the logical nature of learning statistics concepts increases, students are more likely to experience a rewarding or satisfying education for them. According to Kertiyani and Sarjana (2022), logical and critical thinking is an important asset that students must possess to strive for good academic performance that will give them satisfaction in the learning process. Additionally, Graafsma et al. (2023), depicted that logical experience is vital in computing courses which gives a stimulating learning attitude to students.

Table 3. Distribution of students' responses on how logical and rewarding learning statistics is during the distance education

Logical category	**Rewarding category**					**Total**
	Not	***Slight***	***Moderate***	***Above average***	***Very***	
Not	1	2	1	0	0	4
Slight	2	5	2	1	0	10
Moderate	0	1	17	2	2	22
Above average	0	1	7	28	6	42
Very	0	2	1	17	22	42
Total	**3**	**11**	**28**	**48**	**30**	**120**

Predictors of Logical and Rewarding Nature

In the form of the OLS method, the following diagnostic tests were performed which include the Breusch-Pagan test for homoscedasticity, Ramsey RESET test for omitted variable bias, variance inflation factor (VIF) test for multicollinearity of independent variables, and Shapiro-Wilk test for normality of model's residuals as seen in Table 4. The following diagnostic tests are subject to at most a 5% level of significance. In that case, it was found that the first model (Dependent variable: Logical) has suffered from heteroscedasticity (X^2=9.84, p-value=0.001), this means that the variances of the model are not constant. However, model two is considered homoscedastic (X^2=1.61, p-value=0.205), where the variances are constant. In addition, the models have no omitted variable bias (Model 1: F=0.30, p-value=0.83; Model 2: F=0.67, p-value=0.57). Moreover, the two models do not suffer from a multicollinearity problem since VIFs are less than 10 as a rule of thumb by Allison (2012). Furthermore, the models' residuals (Model 1: Z=1.29, p-value=0.09; Model 2: Z=1.42, p-value=0.07) are normally distributed. Hence, the two ordered logistic models are valid and reliable in extracting and interpreting the findings as well as well-rounded for forecasting.

The first model is statistically significant at a 5% level and it has a model fit of R^2=0.095. This implies that some predictors influence the students in their experience of how logically learn statistics during the pandemic through online education. In that case, being logical was statistically influenced by age (p-value<0.10), sex (p-value<0.10), money spent on internet load (p-value<0.05), and how conducive their home is for learning (p-value<0.01). As for the second model, it is highly significant at a 5% level and it has a goodness-of-fit of R^2=0.106. This goes to infer that some causal factors influence the students in their experience of how rewarding learning statistics online is during the health crisis. So, model (2) reveals that being rewarding was statistically influenced by sex (p-value<0.10), household assets (p-value<0.05), physical health (p-value<0.10), money spent for internet load (p-value<0.05), and how conducive is their home for learning (p-value<0.01).

Model 1 revealed that younger students are more experiencing logical attitudes in statistics lessons. This means that younger age is more capable of learning and they are more mentally active as opposed to older students (Sharp, 2002). Also, model 1 has shown that male students perceived that statistics is logically compared to female students. Frid et al. (2020) depicted that mathematical courses are a male students domain wherein they are more engaged and performing better as opposed to female students. In addition, students who spend more money on the internet find statistics more logical and analytical to study. Note that if students can easily access the internet they can have more references that will help them understand their lessons. Clark and colleagues (2021) portrayed that access to the

internet is very helpful to students in doing their assessment tasks and students are well-performing in online learning due to available resources on the World Wide Web. Plus, it is revealed in model 1 that students who find their home as a conducive learning environment are more likely to perceive that statistics class is more logical. This means that students who are not disturbed by any distractions can penetrate the deeper and analytical concepts of statistics. Vollbrecht et al. (2020) stated that a good learning environment can positively contribute to the concentration of students in online learning in which they can perform better and use their cognitive learning attitude at their best.

Table 4. Ordered logistic regression for how logical and rewarding learning statistics online and its corresponding predictors amid the pandemic.

Predictors	**Ordered logistic regression**			
	Model 1: Logical		**Model 2: Rewarding**	
	Coefficient	***Std dev***	***Coefficient***	***Std dev***
Age of students in years	-0.349*	0.216	-0.324^{ns}	0.223
Dummy variable: Male	0.744*	0.425	0.733*	0.430
Dummy variable: Urban	0.001^{ns}	0.436	0.346^{ns}	0.446
Household size (counts)	0.126^{ns}	0.101	0.059^{ns}	0.99
log (Household assets (in Peso (PHP)))	0.101^{ns}	0.225	0.382*	0.228
log (Family monthly income (in Peso (PHP)))	-0.704^{ns}	0.905	-0.599^{ns}	0.918
log (Monthly household expense (in Peso (PHP)))	1.292^{ns}	1.071	0.873^{ns}	1.052
Physical health^{s}	0.137^{ns}	0.112	0.175*	0.108
Mental health^{s}	-0.019^{ns}	0.115	0.013^{ns}	0.113
Leisure activities^{s}	-0.018^{ns}	0.077	0.066^{ns}	0.076
Number of hours studying statistics in a week	0.039^{ns}	0.025	0.006^{ns}	0.019
Internet connectivity rating^{s}	0.038^{ns}	0.112	-0.062^{ns}	0.112
log (Money spent for internet load (in Peso (PHP)))	1.405**	0.596	1.412**	0.614
Statistical online anxiety^{s}	0.116^{ns}	0.104	0.117^{ns}	0.102
Dummy variable: Availability of laptop for online learning	0.243^{ns}	0.489	0.300^{ns}	0.505
How conducive learning at home rating^{s}	0.245***	0.095	0.239***	0.093
Number of observation	120		120	
Chi-square computed (X^2)	31.14**		34.74***	
p-value (two-tailed)	0.012		0.004	
Goodness-of-fit (R^2)	0.095		0.106	

Note: s - Scale 1 to 10. ns- not significant; * - significant at 10% level; ** - significant at 5% level; *** - significant at 1% level.

Model 2 has depicted that male students are more satisfied in learning statistics where they found it rewarding. This means that male students are performing better and are stimulated in doing their statistics learning activities (Frid et al., 2020). Moreover, model 2 revealed that students who have more household assets find their education in statistics more rewarding. It is worth noting that if students have more resources that provide comfort and they are more likely can focus on their studies. In the study by Azubuike et al. (2021), it is mentioned that students get to learn if they have more possessions at home since they can easily get what they need related to their studies and this makes them satisfied. It is revealed also in model 2 that students with good physical health are more active in learning statistics and say that it is rewarding for them. In fact, Apriyanto and Adi (2021) depicted that students with good physical health and activities are more likely effective in online learning. Additionally, model 2 shows that students who spend more money on the internet perceived learning statistics as rewarding. Dubey and Pandey (2020) stated that with the help of a good internet connection, they can perform better in doing their online learning tasks. Further, model 2 has presented that students with a conducive place for learning are more satisfied with learning statistics during the pandemic. This means that students are comfortable studying at their home and they can concentrate on their statistics lessons. Apparently,

Suprianto et al. (2020) stated that the effectiveness in learning takes place in a conducive environment that gives the students a rewarding experience.

CONCLUSION

The main goal of this article is to look into the logical and rewarding experience of engineering students in learning statistics through distance education amid the world health crisis. The descriptive statistics showed that, on average, students' perception of statistics online learning during distance education is both logical and rewarding. It is concluded that students have used their analytical thinking skills in their lessons and found that it is satisfying to learn. In addition, the ordered logistic regression models revealed that the influencing determinants of the logical nature of statistics amid distance education are being a young student, a male student, money for internet load, and a conducive place for learning at their respective homes. On the other hand, the significant determinants of the rewarding nature of statistics amid the new normal are being a male student, having household assets, physical health, money for the internet, and having a conducive place for learning. Thus, young male student is more active and engaging in a statistics class and are logical in their thinking skills which makes them motivated to learn. Moreover, a student with more resources and a comfortable place for learning is likely to perform better and satisfied with learning. Hence, the study suggests that students in distance education must be provided with suitable tools for learning that help them conveniently do their activities. Likewise, teachers must provide their students with a healthy and conducive environment for studying like giving them interest and doable tasks. To further understand the students learning in statistics in the new normal, one may study the students' learning attitudes and interests which is a potential weakness of this current article.

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