ISSN: 0975-833X

Available online at http://www journalcra.com

International Journal of Current Research
Vol. 16, Issue, 02, pp.27164-27167, February, 2024
DOI: https://doi.org/10.24941/ijcr.46747.02.2024

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

PROBLEM SOLVING STRATEGIES: REGRESSION ANALYSIS ON ASSESSMENT

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ARTICLE INFO

Article History:
Received 19th November, 2023
Received in revised form
18th December, 2023
Accepted 15th January, 2024
Published online 27th February, 2024

Key words:

Formative Assessments, Summative Assessments, Regression Equation Model.

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ABSTRACT

Effective assessment informs both students and instructors about learning progress and areas for improvement. Assessments point-out to students and teachers what to do to achieve the intended learning outcomes given the necessary support. This study aims to develop a predictive model that uses formative assessments to predict students' success on summative assessments through cross-sectional analysis. Data are collected from the formative and summative performances of fourth year college students. The collected data are analyzed using Descriptive Statistics, Shapiro-Wilk test, Pearson Product Moment Correlation and One-Way ANOVA. To shed light on formative tests' predictive power for summative outcomes, a linear equation model is created through linear regression analysis. Results show that when formative tests are used successfully to track students' progress, identify learning gaps, give timely feedback, students will have better summative performances. In light of the study, practitioners are encouraged to carefully design classroom assessments putting premium on formative assessments and feedback mechanisms to yield better learning outcomes.

Citation: Ardina, Genaro, Baguio, Apple Joy, Bedina, Socrates, Cejas, Earl Adrian, Niepes, Gendolf, Patindol Danielita, Sabornido, Elna and Villaver, Gerico. 2024. "Problem Solving Strategies: Regression Analysis on Assessment*". International Journal of Current Research, 16, (02), 27164-27167.*

INTRODUCTION

In today's shifting educational world, assessment acts as a compass, directing educators and students equally to the grounds of academic success. In the field of mathematics education, the quest of proficiency goes beyond rote memorization to the development of problem-solving skills and critical thinking abilities. These two goals, which are firmly connected in the foundation of mathematical pedagogy, highlight the importance of evaluation as a tool for navigating and evaluating students' progress on this intellectual journey. A diverse array of consultancies, think tanks, and entrepreneurs has emerged to satisfy that demand, portraying their approach as a pragmatic and objective form of evidence-based policy-making. However, the attempt to translate complex conditions into straightforward solutions leads researchers into a basic paradox that identifies the strategies used to address this paradox and to advocate reforms (Auld & Morris, 2016). Oftentimes, students perceived Mathematics as one of the boring and uninteresting subjects. They even seemed to be less energetic and fell asleep right in the height of class hours. They thought that Mathematics was just a mere subject wherein they simply have to sit down and use a calculator to pass and excel. With the inspiration and hope of improving better performance of the students, the researcher intended to innovate and design an assessment tool that would aid achieve the desired learning outcomes.

In this manner, it is like integrating effective assessment into the learning experiences of the students in measuring efficiently and accurately their academic improvement. Sustainable Development Goal 4 (SDG 4) is part of the United Nations' 2030 Agenda for Sustainable Development and aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." This goal is crucial for sustainable development as it recognizes education as a fundamental human right and a key driver of economic growth, social development, and environmental protection. SDG 4 encompasses various targets, including free primary and secondary education, equal access to quality education, the promotion of vocational and technical skills, and the provision of safe and inclusive learning environments. In the Philippine context, the Commission on Higher Education (CHED) reported that math performance among college students ranked poorly based on the results of the College Math Readiness Test (CMRT). It revealed a poor rating far from the desired and targeted performance. This condition sparked a light to decipher the increasingly alarming gap or space that needed to be filled out - an enormous room for improvement. At the heart of the assessment range are two separate but complementary types: summative and formative assessments. Formative assessments, offer instructors with crucial information about students' increasing comprehension and competency levels.

Formative assessments, through continuous feedback loops, enable educators to fine-tune their teaching strategies, address misconceptions, and scaffold learning experiences according to their students' different needs. This approach to learning not only promotes a culture of continual development, but it also instills in learners the resilience and adaptability required to deal with the difficulties of mathematical study. Summative assessments, on the other hand, provide a comprehensive view of students' overall comprehension and achievement of learning objectives (Ismail et. al., 2022). Addressing the relationship between formative and summative assessments is critical to improving educational processes. Using formative assessments to anticipate summative performance allows educators to proactively identify areas of strength and areas that require additional support, resulting in a more targeted and efficient learning environment.

Objectives: This study sought to develop a predictive model that used formative assessments to predict students' success on summative assessments. The purpose of this study was to address the following: (a) assess the level of the test performance of the respondents in dealing with different problem-solving strategies in mathematics, (b) assess the relationship between the formative and summative assessments, and (c) establish a regression equation model with formative assessments as the independent variable and summative assessments as the dependent variable.

METHODOLOGY

The study employed a cross-sectional analysis research design to examine the relationship and to develop a regression model between formative and summative assessments among fourth-year BEED students enrolled in Problem Solving. The study was conducted within the Higher Education Institution, specifically in the College of Teacher Education located in Cebu province. The college offered Bachelor of Elementary Education (BEED) and Bachelor of Secondary Education (BSED) programs (majoring in English, Mathematics, Filipino, and Social Studies) both of which were PACUCOA level III accredited. The researchers developed assessments tailored to the area of inquiry, including formative and summative assessments, which served as the primary data gathering instruments.

The collected data underwent thorough statistical analysis using a variety of methods. Descriptive statistics (mean, standard deviation, and percentage) were used to assess the students test performance. The Shapiro-Wilk test was used to assess the data's normality assumption. The degree and direction of the association between formative and summative assessments were determined using Pearson Correlation analysis. In addition, one-way ANOVA was used to assess significant differences for the validity of the predictors. Finally, Linear Regression analysis was used to create a linear equation model, which shed light on formative tests' predictive power for summative assessment outcomes. Throughout the study process, ethical considerations were prioritized. The study adhered to the principles of informed consent, recognizing participants' right to be fully informed about the research goal, procedures, and any effects before consenting to participate willingly. To protect participants' identities, confidentiality precautions were established, and individuals had the unambiguous right to exit from the study at any time without penalty. Furthermore, the research was committed to protecting participants' privacy and confidentiality by ensuring that all obtained data was anonymized and securely maintained.

RESULTS AND DISCUSSION

Table 1 shows the level of test performance of the students in different problem-solving strategies. The Summative Assessment, conducted once, resulted in a mean test performance with a standard deviation of ($M = 38.69$, $SD = 3.21$), equivalent to 77.38% performance, interpreted as "Developing." On the other hand, the Formative Assessment, conducted five times with 15 items each for assessment 1 to assessment 5 (*A1-A5*). The weighted mean of these five formative assessments were computed and yielded a test performance of 10 with a standard deviation of 0.46, equivalent to 66.67% performance, interpreted as "Beginning." Thus, other factors resulted in the increase of students' performance such as teaching and learning methodology, feedbacking and study habits of the students (Nicol, & Macfarlane-dick, 2006). The table 2 shows the normality testing of the data using the Shapiro-Wilk test. The test was recommended for its better power compared to other normality tests, especially for small sample sizes, and its results were often used to make decisions about the application of parametric statistical methods (Ghasemi & Zahediasl, 2012; Pandey et al., 2019). In the context of the study, a non-significant p-value ($p > .05$) from the Shapiro-Wilk test suggested that the data is normally distributed, since the test yielded a p-value greater than 0.05. This indicated that the data did not significantly deviate from a normal distribution, thus not violating the assumption of normality, allowing for the appropriate use of parametric statistical methods such as Pearson Product Moment Correlation, Analysis of Variance, and Linear Regression.

Table 3 shows the residual statistics for formative and summative assessments. The standard predicted values and standard residual ranges (-2.16 to 2.16 and -1.89 to 1.73, respectively) did not exceed the threshold value of ±3.00. This indicated that no outliers were included in the data. The absence of outliers in the residual statistics was critical since it meant that the data was not disproportionately affected by extreme values. This increased the reliability of the assessment results and the inferences formed from them. It also validated the strength of the chosen testing techniques and their ability to accurately measure students' performance without being affected by exceptional data points. This information was helpful for educators and researchers because it provided trust in the integrity of the assessment process and the validity of the data-driven findings. The table 4 shows a correlation matrix between formative and summative assessment. There was a moderate positive correlation between formative and summative assessment $r(27) = .649$, $p < .001$. Thus, there was a significant relationship between formative and summative assessment. This implies that as the formative assessment increases the summative assessment increases as well. The significant positive association between formative and summative assessments suggested that the effectiveness of formative assessments could have had a direct impact on student achievement as evaluated by summative assessments. When formative tests were used successfully to track student progress, uncover learning gaps, and give timely feedback, students were more likely to score well on summative assessments.

Table 1. The level of test performance of the students in different problem-solving strategies

Variable	Times of Assessment	M	SD	Performance Percentage	Interpretation
SA	1 time	38.69	3.21	77.38%	Developing
FA	5 times with 15-item each for FA1-FA5	10.00	.46	66.67%	Beginning

Note. N = 29. Beginning – (74% and below), Developing – (75-79%), Approaching Proficiency - (80-84%), Proficient - (85-89%), and Advanced – (90% and above). SA (Summative Assessment) and FA (Formative Assessment)

Table 2. The normality test using Shapiro-Wilk test

Statistic	*p*
.959	.317

Table 3. Residuals Statistics of formative and summative assessment

	Min	Max	M	SD	N
Predicted Value	34.19	43.19	38.69	2.08	29
Residual	-4.69	4.31	.00	2.44	29
Std. Predicted Value	-2.16	2.16	.00	1.00	29
Std. Residual	-1.89	1.73	.00	.98	29

Table 4. The correlation matrix between formative and summative assessment

Variable		A	B
A. Formative Assessment	Pearson's r	_	.649
	df	_	27
	p-value	_	<.001
B. Summative Assessment	Pearson's r	.649	_
	df	27	_
	p-value	<.001	_

Table 5. Model fit measures of formative and summative assessment

Overall Model Test							
Model	R	R^2	Adjusted R^2	F	df1	df2	p
1	.649	.422	.400	19.7	1	27	<.001

Table 6. Model coefficients of summative assessment

						95% Confidence Interval	
Predictor	Estimate	SE	t	p	Stand. Estimate	Lower	Upper
Intercept	-6.31	10.2	-0.62	.540			
FA	4.50	1.01	4.44	<.001	.649	.349	.950

This finding aligned with the work of Black and Wiliam (2010), which emphasized the importance of formative assessment in improving student learning outcomes. Table 5 shows the model fit measures of formative and summative assessment. The r-square value of .422 means that 42.2% of the variance in summative assessment was predicted from formative assessment. This gave light that formative assessment (FA) does predict the summative assessment (SA) mark (Siweya & Letsoalo, 2014). The p-value ($p < .001$) further showed a statistically significant relationship between formative and summative assessment. The one-way ANOVA also confirmed that there was a statistically significant difference in mean test score between formative and summative assessment ($F(1, 27) = 19.7$, $p < 0.001$). These findings suggest that FA is an effective tool for predicting SA and that both types of assessment are important for evaluating student progress. The table 6 shows the model coefficients of summative assessment. The bootstrapped 95% confidence interval for the slope to predict summative assessment from formative assessment ranges from .349 to .950.

This means that for every unit increase of formative assessment there was an increase of summative assessment for about .349 to .950 units. The developed regression equation for predicting the summative assessment from formative assessment was $y = -6.310 + 4.50(x)$ *or* $SA = -6.310 + 4.50(FA)$.The standard error was considered in developing the model especially when applied to population, so the establish a regression equation model may not precisely predict summative assessment. With these, the researchers took into account the error or deviation *(e)* of the study. Thus,$y = B0 + B1x + e$, where $y = B0 + B1$was linear component of the assessment and *(e)* meant error or deviation of the assessment. Generally, the provided information underscored the importance of understanding the limitations of regression models, acknowledging the presence of error, and interpreting coefficients within appropriate confidence intervals. These factors were critical for a thorough analysis and interpretation of assessment data.

CONCLUSION

Thus, formative assessments can predict students' success in their summative assessments in the context of problem-solving strategies in mathematics. Formative assessments create snapshots of the possible students' performance to improve their understanding and skills before the summative assessment. Note the limitations inherent in any predictive model. This should include factors such as teaching methodologies, student feedback mechanisms, and individual study habits, which can also play critical roles in influencing students' overall performance.

RECOMMENDATION

This study recommends that practitioners regularly integrate formative assessments into their teaching practices, using them to provide timely and specific feedback to students for improved understanding and performance in summative assessments. In addition, researchers can replicate the study in different contexts or subjects to check the effectiveness of formative assessments in achieving the outcome of any course or skill—also, students' experiences on the formative-summative assessment as a strategy for their learning.

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