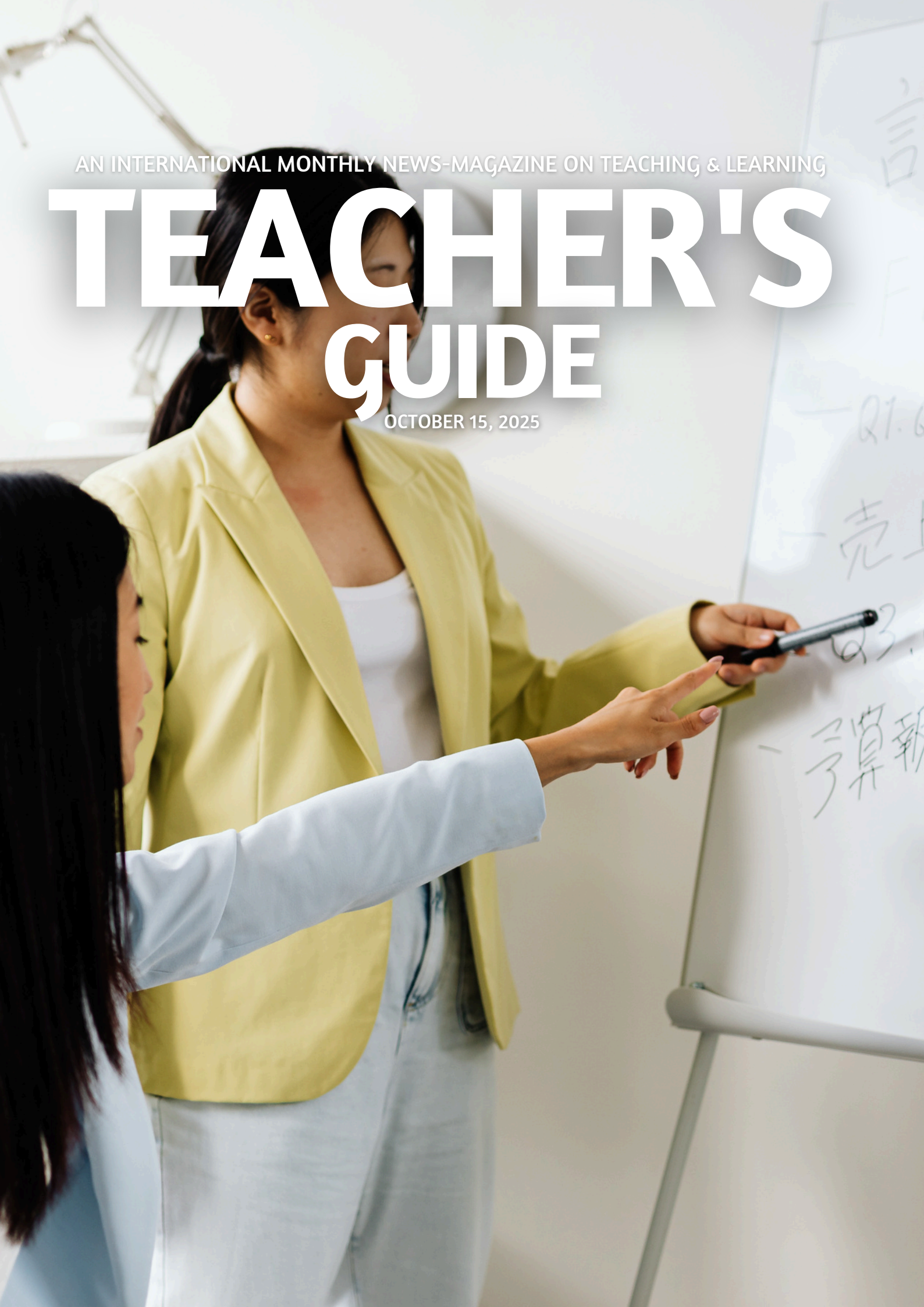


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TEACHER'S GUIDE

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Teacher's Guide

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Scholarly Article

Experimental Design and Analysis of Variance: Unveiling Insights through Controlled Variation *by Jonathan Edwin V. Remegia*

Statistical inference can be defined as an indispensable method for experiment design and analysis of variance (ANOVA), which enables an investigator to systematically investigate the issue of cause and effect and evaluate how different factors affect the observed results. In essence, experimental design provides the framework for performing controlled experiments, and ANOVA is a powerful statistical method for analyzing the data obtained from those experiments.

In this work, the main postulates of experimental design will be discussed, the principle of ANOVA will be considered, and the necessity of combining them in various scientific and practical spheres will be emphasized. Experimental design assumes that, through the manipulation of independent variables (factors) and the evaluation of their effects on dependent variables (responses), researchers can produce plausible claims concerning cause and effect. The presence of a well-designed experiment helps to eliminate the impact of extraneous variables, hence enhancing the internal validity of the study. Randomization, replication, and control are essential elements of experimental design.

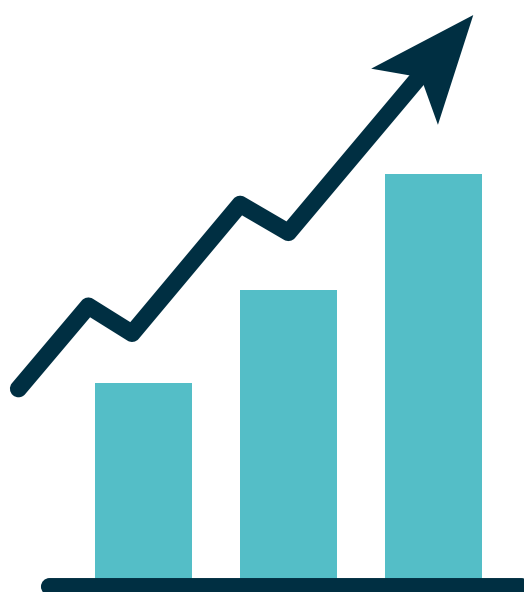
Randomization entails the random assignment of experimental units to different treatment conditions, which is known to help distribute possible confounding variables evenly among the other groups, thereby reducing bias. Replication can be described as the replication of the treatments several times, which increases the precision of estimations and enables us to examine variability. Control can be gained by using control groups or general procedures to establish a baseline effect for comparison, which helps isolate the effects of the variables being investigated. The real strength of a well-designed experiment lies in its ability to distinguish and measure the exact effects of varied factors, thereby presenting credible evidence of a causal effect. As Smith (2023) reiterates, this perhaps best exemplifies the power of a well-structured experiment.

Several popular experimental designs exist; these individual designs can support different research questions and environments. The most basic of these is the completely randomized design (CRD), in which the primary tool is the random assignment of participants to various treatments without any restrictions. When researchers have identified known sources of variability, such as blocks, they resort to randomized block designs (RBD). The method of grouping experimental units into similar groups and then randomly assigning treatments to various groups within these groups allows researchers to normalize the impact of variability among groups. On the one hand, factorial designs facilitate the concurrent analysis of multiple factors and their interactions. It is instrumental in the study of complex phenomena in which the factors affecting them can be intertwined. Factorial designs, as Johnson (2024) observes, enable the determination of interactions between two or more variables to gain a deeper understanding of the phenomenon under consideration.

Upon experimenting, researchers use ANOVA to analyze the data and determine whether there are significant differences among the treatment groups. ANOVA decomposes the total variation in the response variable into components that can be attributed to aspects such as the response to the treatments and random errors. The guiding principle of ANOVA is to examine the variance of the differences of the groups (the treatment variance) against the changes of the groups (the error variance). If there is a significant difference between the treatment variance and the error variance, it indicates that the treatments have a real effect on the response variable.

The key statistic in ANOVA is the F-statistic, which is the ratio of the estimated mean squares (of the treatment) to the error mean square. In the case of a significant F-statistic, it is more likely to indicate that the variance due to heterogeneity of treatments is significantly higher than the variance of error. Thus, the null hypothesis of the study, which states that there are no differences among the treatment groups, is more likely to be rejected. In addition, the p-value of the F-statistic indicates how likely it is that we would have observed the results (or even more drastic ones) if the null hypothesis were true. The small p-value will provide compelling evidence that the null hypothesis is not valid, thus indicating that the effects of the treatments are statistically significant. According to Williams (2022), ANOVA is an effective method for determining whether the observed differences between groups are due to chance events or have a meaningful effect resulting from the treatment.

ANOVA is based on three assumptions, including residuals, equal variances, and independent observations, which are derived from the standard distribution model. The failure of such assumptions may negate the trustworthiness of ANOVA results. To test and adjust these assumptions, tools such as residual analysis and data transformations can be used.



In a recent report by Brown (2023), robust methods of ANOVA have been identified as highly applicable. They are, therefore, significant when conducting tests or studies based on data that fail to comply with traditional assumptions, especially in the field of environmental science and social science.

ANOVA, as well as the application of the experimental design, takes place every day, almost in any sphere. With such methods, scientists in the farming industry use them to determine the effects of various fertilizers, pesticides, and irrigation techniques on yields. Clinical trials are medical experiments performed to evaluate the effectiveness and the safety of new pharmaceutical procedures and drugs. This is because engineers are allowed to make rectifications during the production process, thereby enhancing the quality of the final product. Social scientists use experimental studies to understand the impact that different interventions may have on the behavior and attitudes of people. The primary application of experimental design in business market research is in determining the effectiveness of advertisements for products. Davis (2021) states that ANOVA and experimental design, as a strategic approach, can be valuable in the field of pharmaceutical trials, as they affect the reliability and validity of clinical research, ultimately leading to improved patient outcomes.

After obtaining the required results using ANOVA, the difference between one or several groups of treatments is often assessed using post-hoc tests, particularly Tukey HSD and Bonferroni Corrections. The tests will give hints about the results of interventions. In addition, the magnitude of such effects can be measured in terms of effect size, represented by the size of the effect (Cohen's d or η^2), which provides a more accurate view of the results. Both the post-hoc tests and measures of the effect size, as noted by Lee (2025), help us better understand the results of ANOVA, thereby providing researchers with a clearer picture of the treatment effect.

ANOVA and experimental design help conduct efficient scientific studies and allow people to make informed choices. By performing the manipulation of the independent variables appropriately and analyzing the data obtained as a result, the researchers will not only be informed of the required data on the cause-and-effect relationship but will also be able to refer to the impact that the different variables had on the result. The main ideas of randomization, replication, and control, as well as the statistical power of ANOVA, provide a solid foundation on which to base the analysis of experimental results and draw valid conclusions.

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Dr. Jonathan Edwin V. Remegia completed his Doctor of Philosophy in Mathematics at the Philippine College of Health and Sciences and earned his Master of Arts in Education in Mathematics from Batangas State University. He holds dual licenses as a professional teacher and mechanical engineer. He is affiliated with the Philippine Council of Mathematics Teachers Educators (MATHTED), Inc., Mathematical Society of the Philippines (MSP) CALABARZON 4-A Chapter, and Southeast Asian Mathematical Society (SEAMS). Additionally, he is also affiliated with the Philippine Air Force Reserve Officer and Alpha Phi Omega Philippines. He is an active member of research-related organizations namely, International Congress of Innovation-Based Educators and Researchers (ICIBER), Inc., International Association of Research Scholars and Educators (IARSEI), Inc., Philippine Association of Researchers and Statistical Software Users (PARSSU), Inc., and Pambansang Samahan ng mga Propesyonal at Mananaliksik sa Pilipinas (PSPPI). He is currently a mathematics teacher at Talisay Senior High School situated in the Municipality of Talisay, Province of Batangas, Philippines.

Poem

Logic's Light (A Mathematics Poem) *by Gemma F. Agustin*

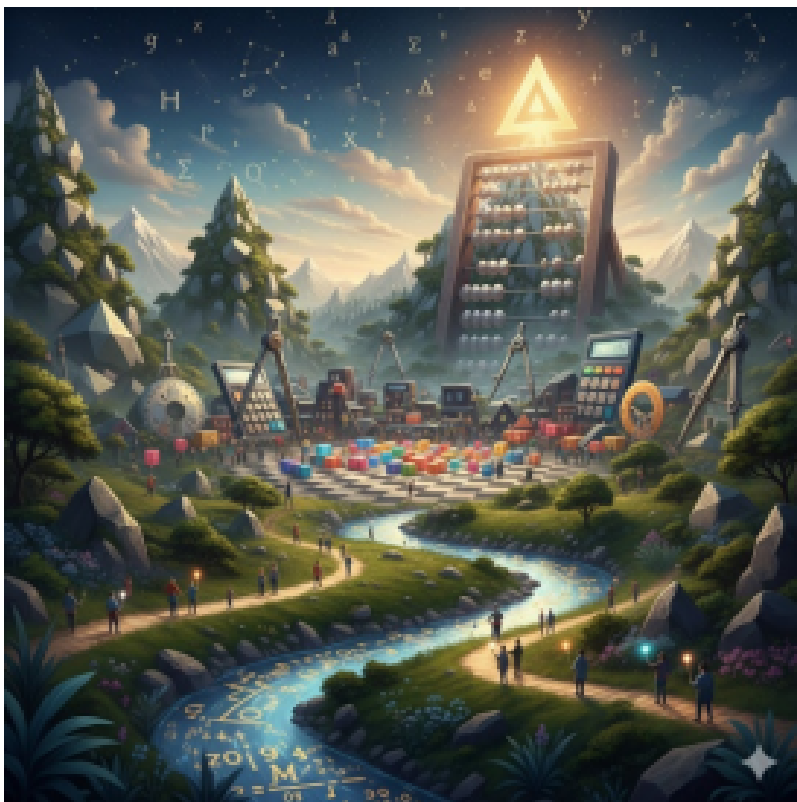
At first glance, it might be hard and boring to see,
One main factor is its difficulty.
But once you understand it, you begin to be
The next big mathematician in history.

Numbers, formulas, even letters of the alphabet,
That's just the surface; you have not seen anything yet.
But that doesn't mean those aren't important,
Take all the information and be absorbent.

Math isn't useless; you will know,
From counting money to using geometry.
In organizing items in rows,
There are many functions beyond compare,
To measuring lawns by the area of a square.

So look around, and you will find,
A world of patterns for the mind.
From simple sums to logic's light, Math turns the gray to
something bright.
No longer a chore or a climb so steep,
But a promise of wisdom you're meant to keep.

Gemma F. Agustin is a faculty member at Capiz State University, Roxas City Main Campus. She graduated Doctor of Education.



Poem

Integrity for the Nation We Share
by Charry B. Tachado

In halls of service sworn to serve the land,
Where public trust is placed in every hand,
Let truth stand firm against the lure of gain,
For corruption feeds the people's loss and pain.

We battle it not only through the law,
But by the courage citizens must draw;
By leaders who choose service over self
And guard the common good above all wealth.

It starts in homes, in schools, in daily ways,
In honest acts that shape our future days;
A nation grows when values guide each choice,
When conscience speaks and Filipinos' voice.

A legacy of honor, strong and deep,
Is the promise that our generation keeps;
So children born tomorrow may behold,
A Philippines whose heart is pure as gold.

Let transparency become our guiding light,
To chase the shadows from the depth of night;
For hidden deals and secrets breed decay,
While open truth restores the brighter day.

So let us rise as one, both firm and true,
To claim the trust the people rightly knew;
For only through integrity and care
Can we rebuild a Philippines more fair.

Charry B. Tachado holds a doctorate degree in Education and is a faculty member at Capiz State University Roxas City Main Campus in Roxas City.



Tula

Bawat Ikot, May Kwento ni John D. Catunao

Lumalakad,
Di tumitigil.
Di natutulog, laging gising
Di napapagod, wala namang sahod.

Ang saya tingnan,
Silang dalawa ay naghahabulan.
Samantala ako laging naghahabol
Sa kanyang walang kasiguraduhan.

Sa bawat ikot ng orasan
may umaalis, may dumarating.
May lumuluhang iniwan ng kahapon,
May tumatawang nakahanap ng pahinga.

Bakit di ka marunong maghintay?
Hindi ka ba napapagod?
Di ka ba nauubusan ng dahilan
para tumigil sandali?

Marahil,
kaya ka patuloy sa pag-ikot,
dahil alam mong may panahon ang lahat,
ang sakit, ang saya,
ang simula, at ang wakas.

Ito'y magsilbing ala-ala,
matututo huminga.
hindi para habulin ang oras,
kundi para mabuhay sa bawat segundo.

Ating pahalagahan,
Ang mga oras natin
Gaya ng tubig na dumadaloy sa batis
Hindi na ito mababalik sa atin

Gumawa ng kabutihan sa kapwa
Gawing kaugalian ang pagkawang-gawa
Hindi kabawasan ang pagiging maalwan
Magpasalamat sa Lumikha.

*John D. Catunao is a faculty member at Iloilo State
University of Fisheries Science and Technology - Dingle
Campus.*



Tula

Alaala ni Ina ni Angeline Mae A. Bueno

Ikaw ang punlang sa lupa'y nag-ugat,
Buhay ko'y bunga ng iyong paglingap.
Ilaw kang gabay sa dilim ng gabi,
Tinig mong wagas, himig ng pag-ibig.
Ngayo'y lumisan sa piling ng langit,
Puso'y naiwan, sugatang tahimik.
Sa kulubot ng palad, kwento ng hiras,
Sa bawat butil, pawis ang nailatag.
Sa bituin ng gabi, tanod kang buhay,
Sa ihip ng hangin, haplos mong tunay.
Ina, ikaw ang ilog na 'di matutuyo,
Sa aking puso'y habambuhay na buo.

Angeline Mae A. Bueno is a faculty member at Capiz State University, Roxas City Main Campus.



Tula

Daluyong ng Korapsyon, Ragasa ng Katarungan ni Ma. Sharmain Jane S. Magallanes

Mahaba-mahaba na rin ang panghahalay at paniniil
Gawa ng mga pesteng pinagpipyestahan ang buwis na sinisingil
Ang pagsusumamo ng nasa laylayan, hindi na nauulinigan
Pag-unlad ng masa, nakasangla sa kanilang bulok na bulsa't kaban

Ragasa ng baha, lubog sa burak ang mga siyudad at probinsya
O daluyong ng pagnanakaw, nagliligalig sa agos ng mga luha
Yaong nagkikihakos, walang awang nagkakandarapa
Estatwa na politiko, ay hayop kung sumunggab sa pera

Kay lubha na ng korapsyon na lumalason sa inang bayan
Tila isang sakit na yumuyurak sa pag-asa ng kinabukasan
O ilang proyekto pa ba ang maglalaho at mawawaldas?
Patuloy na lang ba ang salimuot at pait na ating dinadanas?

Alamano, dapat mapako yaong sinungaling at magnanakaw
Lalo na ang mga anak ng puta na sa salapi ay madaling nasilaw
Paano ang hustisya sa bansang inaalipusta ang mahihirap
At walang pakundangang pinagtatakpan ang madudungis na korap?

Kay lalim na ng baha ng kawalang-pananagutan ng mga nakaupo
Ginagapang rin ba ng leptospirosis ang mga hudas na politiko?
O mahabaging Diyos, lunod at nagpupumiglas na si Juan sa bagyo
Bitak na ang mga dike at tulay, gumuho na rin ba ang mga pondo?

Yung patas na lumalaban, mga komyuter at marangal na naghahapbuhay
Estero ng korapsyong dahan-dahang kumikitil sa kanilang mga buhay
Ramdam ang lalim at alab ng pakikibaka, mga nakapiring mulat na!
Nang sa gayo'y maakahon sa ipo-ipo ng kasakiman at pagsasawalang-bahala

O kayong mga nakaupo, tikman niyo ang hagupit ng bansang inabuso
Nakataas na ang bandila, naglalagablab ang dalisay na puso
Along trono ng mga sakim, ganid at mapagsamantala
Kikitilin ng mamamayan, gamit ang kalasag ng katarungan at pakikibaka

Oras na upang sugpuin ang alimpuyo ng pagkaganid
Reyalidad na nanlulupig, kalbaryo at pagdurusa ang tanging hatid
Ating pukawin ang bayang salat at matagal nang naidlip
Pilipinas gising na, sa kasuklam-suklam mong panaginip!

Ma. Sharmain Jane S. Magallanes holds a doctorate degree in Education and is a faculty member at Iloilo State University of Fisheries Science and Technology San Enrique Campus.

