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Interdisciplinary Research Review

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Editorial Note

The Interdisciplinary Research Review (IRR) was established with academic cooperation by The Royal Society of Thailand Committee of Interdisciplinary Research and Development, Rajabhat University (Western Group), and Rajamangala University of Technology Rattanakosin. This Issue, Volume 19 Number 4 (July – August 2024). This issue contains of four interesting articles in multidisciplinary fields: (1) Weighted Likelihood Estimator for Exponentiated Weibull Distribution, (2) Proximate Analysis and Sensory Evaluation of Processed Lubeg , (3) Cost Effectiveness of Implementing Community Quarantine in Selected Areas , (4) Upgrading Safety Shrimp Farmers to Digital Entrepreneurs of Nakhon Pathom Province, (5) Factors Influencing the Success of ISO 14001 Implementation in Honda Automotive Service Center, Thailand, (6) PREDICTORS OF YOUNG ENTREPRENEURIALLY-ORIENTED GENERATION, (7) Automatic Website Content Change Detection and Notification Using Image Processing, (8) Analyzing Errors in Mathematics Problem-solving Among High School Students

The Editorial Board of the IRR encourages anyone to submit articles for evaluation and review. The processes of submission, review and publication of articles are described on the journal's website, https://www.tci-thaijo.org/index.php/jtir. The Editorial Board and Committees of the IRR sincerely thank all peer reviewers who have sacrificed their time to help us produce a better journal, and also wish to thank all teachers, researchers and other academicians for submitting their valuable research to this journal. Finally, we thank readers of our journal who help to spread the knowledge and benefits gained to others. With your feedback and suggestions, we will strive to improve the quality and relevance of the IRR.

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Yongyudh Vajaradul
Editor
Interdisciplinary Research Review

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Weighted Likelihood Estimator for Exponentiated Weibull Distribution

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Abstract

In this study, weighted likelihood estimator was applied to the Exponentiated Weibull distribution (EW) with contamination and the performance of the maximum likelihood estimator and the weighted likelihood estimator was compared. The central distribution was fixed to be the Exponentiated Weibull distribution (α, β, θ) where α and β are the shape parameters and θ is the scale parameter with (2,1,1) and (2,2,2) and the contamination is Exponentiated Weibull distribution with parameter $\alpha_1 = \alpha(1 + \Delta), \beta_1 = \beta(1 + \Delta), \theta_1 = \theta(1 + \Delta)$ where $\Delta = 1, 5$ and the contamination proportion (ε)= 0.01, 0.03, and 0.05 and the values of pre–assigned small probability k= 0.01, 0.03, 0.05 with shape parameter α = 2. Monte Carlo simulation was performed to compare the performance of the maximum likelihood estimator and the weighted likelihood estimator for estimate β are the shape parameters and θ is the scale parameter. The simulation results are based on the 10,000 replace. The efficiency of the maximum likelihood estimator and the weighted likelihood estimator are compared based on the bias values and the root mean square error (RMSE). The result shows that the sample size increases as the bias and root mean square error of the maximum likelihood estimator and the weighted likelihood estimator decrease in most of the cases. The weighted likelihood estimator method for θ provides better than the maximum likelihood estimator, resulting in term of the bias and root mean square error when k is large for the estimator scale parameter θ. While the maximum likelihood estimator method for β provides better weighted likelihood estimator, resulting in term of the bias and root mean square error for the estimator shape parameter β. A real dataset on breaking stress of carbon fibers was presented to show the performance of the proposed methodology. Therefore, in the presence of contamination in the data highlights that the weighted likelihood estimator does the better estimates for the parameters.

1. Introduction

The Exponentiated Weibull (EW) distribution was introduced by Mudholkar and Srivastava [1], this distribution is an extension of the well-known Weibull distribution by adding shape parameter. The Exponentiated Weibull distribution has a scale parameter and two shape parameters. The properties of the distribution were studied by Gupta and Kundu [2]. They observed that many properties of the Exponentiated Weibull distribution are like those of the Weibull or gamma family. The Exponentiated Weibull distribution as a failure model is more realistic than that of monotone failure rates and plays an important role in the analysis of many types of survival data [3]. The applications of the Exponentiated Weibull distribution are used for modeling of extreme value data using floods, firmware system failure, distribution for excess-of-loss insurance data, and software reliability data [4]. The Exponentiated Weibull distribution has become more appealing in reliability engineering, such as when the performance of airborne optical communications is evaluated by modeling the atmospheric turbulence [5]. The stress data of carbon fibers and life test data of ball bearings

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are also fitted by the Exponentiated Weibull model [6].

The estimation of the parameters for Exponentiated Weibull distribution using the life testing data is an important problem. In life testing, due to the short total time spent on the experiment and the limited number of used units, the experiment is often terminated before all the units fail, according to Manisha et. al [7].

The maximum likelihood (ML) method is an effective and important approach for parameter estimation. The method finds a value of the parameter that maximizes the likelihood function. The maximum likelihood estimation (MLE) method has many large sample properties that make it attractive. It is asymptotically consistent, which means that as the sample size gets larger, the estimates converge to the true values. It is asymptotically efficient, which means that for large samples, it produces the most precise estimates. It is asymptotically unbiased, which means that for large samples, one expects to get the true value on average. The estimates themselves are normally distributed if the sample is large enough. These are all excellent large sample properties. However, it is complicated to solve the maximum likelihood equations by conventional numerical methods.

Real-life data often contain contaminated data due to various reasons. Consequently, we assume any sample group is a mixture of good and bad observations. Contaminated data refers to data points that deviate significantly from the expected pattern or distribution, potentially affecting the accuracy of analysis. Numbers far beyond the normal range, such as a person's height of 10 feet. Data points that don't fit the overall pattern, like a negative age value. Incorrectly recorded information was for example a typo in a numerical value and inaccurate readings from equipment or instruments readings from equipment or instruments. However, when data is contaminated with outliers, maximum likelihood estimation (MLE) becomes highly unreliable [8]. Regarding the Exponentiated Weibull distribution parameter estimation, no single method consistently outperforms others due to estimator properties and data variability. Estimating the EW parameters in the presence of outliers is crucial for reliability applications. Their estimation methods assume, however, that the number of outliers and their distribution families are known. Ahmed, Volodin, and Hussein [9] proposed the weighted likelihood estimator (WLE) for robust estimation of exponential distribution parameters. The weighted likelihood method was introduced as a generalization of the local likelihood method and can be global, as demonstrated by one of the applications in Hu and Zidek [10].

In this paper, the weighted likelihood estimator method for the parameters of the Exponentiated Weibull distribution was developed and proposed to obtain the estimates of the Exponentiated Weibull parameters when the data set shows contamination. Finally, the simulation studies were extended to compare the maximum likelihood estimation and weighted likelihood estimator methods based on the bias and root mean square error of the parameter estimator.

2. Weighted Likelihood Estimators

The Exponential Weibull (EW) family contains distributions with non-monotone failure rates besides a broader class of monotone failure rates [3]. The Exponentiated Weibull distribution has a scale parameter and two shape parameters [11]. The cumulative distribution function (cdf) and the probability density function (pdf) of a random variable described by the EW distribution is given by:

$$F(x) = \left[1 - exp\left(-\frac{x^{\beta}}{\theta^{\beta}}\right)\right]^{\alpha} \tag{1}$$

and $\quad f(x) = \frac{\alpha\beta}{\theta^{\beta}} x^{\beta-1} exp\left(-\frac{x^{\beta}}{\theta^{\beta}}\right)\left[1 - exp\left(-\frac{x^{\beta}}{\theta^{\beta}}\right)\right]^{\alpha-1} \quad ; x > 0, \alpha > 0, \beta > 0, \theta > 0. \tag{2}$

respectively, for $x > 0, \alpha > 0, \beta > 0,$ and $\theta > 0$, where α and β are the shape parameters and θ is the scale parameter.

Let $X_1, X_2, \ldots, X_n$ be a random sample of size n, drawn from a probability density function $f(x)$ where α, β, θ are an unknown parameter. Consider the Exponentiated Weibull distribution a probability density function given in (2), then the likelihood function will be:

$$L(\alpha, \beta, \theta) = \prod_{i=1}^{n} \frac{\alpha \beta}{\theta^\beta} x_i^{\beta-1} exp\left(-\frac{x_i^\beta}{\theta^\beta}\right)\left[1 - exp\left(-\frac{x_i^\beta}{\theta^\beta}\right)\right]^{\alpha-1} \tag{3}$$

Now the log likelihood function can be written as:

$$L(\alpha, \beta, \theta) = n\ln\alpha + n\ln\beta + (\beta-1)\sum_{i=1}^{n}\ln x_i - n\beta\ln\theta - \sum_{i=1}^{n}\left(\frac{x_i}{\theta}\right)^\beta + (\alpha-1)\sum_{i=1}^{n}\ln\left[1 - exp\left(-\left(\frac{x_i}{\theta}\right)^\beta\right)\right]. \tag{4}$$

Therefore, the maximum likelihood estimation of α, β, θ say $\hat{\alpha}, \hat{\beta}, \hat{\theta}$, respectively, where maximize must satisfy the normal equation given by

$$\frac{\partial}{\partial\alpha}L(\alpha, \beta, \theta) = \frac{n}{\alpha} + \sum_{i=1}^{n}\ln\left[1 - exp\left(-\left(\frac{x_i}{\theta}\right)^\beta\right)\right] = 0 \tag{5}$$

$$\frac{\partial}{\partial\beta}L(\alpha, \beta, \theta) = \frac{n}{\beta} + \sum_{i=1}^{n}\ln x_i - n\ln\theta - \sum_{i=1}^{n}\left(\frac{x_i}{\theta}\right)^\beta \ln\left(\frac{x_i}{\theta}\right) + (\alpha-1)\sum_{i=1}^{n}\frac{\left(\frac{x_i}{\theta}\right)^\beta \ln\left(\frac{x_i}{\theta}\right) exp\left(-\left(\frac{x_i}{\theta}\right)^\beta\right)}{1 - exp\left(-\left(\frac{x_i}{\theta}\right)^\beta\right)} = 0 \tag{6}$$

$$\frac{\partial}{\partial\theta}L(\alpha, \beta, \theta) = -\frac{n\beta}{\theta} + \frac{\beta}{\theta}\sum_{i=1}^{n}\left(\frac{x_i}{\theta}\right)^\beta - \frac{(\alpha-1)\beta}{\theta}\sum_{i=1}^{n}\frac{\left(\frac{x_i}{\theta}\right)^\beta exp\left(-\left(\frac{x_i}{\theta}\right)^\beta\right)}{1 - exp\left(-\left(\frac{x_i}{\theta}\right)^\beta\right)} = 0 \tag{7}$$

Numerical computation during data analysis used standard iterative procedures such as Newton-Raphson method [12]. It is obtaining the maximum likelihood estimation by maximizing equation (4).

Let $x^{(n)} = \{X_1, X_2, \ldots, X_n\}$ be a random sample from a distribution with a probability density function $f(x)$ where α, β, θ are an unknown parameter. The weighted likelihood estimators (WLE) of $\{\alpha, \beta, \theta\}$ are obtained by maximizing the weighted likelihood function:

$$L(\alpha, \beta, \theta \mid x^{(n)}) = \sum_{i=1}^{n} w_i(x^{(n)}) \ln(f(x_i; \alpha, \beta, \theta)), \tag{8}$$

where $w_i(x^{(n)}), 1 \le i \le n$ are the weights which depend on the sample. Following the idea presented by Ahmed, Volodin, and Hussein [9], we let the weight w_i that corresponds to the ith observation to be 1, if its estimated likelihood is sufficiently large, and 0 elsewhere. That is:

$$w_i = \begin{cases} 1 & if \quad f(x_i; \hat{\alpha}, \hat{\theta}, \hat{\beta}) > C \\ 0 & otherwise \end{cases} \tag{9}$$

where $\hat{\alpha}, \hat{\beta}, \hat{\theta}$ are the maximum likelihood estimation of the parameter (α, θ, β). We consider,

$$f(x_i; \hat{\alpha}, \hat{\theta}, \hat{\beta}) > C \tag{10}$$

$$\frac{\hat{\alpha}\hat{\beta}}{\hat{\theta}^{\hat{\beta}}} x_i^{\hat{\beta}-1} exp\left(-\frac{x_i^{\hat{\beta}}}{\hat{\theta}^{\hat{\beta}}}\right)\left[1 - exp\left(-\frac{x_i^{\hat{\beta}}}{\hat{\theta}^{\hat{\beta}}}\right)\right]^{\hat{\alpha}-1} > C \tag{11}$$

$$x_i^{\hat{\beta}-1} exp\left(-\frac{x_i^{\hat{\beta}}}{\hat{\theta}^{\hat{\beta}}}\right)\left[1 - exp\left(-\frac{x_i^{\hat{\beta}}}{\hat{\theta}^{\hat{\beta}}}\right)\right]^{\hat{\alpha}-1} > C\frac{\hat{\theta}^{\hat{\beta}}}{\hat{\alpha}\hat{\beta}}. \tag{12}$$

We assume that $C = a\left(\frac{\hat{\alpha}\hat{\beta}}{\hat{\theta}^{\hat{\beta}}}\right)$ where assume that a is chosen from the condition of a small probability of rejection of an observation when we sample from the non-contamination of the Exponentiated Weibull distribution with cumulative distribution function [9]. We define C by the given pre-assigned small probability k as:

$$k = P\left[\max_{1 \le i \le n} X_i > \hat{\theta}\left[-\ln\left(C\frac{\hat{\theta}^{\hat{\beta}}}{\hat{\alpha}\hat{\beta}}\right) + (\hat{\beta}-1)\ln(x_i) + \ln\left[1 - exp\left(-\frac{x_i^{\hat{\beta}}}{\hat{\theta}^{\hat{\beta}}}\right)\right]^{\hat{\alpha}-1}\right]^{1/\hat{\beta}}\right] \tag{13}$$

$$k = 1 - \prod_{i=1}^{n} P\left[x_i \leq \hat{\theta}\left[-ln\left(C\frac{\hat{\theta}^{\hat{\beta}}}{\hat{\alpha}\hat{\beta}}\right) + (\hat{\beta}-1)\ln(x_i) + ln\left[1 - exp\left(-\frac{x_i^{\hat{\beta}}}{\hat{\theta}^{\hat{\beta}}}\right)\right]^{\hat{\alpha}-1}\right]^{1/\hat{\beta}}\right]. \tag{14}$$

We get

$$a \approx \frac{n}{k}\left(x_i^{\hat{\beta}-1}\right)\left[1 - exp\left(-\frac{x_i^{\hat{\beta}}}{\hat{\theta}^{\hat{\beta}}}\right)\right]^{\hat{\alpha}-1} \tag{15}$$

$$x > \hat{\theta}\left[-ln\left(C\frac{\hat{\theta}^{\hat{\beta}}}{\hat{\alpha}\hat{\beta}}\right) + (\hat{\beta}-1)\ln(x_i) + ln\left[1 - exp\left(-\frac{x_i^{\hat{\beta}}}{\hat{\theta}^{\hat{\beta}}}\right)\right]^{\hat{\alpha}-1}\right]^{1/\hat{\beta}}. \tag{16}$$

So we reject an observation from the sample if:

$$x > \hat{\theta}\left[-ln\left(\frac{n}{k}\left(x_i^{\hat{\beta}-1}\right)\left[1 - exp\left(-\frac{x_i^{\hat{\beta}}}{\hat{\theta}^{\hat{\beta}}}\right)\right]^{\hat{\alpha}-1}\right) + (\hat{\beta}-1)\ln(x_i) + ln\left[1 - exp\left(-\frac{x_i^{\hat{\beta}}}{\hat{\theta}^{\hat{\beta}}}\right)\right]^{\hat{\alpha}-1}\right]^{1/\hat{\beta}} \tag{17}$$

$$x > \hat{\theta}\left[ln\left(\frac{n}{k}\right)\right]^{1/\hat{\beta}}. \tag{18}$$

Let the weighted likelihood estimator $(\tilde{\alpha}, \tilde{\theta}, \tilde{\beta})$ of the parameter (α, θ, β) be defined as the solution of the equation $\frac{\sum_{k=1}^{m} \partial f(x_{i_k}; \alpha, \theta, \beta)}{\partial \alpha} = 0$, $\frac{\sum_{k=1}^{m} \partial f(x_{i_k}; \alpha, \theta, \beta)}{\partial \theta}$ and $\frac{\sum_{k=1}^{m} \partial f(x_{i_k}; \alpha, \theta, \beta)}{\partial \beta} = 0$, where $x_{i_1}, x_{i_2}, ..., x_{i_m}$ are the remaining observations in the sample after the rejection method. In the case of the Exponentiated Weibull distribution:

$$L(\alpha, \beta, \theta) = \prod_{k=1}^{m} \frac{\alpha\beta}{\theta^{\beta}} x_{i_k}^{\beta-1} exp\left(-\frac{x_{i_k}^{\beta}}{\theta^{\beta}}\right)\left[1 - exp\left(-\frac{x_{i_k}^{\beta}}{\theta^{\beta}}\right)\right]^{\alpha-1}. \tag{19}$$

Now the log likelihood function can be written as:

$$L(\alpha, \beta, \theta) = m\ln\alpha + m\ln\beta + (\beta-1)\sum_{k=1}^{m}\ln x_{i_k} - m\beta\ln\theta - \sum_{k=1}^{m}\left(\frac{x_{i_k}}{\theta}\right)^{\beta} + (\alpha-1)\sum_{k=1}^{m}\ln\left[1 - exp\left(-\left(\frac{x_{i_k}}{\theta}\right)^{\beta}\right)\right]. \tag{20}$$

Therefore, the weighted likelihood estimator of α, β, θ say $\tilde{\alpha}, \tilde{\beta}, \tilde{\theta}$, respectively, which maximize must satisfy the normal equation given by:

$$\frac{\partial}{\partial \alpha} L(\alpha, \beta, \theta) = \frac{m}{\alpha} + \sum_{k=1}^{m}\ln\left[1 - exp\left(-\left(\frac{x_{i_k}}{\theta}\right)^{\beta}\right)\right] = 0 \tag{21}$$

$$\frac{\partial}{\partial \beta} L(\alpha, \beta, \theta) = \frac{m}{\beta} + \sum_{k=1}^{m}\ln x_{i_k} - m\ln\theta - \sum_{k=1}^{m}\left(\frac{x_{i_k}}{\theta}\right)^{\beta}\ln\left(\frac{x_{i_k}}{\theta}\right) + (\alpha-1)\sum_{k=1}^{m}\frac{\left(\frac{x_{i_k}}{\theta}\right)^{\beta}\ln\left(\frac{x_{i_k}}{\theta}\right)exp\left(-\left(\frac{x_{i_k}}{\theta}\right)^{\beta}\right)}{1 - exp\left(-\left(\frac{x_{i_k}}{\theta}\right)^{\beta}\right)} = 0 \tag{22}$$

$$\frac{\partial}{\partial \theta} L(\alpha, \beta, \theta) = -\frac{m\beta}{\theta} + \frac{\beta}{\theta}\sum_{k=1}^{m}\left(\frac{x_{i_k}}{\theta}\right)^{\beta} - \frac{(\alpha-1)\beta}{\theta}\sum_{k=1}^{m}\frac{\left(\frac{x_{i_k}}{\theta}\right)^{\beta}exp\left(-\left(\frac{x_{i_k}}{\theta}\right)^{\beta}\right)}{1 - exp\left(-\left(\frac{x_{i_k}}{\theta}\right)^{\beta}\right)} = 0. \tag{23}$$

It is obtaining the maximum likelihood estimation by maximizing equation (20) numerically. Numerical computation during data analysis by use of standard iterative procedures such as the Newton-Raphson method. The Newton-Raphson method can be applied to generate a sequence that converges to the weighted likelihood estimator.

3. Simulation Study

The comparison is based on the root mean square error as follows. Generate samples of 10,000 size (n) are 30, 50, and 100. We assume that the sample $(x_1, x_2, ..., x_n)$ is taken from the distribution $G_\varepsilon(x)$, the ε–contamination model is defined as $G_\varepsilon(x) = (1 - \varepsilon)F(x, \Theta) + \varepsilon F_1(x, \Theta_1)$. The central model $F(x, \Theta)$ is the Exponentiated Weibull distribution with parameter (α, β, θ). For the contamination $F_1(x, \Theta_1)$ is Exponentiated Weibull distribution with

parameter $(\alpha_1, \beta_1, \theta_1)$ where $\alpha_1 = \alpha(1 + \Delta), \beta_1 = \beta(1 + \Delta), \theta_1 = \theta(1 + \Delta)$ and $\Delta > 0$. Let ε denoted the contamination proportion where $0 < \varepsilon < 1$. If a random variable U has the uniform distribution on the interval $[0,1]$, it will have the Exponentiated Weibull distribution with parameter (α, β, θ). In this study, we consider the failure rate is increasing function when scale parameter α $\alpha > 1$, so we set $\alpha = 2$ and $\beta, \theta \geq 1$ so the central distribution to be the Exponentiated Weibull with $(2,1,1)$ and $(2,2,2)$. And the contamination is Exponentiated Weibull distribution with parameter $(\alpha_1, \beta_1, \theta_1)$ where $\Delta = 1, 5$ and $\varepsilon = 0.01, 0.03,$ and 0.05 and the values of preassigned small probability $k = 0.01, 0.03, 0.05$. We performed a Monte Carlo simulation to compare the perform of maximum likelihood estimation and the weighted likelihood estimator for estimate when β are the shape parameters and θ is the scale parameter. The simulation results are based on the 10,000 replace and the simulation was done uses statistical software R version 4.1.3. The efficiency of the maximum likelihood estimation and the weighted likelihood estimator were compared based on the bias values and the root mean square error. The bias values were considered as a bias for comparison between estimator methods, which take the following form: $Bias(\hat{\theta}) = E(\hat{\theta}) - \theta$ and $Bias(\hat{\beta}) = E(\hat{\beta}) - \beta$ when fix $\alpha = 2$. The root mean square error (RMSE) was considered as a bias for comparison between estimator methods, which take the following form: $RMSE(\hat{\theta}) = \sqrt{\frac{\sum_{i=1}^{10,000}(\hat{\theta} - \theta)^2}{10,000}}$ and $RMSE(\hat{\beta}) = \sqrt{\frac{\sum_{i=1}^{10,000}(\hat{\beta} - \beta)^2}{10,000}}$ when fix $\alpha = 2$.

4. Result and discussion

In this section, we compared the performance of the maximum likelihood estimation and weighted likelihood estimator methods to estimate parameters Exponentiated Weibull with outlier through simulation.

Table 1 presents the results on bias and root mean square error of the maximum likelihood estimation and the weighted likelihood estimator when the central distribution is the Exponentiated Weibull distribution with parameter $(2,1,1)$ and the contamination is $\Delta=1$. The sample size increases as the bias and root mean square error of the maximum likelihood estimation and the weighted likelihood estimator decrease in most of the cases in term of parameters θ and β. For the maximum likelihood estimation and the weighted likelihood estimator method both of parameters θ and β, the ε increase as the bias and root mean square error increase. For the weighted likelihood estimator method, the magnitude of the bias and root mean square error decrease as k increases. For $\varepsilon=0.03$, the weighted likelihood estimator method provides better results in terms of bias and root mean square error. The weighted likelihood estimator method provides better results in terms of bias and root mean square error compared to the maximum likelihood estimation method.

Table 2 presents the bias and root mean square error for maximum likelihood estimation and weighted likelihood estimator when the central distribution is the Exponentiated Weibull distribution with parameter $(2,1,1)$ and the contamination level is $\Delta=2$. Generally, both maximum likelihood estimation and weighted likelihood estimator decrease bias and root mean square error for parameters θ and β as sample size increases. However, increasing contamination proportion (ε) leads to higher bias and root mean square error for both estimators. The weighted likelihood estimator demonstrates a reduction in bias and root mean square error with increasing weight parameter (k). Notably, the weighted likelihood estimator outperforms the maximum likelihood estimation in terms of bias and root mean square error for sample sizes of 30 and 50 when $\varepsilon=0.05$. Overall, the weighted likelihood estimator shows better performance compared to the maximum likelihood estimation in terms of the bias and root means square error.

Table 1. Bias and RMSE of the MLE and WLE for parameter θ and β when $(\alpha,\beta,\theta) = (2,1,1)$ and $\Delta= 1$.

ε	method	$n = 30$ Bias $\hat{\theta}$	$\hat{\beta}$	RMSE $\hat{\theta}$	$\hat{\beta}$	$n = 50$ Bias $\hat{\theta}$	$\hat{\beta}$	RMSE $\hat{\theta}$	$\hat{\beta}$	$n = 100$ Bias $\hat{\theta}$	$\hat{\beta}$	RMSE $\hat{\theta}$	$\hat{\beta}$
0.01	MLE	0.038	0.067	0.164	0.171	0.030	0.045	0.127	0.125	0.024	0.035	0.090	0.088
	WLE ($k = 0.01$)	0.036	0.066	0.164	0.171	0.030	0.045	0.127	0.125	0.023	0.032	0.088	0.085
	WLE ($k = 0.03$)	0.033	0.065	**0.161**	**0.170**	0.029	0.044	**0.126**	**0.123**	0.024	0.033	0.088	0.085
	WLE ($k = 0.05$)	**0.031**	**0.063**	0.163	0.171	**0.029**	**0.044**	0.127	0.125	**0.022**	**0.030**	**0.086**	**0.084**
0.03	MLE	0.072	0.097	0.175	0.183	0.066	0.077	0.139	0.148	0.061	0.063	0.106	0.103
	WLE ($k = 0.01$)	0.069	0.096	0.173	0.183	0.066	0.077	0.137	0.147	0.060	0.063	0.104	0.103
	WLE ($k = 0.03$)	0.072	0.096	0.175	0.184	0.064	0.073	0.138	0.147	0.060	0.062	0.104	0.102
	WLE ($k = 0.05$)	**0.069**	**0.095**	**0.171**	**0.182**	**0.063**	**0.072**	**0.136**	**0.146**	**0.060**	**0.060**	**0.104**	**0.101**
0.05	MLE	0.108	0.132	0.191	0.206	0.102	0.111	0.160	0.162	0.097	0.093	0.129	0.138
	WLE ($k = 0.01$)	0.106	0.130	0.189	0.205	0.100	0.111	0.157	0.162	0.094	0.092	0.127	0.135
	WLE ($k = 0.03$)	0.107	0.131	0.191	0.210	**0.099**	**0.110**	**0.156**	**0.161**	0.097	0.092	0.128	0.138
	WLE ($k = 0.05$)	**0.103**	**0.130**	**0.188**	**0.204**	0.101	0.112	0.159	0.163	**0.094**	**0.090**	**0.127**	**0.130**

Table 2. Bias and RMSE of the MLE and WLE for parameter θ and β when $(\alpha,\beta,\theta) = (2,1,1)$ and $\Delta= 5$.

ε	method	$n = 30$ Bias $\hat{\theta}$	$\hat{\beta}$	RMSE $\hat{\theta}$	$\hat{\beta}$	$n = 50$ Bias $\hat{\theta}$	$\hat{\beta}$	RMSE $\hat{\theta}$	$\hat{\beta}$	$n = 100$ Bias $\hat{\theta}$	$\hat{\beta}$	RMSE $\hat{\theta}$	$\hat{\beta}$
0.01	MLE	0.096	0.131	0.185	0.211	0.089	0.108	0.150	0.162	0.084	0.090	0.120	0.122
	WLE ($k = 0.01$)	0.096	0.127	0.185	0.207	0.089	0.103	0.150	0.159	0.084	0.085	0.119	0.117
	WLE ($k = 0.03$)	0.095	0.125	0.184	0.197	0.087	0.103	0.149	0.152	**0.082**	**0.082**	**0.118**	**0.114**
	WLE ($k = 0.05$)	**0.092**	**0.118**	**0.182**	**0.195**	**0.087**	**0.098**	**0.148**	**0.150**	0.084	0.084	0.119	0.114
0.03	MLE	0.242	0. 271	0.287	0.328	0.235	0.240	0.264	0.276	0.231	0.218	0.246	0.236
	WLE ($k = 0.01$)	0.240	0.259	0.285	0.317	0.235	0.233	0.264	0.268	0.231	0.211	0.246	0.229
	WLE ($k = 0.03$)	0.239	0.259	0.285	0.317	0.233	0.222	0.262	0.256	**0.229**	**0.203**	**0.243**	**0.220**
	WLE ($k = 0.05$)	**0.235**	**0.245**	**0.281**	**0.299**	**0.232**	**0.218**	**0.260**	**0.252**	0.230	0.207	0.245	0.225
0.05	MLE	0.378	0. 398	0.407	0.447	0.373	0.364	0.391	0.393	0.369	0.338	0.378	0.353
	WLE ($k = 0.01$)	0.378	0. 384	0.407	0.433	0.372	0.351	0.391	0.380	0.369	0.332	0.378	0.347
	WLE ($k = 0.03$)	0.373	0. 366	0.404	0.412	0.370	0.343	0.388	0.372	0.368	0.322	0.377	0.336
	WLE ($k = 0.05$)	**0.373**	**0. 360**	**0.403**	**0.407**	**0.368**	**0.334**	**0.386**	**0.362**	**0.366**	**0.314**	**0.376**	**0.328**

Table 3. Bias and RMSE of the MLE and WLE for parameter θ and β when $(\alpha,\beta,\theta) = (2,2,2)$ and $\Delta= 1$.

ε	method	$n = 30$ Bias $\hat{\theta}$	$\hat{\beta}$	RMSE $\hat{\theta}$	$\hat{\beta}$	$n = 50$ Bias $\hat{\theta}$	$\hat{\beta}$	RMSE $\hat{\theta}$	$\hat{\beta}$	$n = 100$ Bias $\hat{\theta}$	$\hat{\beta}$	RMSE $\hat{\theta}$	$\hat{\beta}$
0.01	MLE	0.035	0.144	0.115	0.252	0.033	0.103	0.090	0.183	0.029	0.064	0.065	0.121
	WLE ($k = 0.01$)	0.034	0.135	0.115	0.247	0.033	0.096	0.090	0.181	0.029	0.061	0.065	0.121
	WLE ($k = 0.03$)	0.035	0.122	0.114	0.234	0.032	0.085	0.089	0.174	0.029	0.057	0.065	0.118
	WLE ($k = 0.05$)	**0.033**	**0.121**	**0.111**	**0.235**	**0.032**	**0.083**	**0.089**	**0.173**	**0.028**	**0.055**	**0.064**	**0.117**
0.03	MLE	0.091	0.208	0.129	0.280	0.085	0.157	0.104	0.203	0.082	0.122	0.084	0.145
	WLE ($k = 0.01$)	0.089	0.199	0.127	0.273	0.084	0.148	0.104	0.200	0.082	0.119	0.084	0.143
	WLE ($k = 0.03$)	0.090	0.186	0.129	0.256	0.084	0.141	0.104	0.194	0.081	0.116	0.084	0.140
	WLE ($k = 0.05$)	**0.086**	**0.185**	**0.127**	**0.257**	**0.084**	**0.138**	**0.104**	**0.191**	**0.081**	**0.113**	**0.083**	**0.138**
0.05	MLE	0.141	0.267	0.148	0.305	0.138	0.217	0.130	0.234	0.135	0.183	0.113	0.176
	WLE ($k = 0.01$)	0.141	0.255	0.148	0.296	0.137	0.208	0.129	0.229	0.135	0.176	0.113	0.171
	WLE ($k = 0.03$)	0.140	0.240	0.148	0.283	0.136	0.200	0.129	0.221	0.134	0.169	0.113	0.168
	WLE ($k = 0.05$)	**0.138**	**0.238**	**0.146**	**0.281**	**0.134**	**0.196**	**0.128**	**0.218**	**0.134**	**0.169**	**0.112**	**0.166**

Table 4. Bias and RMSE of the MLE and WLE for parameter θ and β when $(\alpha, \beta, \theta) = (2,2,2)$ and $\Delta = 5$.

ε	method	$n = 30$				$n = 50$				$n = 100$			
		Bias		RMSE		Bias		RMSE		Bias		RMSE	
		$\hat{\theta}$	$\hat{\beta}$	$\hat{\theta}$	$\hat{\beta}$	$\hat{\theta}$	$\hat{\beta}$	$\hat{\theta}$	$\hat{\beta}$	$\hat{\theta}$	$\hat{\beta}$	$\hat{\theta}$	$\hat{\beta}$
0.01	MLE	0.128	0.242	0.143	0.294	0.123	0.193	0.122	0.219	0.121	0.156	0.105	0.161
	WLE ($k = 0.01$)	0.126	0.226	0.143	0.283	0.123	0.185	0.122	0.215	0.120	0.151	0.104	0.157
	WLE ($k = 0.03$)	0.126	0.217	0.143	0.272	0.122	0.177	0.121	0.210	0.121	0.146	0.104	0.154
	WLE ($k = 0.05$)	**0.124**	**0.213**	**0.142**	**0.270**	**0.121**	**0.173**	**0.120**	**0.206**	**0.120**	**0.143**	**0.104**	**0.152**
0.03	MLE	0.362	0.491	0.277	0.438	0.357	0.434	0.266	0.363	0.353	0.389	0.256	0.304
	WLE ($k = 0.01$)	0.361	0.475	0.277	0.422	0.355	0.424	0.265	0.352	0.353	0.380	0.256	0.297
	WLE ($k = 0.03$)	0.359	0.462	0.277	0.411	0.356	0.414	0.265	0.346	0.351	0.377	0.255	0.295
	WLE ($k = 0.05$)	**0.357**	**0.457**	**0.275**	**0.405**	**0.354**	**0.407**	**0.264**	**0.341**	**0.350**	**0.372**	**0.254**	**0.291**
0.05	MLE	0.589	0.744	0.430	0.602	0.585	0.674	0.422	0.521	0.581	0.624	0.415	0.463
	WLE ($k = 0.01$)	0.589	0.716	0.430	0.579	0.585	0.666	0.422	0.515	0.580	0.618	0.414	0.459
	WLE ($k = 0.03$)	0.588	0.695	0.429	0.562	0.584	0.643	0.421	0.497	0.580	0.604	0.415	0.448
	WLE ($k = 0.05$)	**0.585**	**0.687**	**0.427**	**0.554**	**0.582**	**0.637**	**0.420**	**0.492**	**0.579**	**0.597**	**0.413**	**0.443**

Table 3 presents a comparison of the maximum likelihood estimation and the weighted likelihood estimator in terms of bias and root mean square error for the Exponentiated Weibull distribution with parameter (2,2,2) distribution with a contamination level of $\Delta=1$. Results indicate that both maximum likelihood estimation and weighted likelihood estimator generally decrease bias and root mean square error for parameters θ and β as sample size increases. However, increasing contamination proportion (ε) leads to increases in bias and root mean square error for both estimators. The weighted likelihood estimator demonstrates a reduction in bias and root mean square error with increasing weight parameter (k). Notably, the weighted likelihood estimator outperforms the maximum likelihood estimation in terms of bias and root mean square error for all sample sizes when ε=0.05. Overall, the weighted likelihood estimator method provides better results in terms of bias and root mean square error compared to the maximum likelihood estimation method.

Table 4 presents the results on bias and root mean square error of the maximum likelihood estimation and weighted likelihood estimator when the central distribution is the Exponentiated Weibull distribution with parameter (2,2,2) and the contamination level is $\Delta=2$. As the sample size increases, the bias and root mean square error of both maximum likelihood estimation and the weighted likelihood estimator generally decreases for parameters θ and β. Both estimation methods exhibit increased bias and root mean square error as the contamination proportion (ε) increases. For the weighted likelihood estimator, the magnitude of bias and root mean square error decreases as the weight parameter (k) increases. When ε=0.05, the weighted likelihood estimator outperforms the maximum likelihood estimation in terms of bias and root mean square error across all sample sizes.

Overall, the weighted likelihood estimator provides better performance compared to the maximum likelihood estimation in terms of bias and root mean square error.

5. Real data Analysis

In this section, a real dataset is presented to show the performance of the proposed methodology. We consider a data set on breaking stress of carbon fibers (in Gba) from Nichols and Padgett [13] which includes the following values: 3.7, 2.74, 2.73, 2.5, 3.6, 3.11, 3.27, 2.87, 1.47, 3.11, 4.42, 2.41, 3.19, 3.22, 1.69, 3.28, 3.09, 1.87, 3.15, 4.9, 3.75, 2.43, 2.95, 2.97, 3.39, 2.96, 2.53, 2.67, 2.93, 3.22, 3.39, 2.81, 4.2, 3.33, 2.55, 3.31, 3.31, 2.85, 2.56, 3.56, 3.15, 2.35, 2.55, 2.59, 2.38, 2.81, 2.77, 2.17, 2.83, 1.92, 1.41, 3.68, 2.97, 1.36, 0.98, 2.76, 4.91, 3.68, 1.84, 1.59, 3.19, 1.57, 0.81, 5.56, 1.73, 1.59, 2 ,1.22, 1.12, 1.71, 2.17, 1.17, 5.08, 2.48, 1.18, 3.51, 2.17, 1.69, 1.25, 4.38 ,1.84, 0.39, 3.68 ,2.48, 0.85 ,1.61 ,2.79 ,4.7 ,2.03 ,1.8 ,1.57 ,1.08 ,2.03 ,1.61, 2.12, 1.89, 2.88, 2.82, 2.05 and 3.65. This suggests that the data set following the Exponentiated Weibull distribution were fitted by the method of maximum likelihood. The ML estimators of parameter (α, β, θ) is (1.317, 2.409, 2.682) as shown in Table 5. The goodness-of-fit test for the exponentiated Weibull distribution yielded a Kolmogorov-Smirnov statistic (KS) of 0.0064 with a p-value of 0.8014, indicating a good fit. To create a contamination of 1% (ε=0.01) into the data set, the last observation (3.65) was changed to 7.65. Applying the maximum likelihood approach to the contaminated data

yielded the maximum likelihood estimation of (2.494, 1.628, 2.041) with a log-likelihood of -148.085. The weighted likelihood estimator approach produces estimates of (1.367, 2.353, 2.635) with a log-likelihood of -139.783.

Therefore, the presence of contamination in the data highlights that the weighted likelihood estimator does the better estimates for the parameters.

Table 5. Parameters of the fitted distributions

Method	α (S.E.)	β(S.E.)	θ(S.E.)	-Log Likelihood	KS (p-value)
MLE (original data)	1.317 (0.0001)	2.409(0.0240)	2.682(0.0003)	-141.332	0.0064(0.8014)
MLE	2.494(0.0050)	1.628(0.0030)	2.041(0.0050)	-148.085	
WLE	1.367(0.0040)	2.353(0.0023)	2.635(0.0041)	-139.783	

6. Conclusion

This study conducted a comparative analysis of Maximum Likelihood Estimation and Weighted Likelihood Estimation methods for estimating parameters of the Exponentiated Weibull distribution in the presence of outliers. Simulation studies were conducted under various conditions of sample size, contamination level, and distribution parameters. The results consistently demonstrate the superiority of the weighted likelihood estimator method over the maximum likelihood estimation in terms of bias and root mean squared error for estimating the scale parameter (θ) of the Exponentiated Weibull distribution with parameter distribution, especially when the contamination level is significant. The results on bias and root mean square error of the maximum likelihood estimation and weighted likelihood estimator for the central distribution are the EW (2,1,1) and EW (2,2,2) when fix α=2 and the distribution of the contamination is Δ=1,5. The characteristics of the maximum likelihood estimation and weighted likelihood estimator for each situation are summarized as follows. The sample size increases as the bias and root mean square error of the maximum likelihood estimation and weighted likelihood estimator decrease in most of the cases. For the maximum likelihood estimation and the weighted likelihood estimator method both of parameters θ and β, the ε increases as the bias and root mean square error increases. For the maximum

likelihood estimation method both of parameters θ and β, the ε increases as the bias and root mean square error increase. For the weighted likelihood estimator method for the scale parameter θ, the magnitude of the bias and root mean square error decreases as k increases. The bias and root mean square error when comparing values of the maximum likelihood estimation method are close to those of the weighted likelihood estimator method when k=0.01. On the other hand, the bias and root mean square error values of the weighted likelihood estimator are smaller than those of the maximum likelihood estimation for all cases. Hence, in the case when Δ=1,5 based on the bias and root mean square error of the weighted likelihood estimator method, it provides better results when comparing to the maximum likelihood estimation method when k is large. While both methods showed increased bias and root mean square error with increasing contamination, the weighted likelihood estimator exhibits a more robust performance, particularly for larger values of the shape parameter.

The findings of this study underscore the limitations of the maximum likelihood estimation method in handling outliers within the context of the Exponentiated Weibull distribution. The weighted likelihood estimator, on the other hand, emerges as a more reliable approach for estimating the scale parameter in the presence of contaminated data. The results of this study suggest that the weighted likelihood estimator is a viable alternative to the

maximum likelihood estimation for analyzing data from the Exponentiated Weibull distribution when contamination is suspected. While this research focused on the scale parameter, future studies could explore the performance of the weighted likelihood estimator for estimating the shape parameter under different contamination scenarios. Additionally, investigating the sensitivity of the weighted likelihood estimator to different weight functions would provide further insights into its robustness. The successful application of the weighted likelihood estimator to the Exponentiated Weibull distribution opens avenues for extending this methodology to other complex distributions, such as the exponentiated generalized Weibull distribution. Moreover, incorporating censored observations into the weighted likelihood estimator framework could enhance its applicability to real-world datasets with incomplete information. Overall, the results of this study contribute to the development of robust estimation techniques for the Exponentiated Weibull distribution and provide valuable insights for researchers and practitioners dealing with contaminated data.

7. Acknowledgements

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Proximate Analysis and Sensory Evaluation of Processed Lubeg (Syzygynium lineatum (Roxb.) Merr. & Perry) Fruit Wines

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Abstract

Lubeg tree thrives in tropical climatic conditions, such as in the northern part of the Philippines. Lubeg fruit is characterized as highly perishable and has a sour taste, hence, many fruits were wasted during its peak season. Developing and processing the fruits is considered to maximize the full potential of Lubeg fruits. With this, the study sought to enhance the quality of the developed three Lubeg wines through determining the proximate analysis and sensory evaluation. The Lubeg wines differ in sweeteners being added. The first sample is Lubeg wine with sugar; the second sample is wine with honey; and the third sample has wine with both honey and sugar. Based on the result, the proximate analysis of the Lubeg wine products shows moisture content ranging from 92.86% to 98.54%, ash (0.03%–0.04%), calories (78 kcal–112 kcal), carbohydrates (2 g–10.80 g), and sugar (10.50 g–2.00 g). The total fat of 1% is present in sample 2. The alcohol content of the wine samples ranged from 5.92%-9.17% and was categorized as low-alcohol fruit wine. In terms of sensory evaluation, there was no significant difference between the appearances of the three Lubeg wine samples. However, there were substantial moderate differences between the ratings of the samples for aroma, taste/texture, aftertaste, and overall impression and there was a significant large difference in their totality. Sample 1 consistently received higher ratings for aroma, taste/texture, aftertaste, overall impression, and totality compared to Sample 2. Sample 3 was not significantly different from Sample 1 in all the dimensions, except for taste/texture. All the Lubeg wine samples were accepted by the respondents, but Sample 1 is the most likable among the three samples. The return above the variable cost (12.96% to 20.45%) of the Lubeg wine samples can be a viable income-generating activity. Further studies on the fermentation process of the Lubeg fruit wines, the determination of other parameters of proximate analysis, and other laboratory activities should be conducted to have comprehensive data on the health benefits, vitamins, and mineral components of the produced Lubeg fruit wines.

1. Introduction

Wine is a well-known alcohol beverage in the community. Fruits such as grapes, bananas, berries, oranges and calamansi are commonly used in winemaking. Wine is also considered as part of the culture and tradition among Filipinos. The most common wines in the Philippines are processed from rice, sugarcane and tropical fruits. Lubeg tree (Syzygiumlineatum (Roxb.) Merr. & Perry) is lesser known species that thrives in a tropical environment such as in northern Philippines. The Lubeg tree belongs to the family of Myrtacea that contains vitamin c

and antioxidant contents [7]. Flavonoids, tannins and saponins are present in both the leaf and fruit extracts of Lubeg [11]. The secondary metabolites found in the Lubeg extracts are thought to possess several health-promoting attributes, including antioxidants, blood sugar reduction, anti-inflammatory, anti-cancer, heart health, skin protection, bone health, and immune system stimulation. Moreover, Lubeg fruit has anti-oxidant and anti-inflammatory properties and it can lower cholesterol level and reduce the risk of heart disease.

Preserves, beverages, and fruit concentrate are products that can be derived from Lubeg fruits [14]. Places like Lallo, Cagayan is already processing Lubeg fruits into preserves and beverages as part of their one town one product project. But in Isabela province, it is observed that not many Lubeg tree species are well known, and many locals do not appreciate the sour taste of the fruit. The Lubeg fruits are also highly perishable. During peak season, fruits are simply discarded, leaving a mess behind and frequently serving as a breeding ground for flies and other dangerous insects and bacteria. To maximize the nutritional and economic value of Lubeg fruits, processing the said fruit into wine is conducted in this study.

Wine is considered to be a high- value product of which the Lubeg fruits can be processed into wine [14]. In this study, Lubeg wines containing sugar and honey as additional ingredients were developed. Sugar is commonly added to fruit wines as it can influence the quality of wine, such as concentration, maturation and blending [10]. Furthermore, honey is also used in wine making such as mead and sweet wines. Honey also affects the color and composition variations of wines [4]. The

developed Lubeg wines were compared using sensory evaluation, proximate and mineral analysis and cost of return analysis. The use of Lubeg fruits into fruit wines may encourage the growth of local wine production and may reduce the imports of alcohol-based drinks.

1.1 Research Objectives:

This study aims to develop wines from Lubeg fruit products and conduct proximate analysis and sensory evaluation. Specifically, it aims to:

1. Develop three samples of Lubeg wines and determine their proximate analysis in terms of crude protein, crude fat, moisture, ash, calories, calories from fat, total fat, total carbohydrates, sugars and protein.
2. Determine the alcohol content (% v/v) of Lubeg wine samples;
3. Determine the cost and return analysis of developed Lubeg wine samples;
4. Conduct sensory evaluation of the Lubeg Wine samples in terms of appearance, aroma/bouquet, taste/texture, aftertaste and overall impression.
5. Compare the three Lubeg wine samples in terms of appearance, aroma/bouquet, taste/texture, aftertaste and overall impression.

2. Materials and Methods

2.1 Materials

The main ingredients used for the three Lubeg wine samples are ripe Lubeg fruit extracts, water, sugar, honey and yeast. Measuring cups, measuring spoons, basin, clean cheesecloth, sterilized bottles/jar, casserole, wooden ladle and gas stove are also used in the study.

2.2 Preparation of Lubeg Wines

The preparation of Lubeg wine involves the following steps: Regular size of ripe Lubeg fruits were harvested. Only ripe violet fruits are chosen. The fruits were sorted, washed and the

seeds were removed. They were then chopped into small pieces. Sugar and honey were used as a sweetener. The sweetened extract was boiled and were placed in a stopper (with cotton plug) container and cooled. For every 20 liters of Lubeg extract, the added sweeteners are as follows: sample 1 is 803.45 grams, sample 2 is 946 ml of honey and for sample 3, 402 grams of sugar and 473 ml of honey were added. 14.25 grams of yeast to every 20 liters of Lubeg extract for fermentation was also added. The products was set aside after for two weeks to complete fermentation. When fermentation was finished, the wines were poured into another container and were heated to kill undesirable organisms. The wines were aged for a period of one year in jars. In this research, the subsequent products were designated as Sample 1 (Lubeg wine with sugar), Sample 2 (Lubeg wine with honey) and Sample 3 (Lubeg wine with honey and sugar).

2.3 Proximate Analysis

The proximate analysis of the Lubeg wine samples was conducted at the Department of Agriculture RO2- Regional Food Technology and Incubation Center, Carig, Tuguegarao City, Cagayan. Proximate analysis was carried out according to the procedures of the Association of Official Analytical Chemist (AOAC) official methods 984.13, 934.01, and 942.05 to determine the moisture, ash, calories (kcal), total carbohydrates, sugar and protein of the Lubeg wine samples.

2.4 Alcohol Content

The determination of alcohol content was conducted at the Department of Science and Technology- Regional Laboratory Services, RO2, Tuguegarao City, Cagayan. A 50 ml sample volume was steam distilled to about 50 ml of distillate. The distillate was diluted to 50 ml in a volumetric flask. The apparent specific gravity of the distillate was obtained using the pycnometer method. Percent alcohol by volume

was determined using the AOAC 920.57 procedure.

2.5 Cost and Return Analysis

After determining the gross income, production cost, and net income of each wine sample products, the return above the variable cost was calculated by multiplying the ratio of the net income and production cost by 100 percent.

2.6 Sensory Evaluation

A sensory evaluation was conducted using the 20-point scale wine evaluation chart of the American Wine Society (AWS). The parameters include appearance, aroma, taste/texture, aftertaste, and overall impression of the wine samples. Thirty (30) respondents were selected based on the following criteria: having experience in bartending, being a wine maker, and being knowledgeable various alcoholic beverages.

2.7 Data Analysis

Descriptive statistics such as mean (M) and standard deviation (SD) was used in sensory evaluation. The mean scores for appearance and aftertaste were described objectionable if 0 to .49, poor if .50 to 1.49, good if 1.50 to 2.49, and excellent if 2.50 to 3.00. The mean scores for aroma and taste/texture were characterized objectionable if 0 to .49, poor if .50 to 1.49, deficient if 1.50 to 2.49, acceptable if 2.50 to 3.49, good if 3.50 to 4.49, excellent if 4.50 to 5.54, and extraordinary if 5.50 to 6.00. In terms of overall impression, a mean score of 0 to .49 was poor; .50 to 1.49, good; and 1.50 to 2.00 was excellent.

The total scores were calculated in order to assess the overall description of the samples. Based on the standard scoring for the AWS, a total score of 0 to 5 is poor and objectionable; 6 to 8 is deficient; 9 to 11 is commercially acceptable; 12 to 14 is good; 15 to 17 is excellent; and 18 to 20 is extraordinary.

Further, the qualities of the three (3) Lubeg samples in terms of appearance, aroma, taste/texture, aftertaste, overall impression, and totality were compared by conducting a one-way between-groups analysis of variance. For significant results, the effect sizes or magnitude of differences were estimated using Partial eta squared, which were interpreted as small if .03; medium/moderate if .06; and large if .14 [6]. A post hoc analysis using Tukey HSD was also done to detect which samples significantly differed in the criteria where the difference existed. The software used for data analysis is the Statistical Package for the Social Sciences (SPSS).

3. Results and Discussions

3.1 On Proximate Analysis of Lubeg Wines

Table 1 reveals that the moisture content of the wine samples ranged from 92.86% to 98.54%. Sample 2 has the highest moisture content. The moisture content of a sample determines the stability of the product and the overall nutritional value of the samples. The high moisture content of beverages makes them refreshing and quench-thirsting products [13]. It was observed that the high moisture contents of fruit wines are related to the perishable nature and short shelf life of the fruit under normal storage conditions [16].

The ash content ranged from 0.03% to 0.04% and sample 2 has the highest ash content, therefore indicating the presence of mineral components in the wine. The result is in consonance with earlier reports that fruit juices have minimal ash content [1].

Crude fiber was not observed in the wine samples while a minimal total fat was observed in sample 2. The wine making process affects the absence of other parameters such as crude fiber and total fat but it further demonstrates the desirable nutritive quality of the produced Lubeg wines. Moreover, the absence of fats suggests that the wine could provide protection against excess body lipids (cholesterol) [3] as well as contributed to the shelf life of the products [5].

The calories of the wine samples ranged from 78 kCal to 112 kCal and sample 1 obtained the highest calorie content. These show that the wine samples are good sources of calories. High caloric values in wines are associated with high alcohol content [17].

Moreover, the wine samples contained total carbohydrates that ranged from 2g to 10.80 g. Similar observations were reported [3], [17]. A decrease in amount of carbohydrates present in the Lubeg wine samples was observed. The sugar content of the Lubeg wine samples ranged from 10.50 g to 2.00 g. The decrease in carbohydrate contents of the Lubeg wine samples might be due to a decline in the sugar content as well. It is a result of rapid and effective utilization of the sugar available in the wine must by the yeast cells leading to the fermentation of the wine must [1] [16].

Fermentation affects the protein content of wines [17]. In this study, no protein content was recorded and it can be regarded in the wine process such as fermentation of Lubeg wines. It was reported that low protein content of the wine is good for maintaining cellular organization [3] [17]. In addition, the absence of protein shows that the wine is gluten free [12] and is good for people on a low-gluten diet [5].

Table 1. Proximate analysis of Lubeg wine samples

	Lubeg Wine with Sugar (Sample 1)	Lubeg Wine with Honey (Sample 2)	Lubeg Wine with Sugar and Honey (Sample 3)
Moisture (%)	92.86	98.54	98.09
Ash (%)	0.03	0.04	0.03
Crude Fiber (%)	0.00	0.00	0.00
Total Fat (%)	0.00	0.10	0.00
Calories (kcal)	112.00	78.00	81.00
Total Carbohydrates (g)	10.50	2.00	2.80
Sugar (g)	10.50	2.00	2.80
Protein (g)	0.00	0.00	0.00

3.2 Alcohol Content of the Lubeg Wines

After the fermentation process, sample 1 got the highest alcohol content of 9.17% followed by sample 2 (5.92%) and sample 3 (8.96%) (Table 2). Alcohol in wine is significant in the aging, stability and organoleptic characteristics of wine [10], [15]. Fruit wines are undistilled alcoholic beverages that usually have an alcoholic content ranging between 5 and 13 percent [15]. Wine is categorized as low alcohol wine (below 10%), medium-low alcohol wine (10-11.5%), medium alcohol wine (11.5-13.5%), medium-high alcohol wine (13.5-15%), and high alcohol wine (over 15%) [9]. Therefore, the three samples are categorized as a low-alcohol wine.

The results of the study can be compared with the study of wines in starfruit and dalanghita [9]; apple tea wine [10]; dragonfruit wine [8]; and coconut water and zobo wine [1].

Table 2. Alcohol content of Lubeg wine samples

Parameter	Lubeg Wine with Sugar (Sample 1)	Lubeg Wine with Honey (Sample 2)	Lubeg Wine with Sugar and Honey (Sample 3)
% Alcohol	9.17	5.92	8.60

3.3 On Cost and Return Analysis of the Lubeg Wines

Table 3 provides a cost and return analysis for Lubeg wine samples. Sample 1 received the largest return. It is noteworthy that the Lubeg wine sample products exhibit a return above the variable cost ranging from 12.96% to 20.45%, rendering it a viable source of income. Wine has been commercialized over the years and investing in wine could be a beneficial elective venture choice [4].

Table 3. Cost and return analysis of processed Lubeg wine samples

Product	Gross Income (Php)	Production Cost (Php)	Net Income (Php)	Return above variable cost (%)
Lubeg Wine with Sugar (Sample 1)	220	180	45	20.45%
Lubeg Wine with Honey (Sample 2)	270	205	35	12.96%
Lubeg Wine with Sugar and Honey (Sample 3)	260	225	35	13.46%

3.4 On Sensory Evaluation of the Lubeg Wines

Table 4 shows the qualities of the Lubeg wine samples as assessed by 30 individuals (13 males and 17 females). Sample 1's appearance was good; its aroma, taste/texture, aftertaste, and overall impression qualities were all excellent. In total, Sample 1 got an excellent rating. Sample 2 got a good rating in terms of all the dimensions (appearance, aroma, taste/texture, aftertaste, overall impression) and in general. Sample 3 was excellent as to overall impression, but had a good appearance, aroma, taste/texture, and aftertaste. Overall, Sample 3 was good. It was observed that the appearance of Lubeg wine looked better to the evaluators than the other fruit wine samples [14]. Based on table 1, all the Lubeg wine samples were considered likely to be accepted by the respondents.

Table 4. Qualities of the Lubeg wine samples

Lubeg Wine	Criteria	M	SD	Description
Sample 1	Appearance	2.36	.71	Good
	Aroma	4.76	.89	Excellent
	Taste/Texture	4.66	.99	Excellent
	Aftertaste	2.56	.62	Excellent
	Overall Impression	1.80	.55	Excellent
	Total	16.16	2.58	Excellent
Sample 2	Appearance	2.13	.62	Good
	Aroma	3.76	1.16	Good
	Taste/Texture	3.53	1.35	Good
	Aftertaste	2.03	.85	Good
	Overall Impression	1.23	.67	Good
	Total	12.70	3.96	Good
Sample 3	Appearance	2.33	.80	Good
	Aroma	4.23	1.04	Good
	Taste/Texture	3.93	1.17	Good
	Aftertaste	2.20	.66	Good
	Overall Impression	1.50	.62	Excellent
	Total	14.20	3.72	Good

3.5 Comparing the Sensory Evaluation of Lubeg Wines

There was no significant difference between the appearances of the three samples, F = .922, p > .40. On the other hand, there were significant moderate differences between the ratings of the samples as to aroma (F = 6.94; p < .01; = 13.76%), taste/texture (F = 7.07; p < .01; = 13.97%), aftertaste (F = 4.31; p < .02; = 9%), overall impression (F = 6.23; p < .01; = 12.52); and there was a significant large difference in their totality (F = 7.49; p < .01; = 14.68%).

As compared to Sample 2, Sample 1 consistently got a significantly higher rating in terms of aroma, taste/texture, aftertaste, overall impression, and totality. Sample 3 was not significantly different from Sample 1 in all the dimensions except for taste/texture i. e. Sample 1 (M = 4.66) got a greater rating for taste/texture than Sample 3 (M = 3.93).

In general, sample 1 (Lubeg wine with sugar) is much liked by the respondents. The added sweetener, honey and sugar have affected the quality of the Lubeg wine, especially in taste and aroma. Fruit wine flavours are well accepted by consumers all over the world because of their attractive colors, pleasant flavors and aroma [2] [4] and fruit wines, if consumed properly, are also known for their beneficial effects on health.

Table 5. Comparison between the Lubeg wine samples

Attributes	Lubeg Wine Samples		
	1	2	3
Appearance	2.36±0.71	2.13±.62	2.33±0.80
Aroma	4.76[a]±0.89	3.76[b]±1.1.6	4.23[ab]±1.04
Taste/ Texture	4.66[a]±0.99	3.53[b]±1.35	3.93[b]±1.17
Aftertaste	2.56[a]±0.62	2.03[b]±0.85	2.20[ab]±0.66
Overall Impression	1.80[a]±0.55	1.23[b]±0.67	1.50[ab]±0.62
Total	16.16[a]±2.58	12.70[b]±3.96	14.20[ab]±3.72

4. Conclusion

Lubeg trees thrive in some parts of the northern Philippines. Lubeg fruits are characterized as highly perishable and sour in taste. To maximize its potential values, Lubeg fruit wine samples were processed specifically Lubeg wine samples with sugar as the main ingredient, Lubeg wine with honey as sugar substitute and Lubeg wine with honey and sugar that aid in the wine-making process. Moreover, this study aims to determine the proximate analysis, alcohol content, cost of return analysis, and sensory evaluation of Lubeg wine samples.

Based on the results, the Lubeg wine samples have a high moisture content and a minimal ash content. The wine samples are also good sources of calories. Carbohydrates and sugar are also present in the wine samples. However, crude fiber and protein were not observed in the wine samples and a minimal amount of total fat was only present in sample 2. The components of fruits may be affected when processed such as when fermented. In addition, the wine samples were categorized as low alcohol wines. The Lubeg wine sample products have a return above variable cost, which makes the wine samples a viable source of income.

During the assessment of the respondents, the Lubeg wine samples were generally accepted and liked in terms of appearance, aroma, taste/texture, aftertaste, and overall impression. Sample 1 (Lubeg wine with sugar) was the most highly liked of the three wine samples across all dimensions.

5. Recommendations

In order to enhance the processing of Lubeg fruit wines and their marketability, further studies on the fermentation process of Lubeg fruit wines should be given emphasis. Determine also other parameters of proximate analysis such as pH and acidity, vitamins and other mineral contents, phenolic and anti-oxidant activity to give more comprehensive data on the components of produced Lubeg wines. In addition, further nutritional evaluation of the products should be conducted to enhance nutritional labeling which can be used later as marketing and promotion tools.

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Cost Effectiveness of Implementing Community Quarantine in Selected Areas of the Partido District, Philippines

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Abstract

The study measured the cost-effectiveness of Community Quarantine (CQ) enforced by selected local government units in the Partido District, Philippines. It tracked the incidence of COVID cases; traced the decrease or increase in the number of COVID cases; calculated the average cost of each COVID case; and extrapolated the amount of saving or dissaving. It utilized key informant interview to gather specific sets of data. Based on the raw assumptions of Efficiency and Input-Output Analysis, this is a typical example of inefficiency because there were costs incurred but the benefits were undeterminable. However, the study uncovered that the after-CQ periods presented a relatively lower cost per day than the within-CQ periods. Therefore, it may be surmised that the CQ accomplished what it was meant to carry out—to arrest the transmission of the virus and decrease the number of cases and the cost of caring for patients. Based on the findings and the foregoing discussion, this study posited that the CQ in the study areas was cost-effective. The number of COVID cases dropped considerably after the CQ periods. Correspondingly, the COVID patients' average cost per day also decreased after the CQ periods. The reduction in the cost, logically, represented saving on the part of the local government units.

Keywords: cost-effectiveness, community quarantine, efficiency, COVID case

1. Introduction

The whole world was apparently caught unprepared by the COVID-19 outbreak. In January 2020, the number of cases around the globe started at about 1,900 then rapidly increased to around 1.2 million in June 2020 and then to 4.5 million by year-end [1]. Governments and health organizations were scurrying to cope with the unprecedented rate of transmission of the virus across countries and continents. The Philippines was no exception. Both the national and local governments installed safety protocols and systems to prevent the spread of the virus.

To control the transmission of the COVID-19 virus, the national government established several community quarantine protocols which were directed to all local governments in the Philippines, as follows: (a) Enhanced Community Quarantine (ECQ); (b) General Community Quarantine (GCQ); (c) Modified Enhanced Community Quarantine (MECQ); and (d) Modified General Community Quarantine (MGCQ). The last two categories were intended to control community transmission but at the same time open opportunities, albeit restricted, for economic engagements of business firms and households. Under any circumstance, it cannot be argued that the government needed to establish an infection transmission suppression mechanism because human lives are far more important than any other consideration. Therefore, all branches and levels of government should ensure that community transmission is under control. ECQ was implemented in the Partido District in March 2020, GCQ in May 2020, MECQ in June 2020, MGCQ in August 2020 and up until the rest of the year 2021, and Alert Level in 2022.

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Controlling the transmission of the virus was essential because it was in the interest of everyone, regardless of income and social class. Nonetheless, many sectors in the local community have expressed the detrimental effects of the policy, especially on their economic well-being. Staying at home without certainty of meeting their food and non-food needs is not only an economic concern but psychological and mental as well. A review of literature pointed in two directions: (a) that the lockdown/quarantine was more beneficial than costly; or (b) that the lockdown/quarantine was more costly than beneficial.

As claimed in a study by Rowthorn and Maciejowski [2], there is a growing recognition of the damage the lockdown has caused to economic and social life. Additionally, an examination of over 100 COVID-19 studies by Allen [3] revealed that many relied on false assumptions that overestimated the benefits and underestimated the costs of lockdown. The most recent research has shown that lockdowns have had, at best, a marginal effect on the number of Covid-19 deaths. Generally speaking, the ineffectiveness stemmed from individual changes in behavior: either non-compliance or behavior that mimicked lockdowns [3].

While our understanding of viral transmission mechanisms leads to the assumption that lockdowns may be an effective pandemic management tool, this assumption cannot be supported by the evidence-based analysis of the present COVID-19 pandemic. The price tag of lockdowns in terms of public health is high. It was estimated that, even if somewhat effective in preventing death caused by infection, lockdowns may claim 20 times more lives than they save [4]. Miles et al. [5], in their economic assessment of the first pandemic wave in Europe, recognized that the costs of widespread severe restrictions likely exceeded the benefits. They also pointed out that economics suggests using more targeted measures to deal with the particular effects of COVID-19. Unfortunately, lockdown proponents have often portrayed arguments like this as a type of 'moral bankruptcy' [5].

A study by Alfano [6] showed that lockdown was effective in reducing the number of new cases in the countries that implement it, compared with those countries that did not. This was especially true around 10 days after the implementation of the policy. Its efficacy continues to grow up to 20 days after implementation [6]. An investigation by Melia et al. [7] found that the average expected cost of isolating a patient at home is relatively lower compared to the cost of hotel quarantine. However, this cost significantly increases when there are seniors sharing the house with the patient zero, and hotel isolation may be a cost-saving measure in the context of large families, boarding houses and other group living situations [6]. In sporadic and cluster outbreaks, the isolation of infectious cases and quarantine of individuals exposed to the infected were the most cost-effective measures [8]. A study by Gandjour [9] concluded that the cost-effectiveness ratio of a lockdown policy in conjunction with a booster dose with 95% efficacy is €44,214 per life year gained. A lockdown is cost-effective when the probability of approving a booster dose with 95% efficacy is at least 48%, and 76% when considering uncertainty in input factors [9].

A study conducted by the Asian Development Bank [10] on cost-effectiveness inferred that the community lockdowns were cost-effective ADB 2020. From the perspective of effectiveness and cost-effectiveness of controlling the spread of COVID-19, the joint strategy of personal protection and isolation-and-quarantine was the optimal choice, averting more cases than only isolation-and-quarantine [8]. The study revealed a marked increase in the number of infections when the quarantine delay time reached 6 days. There was no significant difference in numbers in the sporadic area when the quarantine probability changed from 25 to 100%. However, the two-way analysis suggested that at 25% probability, more infections were likely to occur when the quarantine delay time was >2 days [8].

A published article by Boettke and Powell [11] asserted that it has been a sad irony that the COVID-19 policy has not been driven by economics, the discipline that specializes in the study of costs and benefits, but by

epidemiologists who have 'no expertise in weighing health benefits against other costs.'

Given all these developments, the researcher found it imperative to look into these issues at the local level, particularly in selected municipalities of the Partido District, using the Efficiency Analysis and Input-Output Analysis. Partido is the fourth congressional district of Camarines Sur, a province of Bicol Region. Of its ten municipalities, six are among the top ten poorest towns in the province in 2021 [12]. It is located at the far east end of the region and separated from the main thoroughfare of Camarines Sur and other provinces of Bicol. It is bounded on the right by Lagonoy Gulf, on the north by the Philippine Sea and on the west by San Miguel Bay [13]. That is why nine of its municipalities are coastal. Partido was chosen as study area to provide additional information about the community quarantine in poor, remote, rural and coastal communities of the country.

1.1 Objectives

General Objective: The study measured the cost-effectiveness of the Community Quarantine (CQ) enforced by selected local government units in Partido in compliance with the directives of the national government to prevent transmission of the COVID-19 virus.

Specific Objectives. To achieve the general objective, the study sought to:
1. Track the incidence of COVID cases before and during the various categories of the CQ;
2. Trace the decrease or increase in the number of COVID cases at various levels of the CQ;
3. Calculate the average cost of each COVID case as experienced by the LGU; and
4. Extrapolate the amount of saving or dissaving to determine the cost-effectiveness of the CQ.

The selected municipalities were Goa and Siruma. The first is at the commercial center, with relatively greater incidence of COVID cases, and with health facilities and resources. The second one is a coastal area and far from the business hub, with relatively smaller population and inadequate health facilities and resources.

2. Methodology

The study utilized the Efficiency Analysis and Input-Output Analysis. Theoretically, this method is described by Raa [14] in his article entitled "Performance measurement in an input-output framework." Efficiency analysis measures firm performance relative to the best practice, which is determined by a firm or collection of firms operating on the frontier of production possibilities. On the other hand, input-output analysis examines output per unit of input. Efficiency is basically defined as a firm's ability to achieve maximum output with minimum input, making it an essential metric for evaluating performance and identifying areas for improvement. It is calculated by determining the ratio of the output to the input. In this study, the firm was the local government unit, the input was the implementation cost of CQ while the output was the resulting decrease in the number of COVID patients. Each COVID patient represented a specific amount of health care cost. Therefore, a decrease in COVID cases would mean a decrease in cost which then translates into savings.

The implementation cost of the Community Quarantines (CQ) covered all cash outlay from the local government units to implement the said policy. It involved all categories, whether enhanced, general or modified. It included the cost of personnel services in charge of monitoring compliance to health protocols, transport bans, curfew hours and lockdown restrictions, among others.

The study gathered data on the incidence of COVID cases before and during the quarantines. The average cost of each COVID case was calculated from the time a person was tested positive until a person was tested negative. This included hospitalization, doctor's fees, medicines, food and accommodation in quarantine facilities, among others. The number of COVID cases was traced along different quarantine categories and across particular periods.

The amount of savings was determined by estimating the cost that would have been

incurred with each COVID case that was prevented. This was indicated by the decrease in the number of cases on each day after the CQ was implemented. The cost-effectiveness was determined by comparing the cash outlay to implement the CQ with the amount of savings brought about by the decrease in the number of COVID cases under each category of the CQ. The required data from each target municipality were gathered from key informants, as follows: (a) mayor or representative; (b) health officer; (c) finance officer; and (d) person-in-charge of the CQ.

3. Results and Discussion

In the year 2020, the municipalities covered by this study complied with the declaration of community quarantine periods as ordered by the national government. In the entire duration of that year, the municipalities experienced zero cases of COVID. Therefore, there was no basis on analyzing whether or not the community quarantines were cost-effective.

However, the years 2021 and 2022 were a different story. In 2021, the declaration of community quarantine periods was both in compliance with national directives, as well as in response to the existence of COVID cases in the localities. There were particular periods, lasting for two to four weeks at a time, when the local governments announced community quarantine, albeit at different modes depending on the increase or decrease in COVID cases. In 2022, to prevent further transmission of the virus, the national and local governments intervened through the declaration of certain measures of Alert Level depending on the seriousness of the situation.

In the succeeding section, tables present an overview of the community quarantine experiences in the study areas. The data were organized based on the periods when the community quarantine or alert level was declared because the researcher wanted to determine the number of cases and the cost to the local government in caring for the patients during and after these periods.

Table 1 is included herein to show that in 2020, the community quarantines were established to follow the nationwide pronouncement of the chief executive. This was done even if there were zero cases of COVID in the study areas for the whole year of 2020.

Table 1. Community Quarantine periods, number of COVID cases and average cost per case, 2020

Period	Community Quarantine	No. of days	No. of cases
3.16-5.15	ECQ	61	0
5.16-8.15	GCQ	92	0
8.16-12.31	MGCQ	138	0

3.1 Incidence of COVID Cases at Various Levels of Community Quarantine

To accomplish the first and second research objectives, the succeeding section discloses the incidence of COVID cases before and during the various categories of CQ. It also indicates the decrease or increase in the number of COVID cases at various levels of CQ.

Table 2 pertains to the CQ in the first half of 2021. The periods were divided into the first 15 days and the second 15-16 days of each month from January to June. These intervals were based on the observed intervals of the CQ periods. The data exhibited the number of cases

in each set of days, broken down into asymptomatic and symptomatic, then the average cost per case in Philippine Pesos.

It may be inferred from Table 2 that the number of cases was relatively higher within the CQ than without. This may be precisely the reason why the quarantines were declared—to arrest the spread of the virus. It may be stated further that outside of the quarantine periods, the number of cases was comparably lower. There were even three 15-day periods of zero-COVID case.

A case in point, after Alert Level 2 on January 15, 2021, there was zero-COVID case

on January 16-31. Moreover, cases were relatively nil until April 15 except on February 1-15 where there was an abnormally high number of cases at 23. The author surmised that

the celebration of Valentine's Day may have been one of the probable factors for that sudden increase in COVID cases.

Table 2. Community Quarantine periods, number of COVID cases and average cost per case, 2021, 1st half

Period	Community Quarantine	No. of days	No. of cases	No. of asymptomatic	No. of symptomatic	Average cost per case (PhP)
1.1-15	AL2	15	10	7	3	1286
1.16-31	None	16	0	0	0	0
2.1-15	None	15	23	12	11	1000
2.16-28	None	13	0	0	0	0
3.1-15	None	15	1	0	1	1000
3.16-31	None	16	0	0	0	0
4.1-15	None	15	2	2	0	3000
4.16-30	AL1	15	15	12	3	2200
5.1-14	None	14	12	6	6	1286
5.15-31	MGCQ	17	26	12	14	1769
6.1-15	None	15	24	19	5	1167
6.16-30	None	15	10	2	8	1200

Table 3 illustrates the CQ in the second half of 2021 demonstrating the same data as in Table 2. As in Table 2, the number of COVID incidence was comparably higher during the quarantine periods particularly under an Alert Level 4 on September 16-31, 2021 with 78 cases; and under a Modified General Community Quarantine on October 16-31,

2021 with 41 cases. COVID incidence was observably much lower right after the quarantine periods like on September 1-7, 2021 with only 4 cases which was after a General Community Quarantine, and on December 16-31, 2021 with zero case which was right after the declaration of an Alert Level 2.

Table 3. Community Quarantine periods, number of COVID cases and average cost per case, 2021, 2nd half

Period	Community Quarantine	No. of days	No. of cases	No. of asymptomatic	No. of symptomatic	Average cost per case (PhP)
7.1-15	None	15	35	6	29	1114
7.16-22	None	7	1	1	0	1000
7.23-31	MGCQ	9	5	5	0	1000
8.1-13	AL4	13	4	3	1	1000
8.14-31	GCQ	18	28	25	3	2333
9.1-7	None	7	4	0	4	1000
9.8-15	GCQ	8	32	5	27	1375
9.16-31	AL4	16	78	17	61	1101
10.1-15	None	15	9	0	9	1000
10.16-31	MGCQ	16	41	14	27	1146
11.1-15	MGCQ	15	14	11	3	1143
11.16-30	AL2	15	5	3	2	1000
12.1-15	AL2	15	1	0	1	1000
12.16-31	None	16	0	0	0	0

Table 4 displays the CQ in the first half of 2022, indicating the same data as in Table 2 and 3. During this period, the local government manifested a paranoid stance by issuing a long-term alert level status from January 15 to May 31, 2022. The continuous alert levels paid up as

exhibited by the significant decrease in the number of cases from 24 down to single-digit figures including zero cases in five 15-day periods, i.e., February 1-15, March 16-31, April 1-15, April 16-30, and May 16-31.

Table 4. Community Quarantine periods, number of COVID cases and average cost per case, 2022, 1ˢᵗ half

Period	Community Quarantine	No. of days	No. of cases	No. of asymptomatic	No. of symptomatic	Average cost per case (PhP)
1.1-14	None	14	3	1	2	1000
1.15-20	AL3	6	24	8	16	1000
1.21-31	AL2	11	13	8	5	1000
2.1-15	AL2	15	0	0	0	0
2.16-28	AL2	13	3	1	2	1000
3.1-15	AL2	15	1	1	0	1000
3.16-31	AL2	16	0	0	0	0
4.1-15	AL2	15	0	0	0	0
4.16-30	AL2	15	0	0	0	0
5.1-15	AL2	15	4	4	0	1000
5.16-31	AL2	16	0	0	0	0

Table 5 discloses the CQ in the second half of 2022, showing the same data as in Table 2, 3 and 4. The alert levels were up on a sustained basis from June 1 to September 30, 2022. This decision of the local government still paid up as manifested by the substantially low number of cases in the said period. Except on August 1-5 and September 1-15, all the rest of the 15-day periods illustrated only 0-4 cases each, including zero cases on June 16-30, 2022; August 16-31, 2022; and September 16-30, 2022.

Table 5. Community Quarantine periods, number of COVID cases and average cost per case, 2022, 2ⁿᵈ half

Period	Community Quarantine	No. of days	No. of cases	No. of asymptomatic	No. of symptomatic	Average cost per case (PhP)
6.1-15	AL2	15	2	1	1	1000
6.16-30	AL2	15	0	0	0	0
7.1-15	AL1	15	3	3	0	1000
7.16-31	AL1	16	4	4	0	1000
8.1-15	AL1	15	10	10	0	1000
8.16-31	AL1	16	0	0	0	0
9.1-15	AL1	15	17	9	8	1000
9.16-30	AL1	15	0	0	0	0

3.2 Cost of Each COVID Case and Cost-effectiveness of the Community Quarantines

To accomplish the first and second research objectives, the following section discussed the calculation of the cost per COVID case and the saving or dissaving that resulted from the declaration of CQ, including the alert levels. Each COVID case represented an amount of expenditures. In the study areas, the cost of each case was composed of medicine, hygiene kit, food pack, water and electricity. The asymptomatic cases went on home quarantine and were provided with medicine and food pack. The symptomatic were sent to a quarantine facility or hospital depending on the seriousness. They were provided with medicine, food, water, electricity and health care services. The expenses per case ranged from PhP1,000 to 3,000.

In this study, the cost was expressed in terms of the average figure per COVID patient. The calculation was done covering particular periods, specifically those that fell within the CQ and those that were without the CQ. Then for each period as mentioned, the average number of cases per day was computed. The last step was the determination of the average cost per day.

For example, in Table 6, January 1-15, 2021 was under Alert Level 2. This represented a 15-day period within the CQ period. The number of cases was determined. Next were the calculations of the average cost per case, the average number of cases per day, and the

average cost per day. For the period earlier mentioned, the average cost per day was PhP857.33. This can now be compared with the average cost per day of the periods under the CQ or outside of it.

Table 6 clearly shows that the average cost per day was increasing from January 1 to May 31, 2021. Nonetheless, it is also apparent that the after-CQ periods presented a relatively lower cost per day. First, the average cost per day on January 16 – April 15, 2021 decreased by 43% from the CQ period on January 1-15,

2021. Second, the average cost per day on May 1-14, 2021 went down by 50% from the CQ period on April 16-30, 2021. Third, the average cost per day on June 1-30, 2021 dropped by 51% from the CQ period on May 15-30, 2021.

This may reveal that the declaration of the CQ was done right in time. It accomplished what it was meant to accomplish—to arrest the transmission of the virus and significantly decreased the number of cases and the cost of caring for patients.

Table 6. Community Quarantine periods, average cost per case, average number of cases per day, and average cost per day, 2021, 1st half

Period	Community Quarantine	No. of days	No. of cases	Average cost per case	Average no. of cases per day	Average cost per day (PhP)
1.1-15	AL2	15	10	1286.00	0.67	857.33
1.16-4.15	None	90	26	1666.67	0.29	481.48
4.16-30	AL1	15	15	2200.00	1.00	2200.00
5.1-14	None	14	12	1286.00	0.86	1102.29
5.15-31	MGCQ	17	26	1769.00	1.53	2705.53
6.1-30	None	30	34	1183.50	1.13	1336.79

Table 7 exhibits a similar trend as illustrated in Table 6. The after-CQ periods demonstrated a comparably lower cost per day. First, the average cost per day on July 1-22, 2021 declined by 36% from the CQ period on May 15-21, 2021. Second, the average cost per day on September 1-7, 2021 fell by 58% from the CQ period on July 23–August 31, 2021. Third,

the average cost per day on October 1-15, 2021 diminished by 89% from the CQ period on September 8-31, 2021. Fourth, the cost on December 16-31, 2021 was zero as there were no more COVID cases at this time, compared to PhP1,072.25 average daily cost on October 16 – December 15, 2021.

Table 7. Community Quarantine periods, average cost per case, average number of cases per day, and average cost per day, 2021, 2nd half

Period	Community Quarantine	No. of days	No. of cases	Average cost per case	Average no. of cases per day	Average cost per day (PhP)
7.1-22	None	22	36	1057.00	1.64	1729.64
7.23-8-31	MGCQ, AL4, GCQ	40	38	1444.33	0.95	1372.12
9.1-7	None	7	4	1000.00	0.57	571.43
9.8-31	GCQ, AL4	24	110	1238.00	4.58	5674.17
10.1-15	None	15	9	1000.00	0.60	600.00
10.16-12.15	MGCQ, AL2	61	61	1072.25	1.00	1072.25
12.16-31	None	16	0	0	0	0

Table 8 displays the same situation as in Table 6 and 7. The average cost per day was comparatively lower on January 1-14, 2022

which may presumably be traced back to the prevention of transmission resulting from the CQ on October 16 – December 15, 2021.

Table 8. Community Quarantine periods, average cost per case, average number of cases per day, and average cost per day, 2022

Period	Community Quarantine	No. of days	No. of cases	Average cost per case	Average no. of cases per day	Average cost per day (PhP)
1.1-14	None	14	3	1000.00	0.21	214.29
1.15-5.31	AL2, AL3	137	45	1000.00	0.33	328.47
6.1-9.30	AL1, AL2	122	36	1000.00	0.30	295.08

4. Conclusion and Recommendation

In 2020, the community quarantines were established to follow the nationwide pronouncement of the chief executive. This was done even if there was zero incidence of COVID in the study areas for the whole year. Based on the raw assumptions of Efficiency and Input-Output Analysis [14], this is a typical example of inefficiency. In other words, there was no need to input anything because there was no intended output or no problem at hand. While there was zero instance of COVID in 2020, costs were incurred from the stoppage of economic activities and closure of enterprises producing goods and services. However, there was no evidence that COVID was zero because of the CQ. With or without the quarantine, there may still be no COVID case due to other factors such as remoteness of the study areas or lack of mobility of the residents. There were sacrifices made but the direct benefits were undeterminable. Therefore, the CQ at the time of zero COVID case created only costs but no gain.

Moreover, this investigation did not recognize assumptions that were not validated to observe the assertion in the study by Allen [3] and Yanovsky [4]. The former pointed out some studies that used false assumptions which led to the overestimation of benefits and underestimation of costs while the latter concluded that some studies made assumptions that cannot be supported by evidence-based analysis.

It may be inferred from the data that the number of cases was relatively higher within the CQ than without. This may be precisely the reason why the quarantines were declared—to arrest the spread of the virus. It may be stated further that outside of the quarantine periods, the number of cases were evidently much lower as manifested by several 15-day periods of zero COVID case. Furthermore, in the year 2022, the local government exhibited a paranoid stance by issuing a long-term alert level status. The continuous alert levels paid up as revealed by the significant decrease in the number of cases.

Results of the data analysis uncovered that the after-CQ periods presented a relatively lower cost per day than the within-CQ periods. Based on this, it may be surmised that the declaration of the CQ was done right in time. It accomplished what it was meant to accomplish—to arrest the transmission of the virus and significantly decreased the number of cases and the cost of caring for each patient.

Based on the findings and the foregoing discussion, this study posits that the CQ in the study areas were cost-effective. The number of COVID cases dropped considerably after the CQ periods. Correspondingly, the average cost per day on COVID patients also decreased after the CQ periods. The reduction in the cost, logically, represented saving on the part of the local government units.

As supported by data and evidence, this inquiry affirms the conclusion of Alfano [6] and ADB [10] that lockdowns were effective in reducing the number of new cases. The average cost per day as used in this research was mostly based on the amount of government subsidy for patients on home quarantine. The results align with the study of Melia [7] that home quarantine was more cost-efficient than hotel quarantine. The findings likewise confirm the study of Wang [8] that isolation of cases and quarantine of those exposed was highly cost-effective. This inquiry likewise affirms the conclusion of Wang [8] that the joint strategy of personal protection and isolation-and-quarantine was the optimal choice. The findings of this study were consistent with the claim of Wang [8] that more infections were likely to

occur when the quarantine delay was greater than two days.

Local government units may be guided by the findings of this study, which manifested that when the rate of COVID cases increased, the community quarantine was declared. The period-specific data clearly revealed that COVID cases significantly decreased, which translated into monetary savings due to the reduction in the cost of patient care. As concluded in the study of Gandjour [9] that a lockdown is cost-effective, when the probability of approving a booster dose with 95% efficacy is at least 48%, it is further recommended that the local government implement a lockdown coupled with 95% of efficacy booster dose.

Local government units will always face the predicament between minimizing economic costs and maximizing health benefits. Community quarantine certainly prevents transmission and promotes health benefits, but it entails economic costs. While economic costs may be easily measured, health benefits cannot be fully quantified. Health benefits have far-reaching effects such as higher productivity, sound physical and mental fitness, and better quality of life, now and in the future. That is why this research would be inclined to give more value to health, being one of the main goals of CQ, since good health has continuous and long-term benefits to an individual and society, over the financial sacrifice at present. The value of money continues to decline due to increasing prices while the value of health may be considered priceless as it sustains an individual's capacity to effectively function as a member of society in particular and a human being in general.

Recommendation for Future Research

For future research, a more detailed cost-benefit analysis may be done, which may account for other variables—that could influence COVID cases and costs—such as vaccination rollouts and natural immunity. A future study may identify potential confounding factors relevant to the matter being investigated. Multivariate regression analysis may be used to isolate the effect of community quarantine; discuss how the confounding factors might have influenced the results; and consider their implications in the findings. A sensitivity analysis may be done to determine how robust the results are to the variations in the confounding factors. Future research may incorporate a more detailed examination of indirect economic costs and benefits to provide a fuller picture of the impact of community quarantine. Additional data may be gathered on the comprehensive breakdown of the cost component, e.g., hospitalization expenses and doctor's fees. Lastly, there is a need for further research on the long-term effects of community quarantine.

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Upgrading Safety Shrimp Farmers to Digital Entrepreneurs of Nakhon Pathom Province

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Abstract

Nowadays, technology and marketing are rapidly changing. Therefore, to run a successful business, farmers need to be equipped with both theory and digital skills. This research focuses on the investigation and development of a short training course to improve the knowledge required for shrimp farmers to become digital entrepreneurs. The purposes of this research study were to 1) develop a course for safety shrimp farmers in Nakhon Pathom province to become digital entrepreneurs; 2) prepare an electronic manual on a digital entrepreneurship course and business alliance network linkage in Nakhon Pathom province; and 3) create business alliance networks for safety shrimp farmers in Nakhon Pathom province to become digital entrepreneurs. The problem scenario and needs of a group of 100 farmers, as well as the knowledge of eight experts in entrepreneurship, were investigated in order to design the course and the electronic manual.

The results found that 1) the developed digital entrepreneurship course is 16-hour training, consisting of 4 units necessary to upgrade farmers' knowledge to become digital entrepreneurs: 1) smart farming technology, 2) marketing, 3) finance and accounting, and 4) business plan. The suitability of the course was at the highest level with an average of 4.95. In addition, the result of the trial with a sample of 30 people showed that the participants' scores after attending the course were significantly higher than before learning at the level of .05. 2) The examination of the course manual showed that it was an electronic book on a web application that was most suitable for the participants with an average of 5.00. The participants were most satisfied with the course and electronic manual with an average of 4.60. 3) The business alliance networks were created by organizing focus groups to provide opportunities for all participants to build good relationships, form partnerships, and work with mutual benefit. The knowledge and expertise of each person could be used to create new things, providing a platform for workers to develop or solve common problems together. As a result, enhancing knowledge and the ability to stay up with current situations might strengthen one's potential, leading to the success of running a business.

1. Introduction

With the current Thai Economic Council in the process of adapting and wanting to turn crisis into opportunity for sustainable development, the government has issued various policies to push and accelerate the country's economic recovery. Nakhon Pathom province is one of the metropolitan provinces affected by the emerging economic conditions, but there are signs of improved economic conditions. In August 2022, the Fiscal Conditions Report of Nakhon Pathom province demonstrated economic expansion, indicating that the economy in the province has continued to expand compared to the same month of 2021.

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After easing the control of the pandemic and travel restrictions, most of the economic activities have returned to a normal state, as can be seen by the expanding supply-side economy. The service output index has expanded by 27.7 percent. The industrial output index has expanded by 7.4 percent, but the agricultural productivity index shrank by - 5. 2 percent, which was due to risk factors, health problems on farms, continuing higher costs of cultivation, and adaptation of the farming system to biological safety [1].

At present, agricultural production in Nakhon Pathom province comes in part from aquaculture. The main aquaculture production for consumption comes from three economic aquaculture: Vannamei white shrimp, giant freshwater prawn, and Nile tilapia. The total production is about 90 percent of the total aquaculture production for the year 2020. The proportion of aquaculture production for only Vannamei white shrimp accounted for 47 percent and giant freshwater prawns accounted for 31 percent. In 2021, the consumption of Vannamei white shrimp trended up, but the giant freshwater prawn declined slightly due to the safety confidence affected by the COVID-19 pandemic situation, with yields equal to 4,131,115 and 2,028,890 metric tons, respectively [2].

In the past, the shrimp industry in Thailand used to be the main income-generating industry for the country. Thailand was the world's number one shrimp exporter in 2010. However, after 2012, the pandemic of quick-dead shrimp caused Thailand's shrimp production to decline by more than half and lose enormous economic value. At present, many agencies are working together to solve urgent problems in order to revive the economy and resume the Thai shrimp industry in the future [3].

According to the study of the National Economic and Social Development Plan, the study of national strategies, policies, and ideas that are trying to help drive Thailand's economy back to normal after being affected by the outbreak of COVID-19, the research team,

domiciled and working in education in Nakhon Pathom, realized the importance of contributing to safety shrimp cultivators. Since shrimps are considered the main economic aquatic animal in Nakhon Pathom, it is necessary to educate farmers and enhance their ability to compete in the shrimp market by producing products that meet the needs of consumers who are aware of food safety. Additionally, this can help drive the Thai shrimp industry to flourish again.

Therefore, the researchers aimed to upgrade shrimp farmers in Nakhon Pathom province to digital entrepreneurship. As a result, they can integrate and add value to safety shrimp farming, as well as expand business networks of enterprises, communities, and cooperatives to get opportunities to access capital sources and become stronger, more self- reliant, and more acceptable.

2. Research Methodology

This study was a research and development. The research sequence was divided into four steps.

2 .1 Step 1: Study problem conditions and needs of safety shrimp farmers in Nakhon Pathom and the development of the electronic course manual to elevate safety shrimp farmers to digital entrepreneurship. The details are as follows:

Resources

- Studying secondary data from textbooks, academic documents, research articles, and websites to acquire concepts and theories about good aquaculture practices, entrepreneurship, digital business, human resource development, curriculum development, e- book development, networking, cooperation, and related research. Data were analyzed and synthesized for developing data collection tools.

- Studying primary data from individual sources by selecting specific key informants through purposive selection, as follows:

- 100 safety shrimp farmers in Nakhon Pathom province with the following qualifications: 1) being Vannamei white shrimp

and/or giant freshwater prawn farmers in Nakhon Pathom province with three years or more experience; 2) owning a shrimp pond with an area size of not less than 5 rai; 3) having registered as a controlled aquaculture operator with the province; 4) doing shrimp farming according to Good Agricultural Practices (GAP) for not less than 3 years; and 5) being voluntary to provide information for this research study.

- Eight experts in entrepreneurship with the following qualifications: 1) owning a successful establishment in digital business with at least two years of experience; 2) being recognized as a successful entrepreneur, e.g., by being awarded or interviewed in different media; and 3) being voluntary to provide information for this research study.

Data collection tools

The research team developed data collection tools based on secondary data obtained from the study. The research tools are as follows:

- A structured interview with open-ended questions for farmers to collect data on shrimp farming.

- A questionnaire for farmers to assess their qualifications for entrepreneurship.

- A structured interview with open-ended questions for qualified experts to collect information on training course development.

Data analysis

The researchers analyzed data obtained from questionnaires, structured interviews, and focus groups using content analysis and quantitative analysis using descriptive statistics.

2.2 Step 2: Develop a training course and electronic manual accompanying the course to upgrade safety shrimp farmers in Nakhon Pathom to digital entrepreneurship.

The researchers utilized the data collected in Step 1 to create a training course and an electronic course manual by drafting course objectives and considering their suitability according to principles and concepts as follows:

The objectives of the course were to provide students with the following knowledge and understanding: 1) digital age perspective on entrepreneurship; 2) digital entrepreneurship skills, including technology, marketing, financial and accounting, and business plan; and 3) personal traits that influence digital entrepreneurship, such as leadership and readiness for digital entrepreneurship.

The course competency refers to the ability to apply knowledge, skills, and personal characteristics to performance.

The course description defines the course name, the amount of time to attend the training, details about the training material, and course content.

The course content comprises the content consistent with course objectives, course duration, maturity of participants, and the scope of the content according to the details of digital entrepreneurship. The content was divided into four learning units: 1) smart farming technology, 2) marketing, 3) finance and accounting, and 4) business plan, with a total duration of 16 hours.

The research team designed course materials in the form of electronic lessons, e-books, and videos.

Guidelines for the evaluation of course learning outcomes were established by assessing learners before learning (pretest) and after learning (posttest). The tests comprised multiple-choice questions and were prepared with a chart or table of analysis/ indicators scoring weight. The criteria for passing the course was 60%.

Seven qualified experts, who are knowledgeable in assessment and evaluation, were asked to examine the quality of the course to ensure the appropriateness and consistency of the training content and the accompanying electronic manual. The experts are required to be 1) knowledgeable instructors in the development of assessment and evaluation in public or private institutions with at least three years of experience; 2) outstanding in the development of entrepreneurship programs, or

published research studies and development of training courses for the incubation of entrepreneurs; and 3) voluntary to provide information for this research study.

The course was piloted with 15 shrimp farmers who were not in the sample group but had similar natures and qualifications to the research sample. The aim was to examine the practical use of the developed course and electronic course manual, as well as study problems and obstacles during the trial.

2.3 Step 3: Trial the training course and electronic manual to elevate safety shrimp farmers in Nakhon Pathom to digital entrepreneurship. The details are as follows:

- Utilize the developed course and electronic manual with a sample of 30 people. The sample was selected by purposive sampling. They were qualified as follows: 1) be literate with any level of education; 2) have Thai nationality; 3) be a safety shrimp farmer in Nakhon Pathom province, located in Mueang District, Don Tum District, Kamphaeng Saen District, and Bang Len District; 4) have at least three years of shrimp farming experience; and 5) be voluntary to participate in the training course until the required learning hours have been completed.

- Prepare a place, set a date and time, prepare various documents, and start the activity to ensure the participants are aware of the necessary information. Then, the researchers measured the participants' knowledge, let them study the course and use the electronic manual, as well as assessed their knowledge after the course, and recorded information on the activities in order to summarize the results and present them in the research.

2.4 Step 4: Evaluate the training course and the electronic manual accompanying the course to elevate safety shrimp farmers in Nakhon Pathom province to digital entrepreneurship and establish business alliance networks.

- Assess the sample's satisfaction with the course and the electronic manual. Data were analyzed for feedback using descriptive statistical analysis to improve the developed course and the electronic manual.

- Organize a focus group of 30 people to create the alliance networks (the participants were the same sample group that utilized the course and the electronic manual in Step 3) and conduct a trial with 15 people from the sample group (the same experimental group in Step 2). The research team prepared a venue and set a date and time for organizing the meeting to educate and transfer knowledge about the creation of business alliance networks. After that, the researchers summarized the results of the focus group and the opinions received.

3. Results of the Study

3.1 The results of the study are as follows:

According to Step 1, there were 100 informant farmers. The majority of them, 72 people, had never developed a business plan for shrimp farming, while 21 of them had done it before, and seven did not provide information. Furthermore, 73 people could develop a business plan, 16 informant farmers could not, and 11 people did not provide information. After an investigation into the essential skills that digital entrepreneurs should possess, 100 farmers agreed that the most necessary knowledge is finance and investments (93.4%), followed by marketing (73.6%), business plan writing (31.9%), digital technology (26.4%), and product processing (25.3%), respectively. In addition, data from the interview of eight experts suggested that understanding one's own business was the most crucial skill for a successful entrepreneur. Data analytics for business management, product marketing and value addition, advanced technology, finance and accounting, and business planning were also on the list. To help farmers become digital entrepreneurs, a training course should cover digital marketing, help them create a business plan that outlines their strategy and goals, teach them how to use innovation and modern technology, and explain how to define their business's objectives, as well as the creation of

unique goods and services and accounting and financial expertise. The researchers, therefore, used the above information to develop a training course and an electronic manual to upgrade safety shrimp farmers in Nakhon Pathom province to become digital entrepreneurs. The training was a short course under the name of digital entrepreneurship. The course duration was 16 hours, consisting of four units: 1) smart farming technology, 2) marketing, 3) finance and accounting, and 4) business plan, with assessment and evaluation activities and a 30-question test.

The research team reviewed the course and the accompanying electronic manual by assessing the suitability and consistency of the training course and the electronic manual with seven experts. The results showed that, overall, the qualified experts found that the training course and the electronic manual were most appropriate with an average of 4.95 and the S.D. of 0.22. When considering each component, it was found that all eight components—1) principle and background, 2) course objective, 3) course competency, 4) course description, 5) course content, 6) learning activities, 7) learning material, and 8) learning evaluation—were suitable at a high level. The top three components of appropriateness with the highest average were learning material ($\bar{x} = 5.00$ and S.D. $= 0.00$), learning activities ($\bar{x} = 4.96$ and S.D. $= 0.19$), and principle and background ($\bar{x} = 4.96$ and S.D. $= 0.20$), respectively.

The results of the trial of the training course and the electronic course manual to elevate safety shrimp farmers in Nakhon Pathom province to digital entrepreneurship revealed that the participants who completed the 16-hour course and studied the electronic manual had higher results than before learning. The participants' average scores before and after learning were 12.13 and 25.83, respectively. Consequently, the posttest was significantly higher than the pretest with a significance level of .05.

The results of participants' satisfaction with the training course and the electronic course manual to elevate safe shrimp farmers in Nakhon Pathom province to digital entrepreneurship showed that 30 participants were most satisfied with the course and the electronic manual with an average of 4.60 and the S.D. of 0.65. When considering each component, the participants were most satisfied with the process ($\bar{x} = 4.63$ and S.D. $= 0.66$), followed by course management ($\bar{x} = 4.61$ and S.D. $= 0.64$), facilitator ($\bar{x} = 4.60$ and S.D. $= 0.65$), results and benefits ($\bar{x} = 4.60$ and S.D. $= 0.63$), assessment and evaluation ($\bar{x} = 4.59$ and S.D. $= 0.61$), product ($\bar{x} = 4.57$ and S.D. $= 0.70$), and import ($\bar{x} = 4.56$ and S.D. $= 0.65$), respectively.

3.2. The results of the development of the electronic manual on digital entrepreneurship and business alliance networks in Nakhon Pathom province showed that the electronic manual accompanying the course to elevate safety shrimp farmers in Nakhon pathom province to digital entrepreneurship through an assessment by seven qualified experts was most suitable with learners with an average of 5.00, and S.D. of 0.00.

3.3 Regarding the results of creating business alliance networks for safety shrimp farmers to digital entrepreneurs in Nakhon Pathom obtained from conducting a focus group, the participants made useful recommendations as follows:

1. Organizing a small group meeting provided opportunities for everyone to build a good relationship, create cooperation, and work with mutual benefit. The developed course integrated technology knowledge into today's business, which was important for entrepreneurs to apply to their businesses. Idea exchange within the groups brought out expertise in each person to create new things.

2. Providing a forum for farmers to develop or solve problems in various areas of work could increase production opportunities, marketing channels, and bargaining power,

which brings cooperation to help protect the interests of all.

3. Utilizing the knowledge gained from the business plan training helped farmers make use of what is left over from production, such as processing small shrimp that are not the right size into sweet shrimp. This allows them to

adjust the plan according to what they have to maximize their financial return.

4. There should be a promotion of negotiation knowledge creation for dealing with other entrepreneurs and middlemen. This could allow farmers to do business negotiation effectively.

Figure 1. Electronic books and web application

4. Discussion and Conclusion

According to the study, the findings could be discussed as follows:

4.1 The primary information needed for the development of the training course and the accompanying electronic manual for upgrading safety shrimp farmers to digital entrepreneurship in Nakhon Pathom province was obtained from the informants, consisting of 100 farmers and eight successful entrepreneurs. The data were studied, analyzed, and synthesized resulting in the ability and development needed to raise farmers to digital entrepreneurship. It made possible to determine the course's objectives and also influence the selection of content, organization of the content system, selection of learning experiences, assignment of activities, and determination of whether the evaluation was appropriate for

those who would attend the course. This was in line with Taba's model for developing curriculum, which suggested that the curriculum development process consisted of seven stages: 1) needs analysis; 2) objective formulation; 3) content selection; 4) content organization; 5) learning experience selection; 6) organizing activities and learning experiences; and 7) evaluation (Hilda Taba, cited in Marut Patphol, 2019) [4]. This was also in accordance with the concept of Chanasith Sithsungnoen (2021, p. 155), which suggested that curriculum development was an important process in

education development. There must be a plan for improvement of the study of basic data analysis, the study of the criteria, and the procedure of selecting the appropriate model. The curriculum development process was a continuous process. The important purpose was

to acquire the effective curriculum of a development model, which was a continuous and complete overview. It consisted of eight steps: Step 1 basic data analysis and collection; Step 2 determining the principles and aims of the curriculum; Step 3 choosing and organizing content and learning experiences; Step 4 determining guidelines for evaluating the achievement of learners; Step 5 checking the quality of the curriculum before applying it; Step 6 implementing the curriculum; Step 7 evaluating the curriculum; and Step 8 improving curriculum changes and curriculum development. The researchers' course development in this study was also in accordance with the concept of Marut Patphol's development (2019) [4], which proposed the results of the education, curriculum qualifications, and curriculum development of four scholars, including Ralph W. Tyler, Hilda Taba, J. Galen Saylor and William M. Alexander, and Peter F. Oliva. It was stated that the curriculum development model had a common focus on the systematicity of curriculum development. When analyzing the concept of curriculum development, it was found that various systems could be linked to each other. There were three systems, consisting of curriculum design system, curriculum implementation system, and curriculum evaluation system. The stages of curriculum development from synthesis were common: 1) basic data analysis for curriculum development; 2) curriculum design; 3) curriculum implementation; and 4) curriculum evaluation.

4.2 By examining the course and the electronic manual, the suitability and consistency of the training course and the electronic manual were evaluated by seven experts. The results showed that, overall, the course and the electronic manual were most suitable, with an average of 4.95 and S.D. of 0.22. When considering each component, it was found that all eight components—1) principle and background, 2) course objective, 3) course competency, 4) course description, 5) course content, 6) learning activity, 7) learning material, and 8) learning evaluation—were suitable at the high level. The top three of the components, which had a high average of suitability, were: 1) the learning material with an average of 5.00 and S.D. of 0.00; 2) the learning activity with an average of 4.96 and S.D. of 0.19; and 3) the principle and background with an average of 4.96 and a S.D. of 0.20, respectively. It could be said that the systematic synthesis of information and curriculum development resulted in a complete set of key curriculum components. This was consistent with the idea of Wareerat Kaewurai (2021, p. 35) [6], which proposed that the course components should generally consist of course objectives, course content, teaching process, and assessment and evaluation guidelines. When classifying the curriculum components, there might be some differences in the details, but mainly, there would be completely the same important issues or important components that will allow the instructor to apply the curriculum effectively. Curriculum developed at different levels might have different contextual components. However, the key components must be: 1) principles; 2) aims or objectives; 3) structure, a section that discusses the subject material for learners to learn from and details the content; 4) guidelines for learning experiences; and 5) learning evaluation.

4.3 Implementation of the course with a sample of 30 people revealed that the participants in the training course studied the electronic manual accompanying the course to elevate safety shrimp farmers in Nakhon Pathom province to digital entrepreneurship for 16 hours, and their test results after attending the course were higher than before learning. When comparing the pretest and posttest scores, the posttest scores were significantly higher than before learning at the level of .05. When assessing the satisfaction of participants with the training course and the electronic manual, it was found that the participants were most satisfied with the training course and the

electronic manual with an average of 4.60 and S.D. of 0.65. This was consistent with the results of the research study by Phisit Suvarnaphaet (2560) [7], which presented the results of the research study on the Development of the Training Course on Method for Calculating Day Length for Agriculture, and the results showed that the course was very consistent and appropriate. As for the knowledge of learners after training, it was significantly higher than before the training at the .05 level, and learners were very satisfied with the training course. Therefore, it could be concluded that the training course and the course manual contributed to learners' ability to develop themselves effectively and created a high level of satisfaction with the course.

4. 4 The examination of consistency and suitability of the electronic manual accompanying the course to upgrade safe shrimp farmers to digital entrepreneurs showed that it was suitable for learners at the highest level with an average of 5.00 and S.D. of 0.00. This was consistent with the concept of Jintavee Khlaisang (2012, p. 26–31). [8]. It suggested that e- books facilitate learners' learning. Learners could study at their own pace, both online and offline, through various electronic devices, allowing them to quickly access information, leading to effective learning and affecting learning achievement, as well as increasing their interest in learning and responding to the needs of learners. The outstanding feature of the e- books was that learners could study and learn anywhere. It could be opened and read through a computer or other portable electronic devices over the Internet. This was also aligned with the assessment results of satisfaction with the training course and the electronic manual accompanying the course developed in this study, which was found at the highest level with an average of 4.60 and S.D. of 0.65. Thus, it could be concluded that the course's electronic manual could facilitate learners' learning. Learners could use it anytime and anywhere, following their interests.

4.5 The research team held a focus group to connect business alliance networks for safety shrimp farmers to digital entrepreneurship in Nakhon Pathom. The results showed that the participants proposed four points of usefulness in organizing the meeting, as follows: 1) the focus group was an opportunity for everyone to build good relationships with each other, create cooperation, and work in a mutually beneficial manner. It was accepted as a course that applies technology knowledge to today's business. 2) The meeting provided farmers a place to discuss and work through problems across various fields that could expand their farming options, marketing avenues, and bargaining power. All of which encourage collaboration and the protection of everyone's interests. 3) Farmers could create new uses for their leftover produce by applying the knowledge they received from the business plan training. For example, they could turn small shrimp that did not meet the proper size into sweet shrimp. This enabled them to maximize their financial return by modifying the plan based on what they had. 4) To help farmers successfully negotiate trading, they should be encouraged to develop negotiating skills for interacting with other business owners and middlemen. The results were consistent with the concept of Surasak Nananukul (n.d.) [9], which suggested that the creation of business alliance networks encouraged cooperation between many businesses in various ways, as well as doing business together so that businesses in the network could do things that an individual could not. The business networks could do various activities together as a large business because they operated together for mutual benefit. Therefore, it had higher capabilities, higher efficiency, and higher mobility, including having a better initiative that each business could do alone. Business networks allowed small and medium- sized businesses to survive and compete with global businesses. In addition, this was in line with the concept of Preedee Nukulsomprattana (2020), which proposed that collaboration was a creative

business. Networking was essential to doing business in this highly competitive era. Business networking was a great way to create value, expand your customer base, and learn more about your business. It was not only about exchanging information but also about building long-term relationships for mutual benefit. By building a strong business network, your business could grow and prosper in the future [10].

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Factors Influencing the Success of ISO 14001 Implementation in Honda Automotive Service Center, Thailand

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Abstract

The objective of this research is to find out the factors influencing ISO 14001 implementation in Honda automotive service center, Thailand by using Grounded Theory. The data of the study is collected by using mixed research method, that is, in-depth interviews, observation, and notes, as well as document studies after the in-depth interviews with key informants. In-depth interviews were conducted with managers of Honda Automotive Service Center with ISO 14001 certification. The result found out the success factors for ISO 14001 implementation as follows:1) Knowledge and understanding of ISO 14001; 2) Training of related staff before implementing ISO 14001; 3) A unique environmental policy; 4) The implementation as planned 5) Adequacy of related staff 6) Staff participation 7) The intention of management level; 8) Attractive payment to good supporter; 9) Implementation of appropriate technology 10) Monitoring and evaluation activities 11) Reviewing of Management 12) Continual improvement. The result concluded that the success of Honda automotive service centers in the implementation of the ISO 14001 system requires input factors, operational procedures factors, and supporting factors.

1. Introduction

At present, Thai society has many activities in daily life. It has a car to help with transportation. The number of cars is increasing every year and tends to increase too. The total number of registered vehicles is totaled 44,716,614 units on July 31, 2024 [1]. Also, the car is a transportation facility, but the car must be maintained and repaired to extend the service life, reduce energy used, and reduce air pollution such as PM2.5 [2] by bringing the car to the service center for automotive technicians who have experience in engine maintenance.

Automotive service centers in Thailand are continually expanding and can be categorized into two types: 1) standard service centers, which are part of the car manufacturers' network, such as Honda, Toyota, Nissan, Isuzu, etc., and 2) independent service centers, which are not affiliated with carmakers. These independent centers may specialize in repairing a single brand or multiple brands, offering services such as engine repair, body paintwork, or undercarriage maintenance. Automotive service centers have various production and service activities that can impact the environment both directly and indirectly, contributing to water pollution, air pollution, and noise pollution [3], [4]. Additionally, factors such as customer demand, environmental image, and a good working environment play an essential role in encouraging the industrial and service sectors to focus on environmental management [5]. Honda Co., Ltd. has become a leader in integrated vehicle production and is recognized as the 6th largest manufacturing facility among Honda factories worldwide, excelling in both production technology and environmental

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standards. One of Honda's main global policies is to maintain a strong environmental management system, efficient energy use, and responsible resource management. Consequently, the company has adhered to the concept of environmentally friendly business operations with its dealers through the Green Factory Program, which encompasses energy management, pollution control, waste management, and hazardous waste handling in compliance with the principles and specifications of the ISO 14001 environmental standard. These activities result in Honda Automotive Service Center being certified ISO 14001, which is an environmental management standard that can confirm the leadership in the automotive industry in Thailand, along with being a leader in environmental quality, which is a standard set up to be used voluntarily but is considered a practice by the workplace and partners voluntarily [6].

In this study, the researcher aims to study the factors that affect the success and awareness of the staff in implementing the ISO 14001 system of the automotive service center as a case study because it causes water pollution, air pollution, noise pollution, waste management and hazardous waste that is not suitable as a guideline for other organizations or organizations who are interested in environmental management to be able to apply more efficiently.

1. Objective

To establish the Grounded Theory Study of factors affecting the success of the ISO 14001 system operation of Honda Automotive Service Center in Thailand.

3. Scope of the Study

1. Scope of content: the study of factors affecting the successful implementation of the ISO 14001 system of the Honda Automotive Service Center.

4. Research methodology

4.1 Study area and key informants

The selection of research areas and key informants for the Grounded Theory Study of the factors that contribute to the successful implementation of the ISO 14001 system of the

Honda Automotive Service Center, Thailand that has received the ISO 14001 certification. The researcher has chosen the theoretical sample under the important principle that the informants are consistent and meet the objectives of the research. Therefore, employees with work experience in environmental management systems then it is a theoretical sample group because those people have the knowledge, understanding, and expertise in operations clearly to use in creating the theories that need to be studied.

4.2 Research tools

The important research tool is the researcher, in order to obtain complete and detailed information. Therefore, the researcher must be of theoretical sensitivity. The researcher has prepared the knowledge section by studying the documents and related research in order to establish the Grounded Theory Study of factors affecting the success of the ISO 14001 system operation of the Honda Automotive Service Center. The researcher has prepared the research questions based on the conceptual framework and theories by using open-ended questions. In addition, proceed to prepare a voice recorder, video record, notebook, and pen recorder for field data recording.

4.3 Ethics and code of conduct

This qualitative research is to establish the Grounded Theory Study of factors affecting the success of the ISO 14001 system operation of Honda Automotive Service Center. The researcher is aware of ethics. Therefore, attach importance to the research process by informing the key informants of the objectives before data collection as well as making appointments in advance before the interview by requesting the affiliation of the Faculty of Environment and Resource Studies, Mahidol University is the issuer of the interview request. However, the key informant is an employee at the Honda Automotive Service Center, may be affected by the information provided. The researcher did not reveal the names of key informants.

4.4 Data collection

Data collection methods in the field. The interview method, which is an important part of data collection, is flexible and can be changed while studying but requires observation, documents, and audio recording during the interview. Therefore, to obtain complete and detailed information according to research objectives, the researcher used 3 methods of data collection, in-depth interview, observation and note, and study documents as follows;

4.4.1 In-depth interview

The in-depth interview used open ended-questions. It uses to be a guideline for informal discussions with key informants, without attaching to any concepts that the researcher had in advance. Therefore, the question in the interview is real practice. Collecting data with key informants including executives, environmental management representative and employees with work experience in environmental management systems. For example, asking about knowledge, understanding, experience, to find out the facts. The interviewer must also be able to observe various behaviors such as facial expressions, eyes, voice, and feelings of the interviewee. It takes about 30-60 minutes while interviewing. The researcher checked the understanding to match the key informants and periodically summarize issues along the way as well as observe behavior at the same time stop the interview when getting saturated data.

4.4.2 Observe and take notes

Data collection by observing what is happening as intended for this qualitative research, use Non-Participant Observation. Which is an observation of the real practice. In terms of the dealer environment, environmental management representative and employee performance according to ISO 14001 requirements. Observation data will be combined with data collected through in-depth interviews and document studies. The researchers recorded data from observations using the notes and interview recordings.

4.4.3 Documentary research

The main methods for collecting data in qualitative research are in-depth interviews and observations, but there is another type of information used in qualitative research, is documentary research. The data from the document gives a visual view of the study and the environment of the Honda Automotive Service Center, as preparation before and during data collection, it is the analysis of documents related to research from many sources.

4.5 Reliability test

The importance of data checking and analysis in qualitative research is to examine the data sources. Sources to be considered in the audit are;

- Time

It means in each period; the information will be the same or not. For example, if the researcher interviewed of environmental operations are continual improvement and consistent with ISO 14001 reequipment such as training plans, environmental objective and management review.

- Place

It means if the locations are different, the information will be the same or not. For example, considering Honda Thailand automotive service centers that have received ISO 14001 certification, is the implementation of the ISO 14001 system consistent across all branches, or does it differ from one branch to another?

- People

It means if changing the key informant, the information will be the same or not. For example, ask questions from the manager of dealer, change to the question of the environmental management representative or employee or change from individual to a group or social group [7].

4.6. Data analysis

In this research, the researcher periodically analyzed the data both during data collection and after data collection was completed by analyzing the data obtained from in-depth

interviews, observation, and notes, and document studies after the in-depth interviews with key informants. The researcher will transcribe from the voice recorder and record the details that occurred during the interview which the interview results will be the guideline for the next interview, with the data from the document study to be analyzed together with the triangular inspection The data analysis of the researcher uses the systematic model of Strauss and Corbin (1990) [8] as the basis. It is divided into 4 steps: open coding, axial coding, selective coding and development of a theory with details as follows;

- Step 1 Open coding

It is the taking of data collected from various sources such as in-depth interviews, observation and taking notes, and document studies, to analyze thoroughly to find the essence in the data and then define it as a concept. When obtaining sufficient codes, it is classified by categories which can be considered as closing the code to reduce the data with clear principles.

- Step 2 Axial coding

To select the main category from one category to analyze the relationship between large categories and sub-categories by focusing on relevant conditions, the researcher will continuously alternate between data collection and data analysis, including classification and correlating data to summarize concepts.

- Step 3 Selective coding

The researchers will combine data types and data relationships to create a "chapter" which will explain that "what happened" in the research phenomenon

- Step 4 Development of a theory

The theory that occurs to describe the studied phenomena which may be in the form of language or pictures, which the theory will indicate the nature of the phenomenon. The theory and explanation of the rational relationship between various factors are obtained from data collected from the phenomenon.

5. Results

The results of the Grounded Theory Study are the factors that contribute to the success of the ISO 14001 system of Honda Automotive Service Center, consisting of 12 factors.
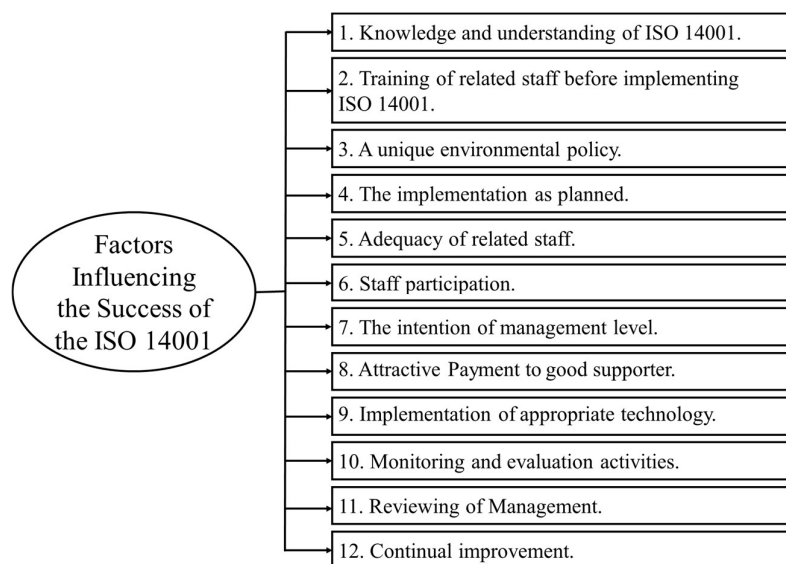
Figure 1. Factors affecting the success of the implementation of the ISO 14001 system obtained from the Grounded Theory Study

1. Knowledge and understanding of ISO 14001.

It is the basic information that every employee must know that ISO 14001 is what, from where, where to do it, what the steps are, what to do, and how to do it. If all employees know and understand the ISO system it will help to proceed with the next step more easily and conveniently.

2. Training of related staff before implementing ISO 14001.

Environmental training courses will be available at the consulting company or the Headquarter of Honda Company who will come to train in various courses such as environmental awareness, system requirements of ISO 14001 system, internal audit, including the identification of environmental issues, etc. Before employees operate the ISO 14001 system, they must train environmental courses to achieve system efficiency and there will be tests before-after training that employee know, understanding that they can be implemented or not.

3. A unique environmental policy.

It is the main goal of the organization that announced to all employees that asked the direction of the organization concerning the environment. The management has set guidelines for the environmental policy, which must be concise, easy to understand, and must cover 3 principles; pollution prevention, law compliance and continuously updated, to serve as a reminder before every operation and the environmental policy must be consistent with our culture and organization size.

4. The implementation as planned.

The ISO 14001 implementation plan is planned year by year for the correct implementation and at the end of the project will be assessed that how successful was the plan, such as waste separation, grease trap system management, maintenance, and inspection of tools, overseeing the transportation of used oil, etc. Each item must have a weekly, monthly, and yearly summary form for use in the examination and evaluation. Each item must have a weekly, monthly, and yearly summary form for use in auditing and evaluation.

5. Adequacy of related staff.

There will be a supervisor from various departments representing the staff. Joining the organization's environmental management committee and able to communicate with staff in the department themselves. There will be activities such as the administrative department will design the data record and then the technician department will take it to check the tools, chemicals, or the service department and pick up the car have to communicate with customers that our organization has environmental operations, considered external communication. In addition to regular duties, it must perform environmental concurrently. Therefore, the number of employees is necessary for operation ISO 14001 system.

6. Staff participation.

Require cooperation and participation of all employees in all departments in the Honda Automotive Service Center because environmental management is considered the responsibility of everyone to help each other to enable the ISO 14001 system to proceed completely. Each department has different environmental problems such as the paint and tank repair department that will control the noise, odor from the paint, and thinner by working in each room of work. The office department will use 2-sided paper and separate the waste into the correct type.

7. The intention of the management level.

Now, the green trend is trending in every business circle and the automotive business has an impact on various pollution problems. Other companies in the automotive business industry have already cared for the environment. Therefore, executives who have absolute power to make decisions in the organization must pay attention to the environment so that the business of the organization can be comparable with international because the ISO 14001 is the international standard for an effective environmental management system.

8. Attractive payment to good supporters.

Environmental problems in the water, air, or noise in the organization all-cause annoyance both within the organization itself and the surrounding communities, such as the paint and body repair department making noise when scrubbing or having a foul odor from the paint room. If there is support from the management to solve various environmental problems, decreasing the operation of environmental activities tend to be costly and there is no monetary return but will get back in the corporate image

9. Implementation of appropriate technology.

To solve environmental problems, modern technology must be applied in the organization to achieve good efficiency and help reduce environmental problems such as creating a grease trap to help reduce wastewater that has high BOD, COD, oil &grease, will not be exceeded the standards that set by law or using a pump with a meter to fill the oil to reduce problems of spills or overflows that may be caused by the carelessness of employees. Install the sensor lights for bathrooms, it will save when there is no one using this service. It will help to reduce environmental problems.

10. Monitoring and evaluation activities.

The ISO 14001 certificate will be valid for 3 years but it will be audited annually by Auditor to monitor the organization's system to maintain the standard or not. The environmental management system representative will have to monitor the organizations overall and have an internal audit every year to be able to assess the expected environmental problems. The third thing is to check the authenticity of the documents, to inquire and order of the area of operations. This may be a way of helping to manage environmental monitoring as well as to the ISO 14001 system operating smoothly.

11. Reviewing of Management.

In weekly or monthly company meeting, the environmental management committee should propose environmental problems or audit results to the management to acknowledge and comment on the environment to see whether each year, the organization has any environmental problems and is ready to approve the implementation of an urgent project. The review depends on the suitability of each organization. Every time a review is signed, a memorandum is required to attend the meeting and listen to various problems in the organization, including environmental management.

12. Continual improvement.

After receiving the ISO 14001 certification, the system should be continuously improved. For the system to maintain the standards, such as legal conformity assessment, internal auditing, etc., for the system to be able to proceed successfully.

6. Conclusion

1. The Honda automotive service center has the main components of all 12 factors will successfully achieve ISO 14001 system management. These factors include: knowledge and understanding of ISO 14001, training of related staff before implementing ISO 14001, a unique environmental policy, the implementation as planned, adequacy of related staff, staff participation, the intention of management level, attractive payment to a good supporter, implementation of appropriate technology, monitoring and evaluation activities, reviewing of management and continual improvement.

2. The Honda environmental management committee consists of management representatives, staff representatives from various departments, which is the input that factor in operating the ISO 14001 system. If the inputs factor, have knowledge, understanding and have received training, as well as having appropriate qualifications and seniority, would result in the Honda automotive service center being successful which is consistent with the research of Tanacharoenpisarn (2011) found that the factors related to the adoption of the ISO 14001 environmental management system were three factors: age, knowledge and understanding of the ISO 14001 environmental management system and awareness of environmental management system ISO 14001 [9]. Khaophong (2008) studied the Knowledge, Participation and Awareness on Environmental

Management System of the Environmental Management System (ISO 14001) Accredited Organization Personnel: A Case study of Chantaburi Sea Food Co., Ltd., and Chantaburi Frozen Food Co., Ltd. found that there are 6 factors related to the awareness of the environmental management standard system: education level, perception of information, receiving training in the environmental management system, having a model for environmental management and participation in the environmental management system [10].

3. Operating process factors have a unique environmental policy, the implementation as planned, implementation of appropriate technology, monitoring, and evaluation activities, reviewing of Management and continual improvement, which the operational procedures are considered important in operating the ISO 14001 system because the system must start from setting up the policy to continuous examination and improvement, there is no shortage of steps, this is consistent with the results of the Suttprasert (2012) study on Climate Change Management of Local Authorities in Samutsakhon Province, it was found that both local government organizations have designated responsible agencies and have policies, plans and projects, allocating budgets, with comprehensive performance monitoring [11]. Hongchinda and Chompunth (2014) has studied the implementation of the Environmental Management System (ISO 14001) that can achieve the specified objectives and goals, and the performance results must be monitored in accordance with the environmental policy, objectives, goals and plans [12].

4. Supporting factors consist of the adequacy of related staff, the intention of management level, attractive payment to a good supporter, which helps to improve the ISO 14001 system, such as budgets for environmental activities which is consistent with the study of Pinaksornskul (2001), factors affecting the success of the ISO 14001 environmental management system in Kawila Wittayalai School, Muang District, Chiang Mai Province, which found that the success of the application of the ISO 14001 environmental management system in schools by two factors: commitment of the management and the

cooperation of the personnel within the school [13]. Tepkaew (2002) has studied A study on ISO 14000 environmental system in printed circuit industry: a case study of PCTT company limited, it was found that establishing an ISO 14001 Environmental Management System to be successful, it should start from senior management, must have a clear policy and drive it to be part of the organizational culture, creating support from all parties involved, as well as providing knowledge and training to employees in order to continue effective system development [14].

5. The success of Honda automotive service centers in the implementation of the ISO 14001 system requires input factors, operational procedures factors, and supporting factors, to be successful in operating the ISO 14001 system this is consistent with the results of the Intaratoot and Chompunth (2015) study of Factors affecting the implementation of Environmental Management System (ISO 14001) of Petrochemical industry: A Case study of IRPC Public Company Limited, there are 3 major influencing factors as follows: 1) Context (Political, Economic and Social and Environmental) 2) Input (human resources, budget, technology, management and working method) 3) Process (planning, program implementation, monitoring and evaluation, review and improvement, and personnel participation) 4) Product (achievement of environmental objectives and targets, and the environment within the area) 5) Impact (social and environmental, and development) [15].

6. Customers receive the service from the Honda automotive service center that is certified with the ISO 14001 Environmental Management System, which ensures that when entering the service, there will be no impact on the environment. The pride and loyalty to our service center and they will come back to use the service again this is consistent with a Castka and Prajogo (2012) study, that found that when receiving ISO 14001 certification, the company is recognized by its stakeholders. Therefore, the implementation of a good environmental management system will benefit both the environment and the image of the organization [16].
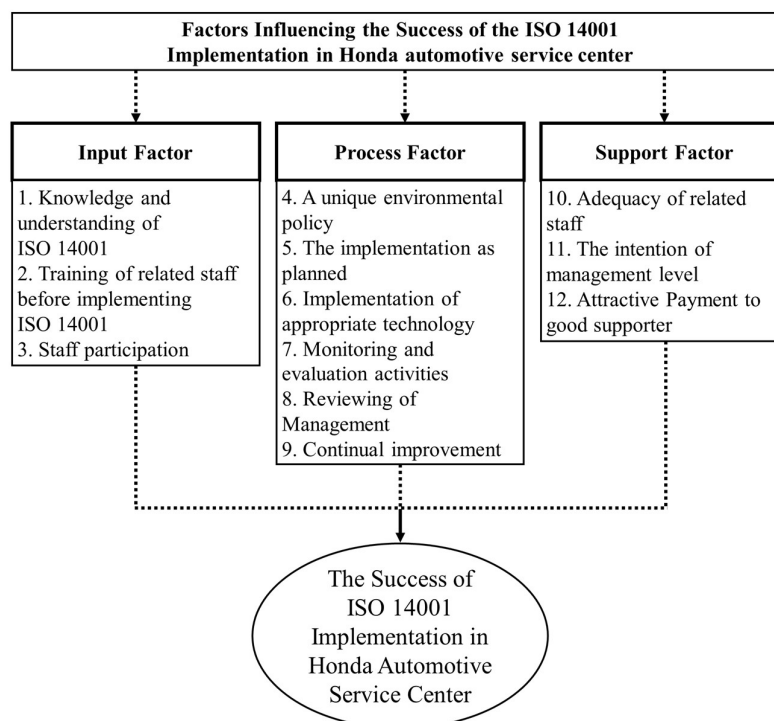
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│         Factors Influencing the Success of the ISO 14001      │
│      Implementation in Honda automotive service center        │
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Input Factor	Process Factor	Support Factor
1. Knowledge and understanding of ISO 14001 2. Training of related staff before implementing ISO 14001 3. Staff participation	4. A unique environmental policy 5. The implementation as planned 6. Implementation of appropriate technology 7. Monitoring and evaluation activities 8. Reviewing of Management 9. Continual improvement	10. Adequacy of related staff 11. The intention of management level 12. Attractive Payment to good supporter

The Success of ISO 14001 Implementation in Honda Automotive Service Center

Figure 2. The relationship of factors affecting the success of the ISO 14001 system of Honda Automobile Service Center

7. Suggestions

1. The management must be committed to solving environmental problems by leading to ISO 14001 immediately.

2. Employees in the organization must help verify the effectiveness of ISO 14001 to prevent environmental problems.

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PREDICTORS OF YOUNG ENTREPRENEURIALLY-ORIENTED GENERATION

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Abstract

Education is seen as a vital factor of success in the Philippines. One tends to forget that entrepreneurial characteristics such as skills, mindset, and intention are as crucial as education. Students' exposure to social media platforms encouraging entrepreneurship has increased online entrepreneurial activities. The study analyzed the collected data from 122 young and student entrepreneurs. Ordinal regression was utilized in data analysis. This study showed that the low, medium, and high levels of entrepreneurial intention, skills, and mindset are good predictors of each other. A probability that a unit increase in one will increase the other. The result shows the importance of each entrepreneurial characteristic to make entrepreneurially-oriented youth. Other variables used are age, gender, course, and motives. Though age and gender variables were not significant, the study found that opportunity and necessity motivation and achievement, challenges, and learning increase the level of entrepreneurial skills of young entrepreneurs. Business students were found to have a higher entrepreneurial mindset than other student respondents. A recommendation of combining entrepreneurship and education through course offerings and deep engagement in entrepreneurial activities of young potential entrepreneurs could lead to a higher level of entrepreneurial intention, mindset, and skills.

1. Introduction

Young minds are always curious and creative. How can we describe young people nowadays? They are divergent and convergent thinkers. They think like entrepreneurs, anticipate problems, and always find solutions. The transformation of entrepreneurship can be significantly aided by an entrepreneurial mindset [1]. Risk-taking and working with others are linked to cultivating an entrepreneurial mindset. Without an entrepreneurial mindset, entrepreneurial skills cannot significantly affect entrepreneurial intention [1].

The interplay between entrepreneurial intention, mindset, and skills has been a focal point of research in entrepreneurship studies. These elements often influence and reinforce each other in complex ways. While the entrepreneurial intention is a self-acknowledged conviction by a person to set up a new business venture [2], the entrepreneurial mindset is described by [3] as a growth-oriented perspective through which individuals promote flexibility, creativity, continuous innovation, and renewal. Entrepreneurial skills refer to the competencies necessary to start, develop, finance, and succeed in one's own enterprise [4]. These three are interconnected factors that play a crucial role in entrepreneurial behavior.

Students regard the generation of personal income as the business activity's most significant reward but find the lack of knowledge an obstacle to engaging in a business [5]. Even if students lack business knowledge, they still engage in entrepreneurial

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activities to fulfill their passion, gain experience, and generate income [6].

Challenge-based learning programs significantly impact students' entrepreneurial mindset and skills, specifically financial education, planning, and creativity [7]. Other universities in the Philippines employ entrepreneurial challenge-based programs for business students only. Other majors do not include like-approached programs, which may be a factor in the mindset and skill of young entrepreneurs. Business majors, those in related professions like education and information technology, and even senior high school students are engaged in business activities.

Students' entrepreneurial intentions and self-efficacy are stronger after receiving more entrepreneurship education than after participating in practicals [8]. Entrepreneurial awareness and skills are improved through teaching methods, including operating an actual business, visiting a business location, and conducting an entrepreneur interview [9].

Businesses and entrepreneurial skills are essential in youth employment [10]. Entrepreneurial skills are methods that entrepreneurs can employ in unpredictable settings to produce positive results. Skills develop high entrepreneurial intention. [11].

Age has been found to have a complex relationship with entrepreneurial intention. [12] proposed that as individuals age, they become less likely to choose self-employment due to the opportunity cost of time. However, [13] found that the relationship between age and entrepreneurial activity is U-shaped, that both young and old individuals show a higher propensity for entrepreneurship.

Motivations for entrepreneurship can vary. Opportunity-driven entrepreneurship is more likely to encourage opportunity than necessity-driven business [14]. [15] provide evidence to support the expectation that growth-oriented entrepreneurs will exhibit increased intrinsic motivation.

Various studies on entrepreneurship targeting business students as respondents have already been done. This study's objective is to broaden its focus and examine the viewpoints of other students from various academic disciplines and levels of analysis.

In the article published by inc.com, Generation Z was described as entrepreneurially oriented. They are getting themselves into business. The results of this study will show whether entrepreneurial mindset and skill levels can predict low, medium, and high entrepreneurial intention levels. Another objective is to show that entrepreneurial intention and mentality can predict entrepreneurial skill levels and entrepreneurial skill levels can predict entrepreneurial mindset. Other predictors or independent variables used were age, gender, course, and motives.

2. MATERIALS AND METHODS

Data were analyzed using logistic regression because the Relational Screening Model was used in the investigation. Its main goal is to create a valid model that describes the link between the predictor and the predicted variables.

As shown in Fig. 1, the dependent variables used in this study are entrepreneurial intention, skills, and mindset. These variables were also used as predictors of each other. Other predictors were age, gender, course, and motives.
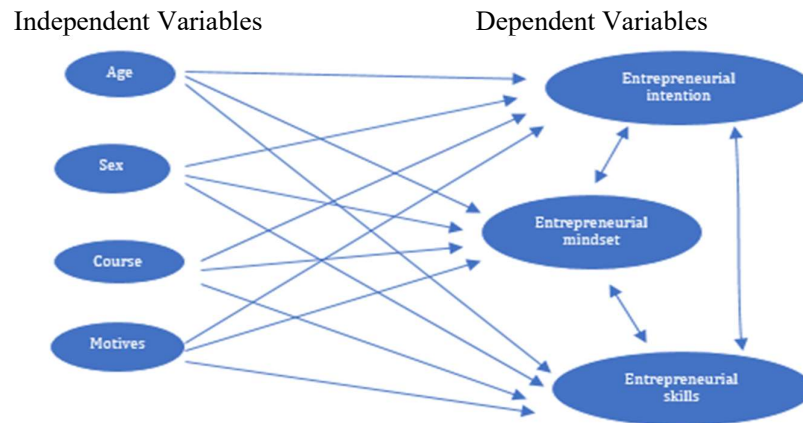
Independent Variables   Dependent Variables

Fig. 1. Conceptual Framework

2.1 Data Gathering Instrument

The survey questions were adapted from the developed instrument by Moberg et al. [16]. The seven-point Likert scale was utilized to create a specific set of items to examine each entrepreneurial characteristic. The variables and domains of the study are shown in table 1.

The entrepreneurial mindset consists of 8 items with two factors (entrepreneurial mindset and core self-evaluation). Entrepreneurial skills comprised 22 items with six elements (creativity, planning, financial education or literacy, managing resources, managing ambiguity, and entrepreneurial knowledge). Lastly, entrepreneurial intention consists of 3 items with one factor. Reliability coefficients are the following: 0.895 for an entrepreneurial mindset, 0.711 for core self-evaluation, 0.849 for creativity, 0.905 for planning, 0.860 for financial literacy, 0.856 for managing resources, 0.852 for managing ambiguity, 0.610 for entrepreneurial knowledge, and 0.809 for entrepreneurial intention. The overall scale of reliability are 0.845. These figures show a good fit value of scale.

Table 1. Variables, their domains, and reliability coefficients

Domain	Variable	Cronbach's α
Mindset	Entrepreneurial Mindset	0.895
	Core Self-Evaluation	0.711
Entrepreneurial Skills	Creativity	0.849
	Planning	0.905
	Financial Literacy	0.860
	Managing of Resources	0.856
	Managing Ambiguity	0.852
	Entrepreneurial Knowledge	0.610
Intention	Entrepreneurial Intentions	0.809
Overall		0.845

Many sorts of entrepreneurial motivation are additional independent variables. According to [17], types of entrepreneurial motivation include the following:

1. Opportunity and necessity motivation – also called push-pull. It recognizes that sometimes choosing to be an entrepreneur is a matter of need and opportunity.
2. Achievement, challenge, and learning – This dimension encapsulates a desire to achieve oneself via entrepreneurship.
3. Independence and autonomy – This aspect emphasizes the entrepreneurial motivation to have autonomy over one's time and work, the ability to make independent judgments, and the flexibility to balance work and family life.
4. Financial success and secured income – This factor adequately expresses the significance of entrepreneurship's economic gains.
5. Recognition and status – This dimension includes social status-related factors, including the desire to be respected and acknowledged for one's entrepreneurial efforts by friends, family, and the larger community.
6. Family and roles – This dimension encapsulates the urge to uphold family traditions and emulate other role models.

2.2 Participants and Procedures

The researcher approached student entrepreneurs from different fields of study. Data from the participants were gathered using the direct interview method. The method was used to explain further some of the business terms that the other participants may not know or are not familiar with. Online student entrepreneurs were selected and identified through social media if they were engaged in entrepreneurial activities such as marketing and selling different products. Others not involved in online entrepreneurial activities were asked if they were into business ventures before they were interviewed.

A purposive sampling technique was used. Respondents were selected for the purpose of entrepreneurial activity engagement. Eighty-five college students from Romblon State University – Romblon campus and 37 senior high school students in Romblon island, province of Romblon, have been identified and willingly participated in the study. Their mean age is 22 years old. Females made up 75.4 percent (N=92), while males made up 24.6 percent (N=30) (Table 1). The respondents have five groups of entrepreneurs from different fields of study: 25.4 percent (N=31) from business, 9.8 percent (N=12) from information technology, 34.5 percent (N=42) from education, and 30.3 percent (N=37) from senior high school. Motives for engaging in entrepreneurial activities were also asked. Their primary reason or justification is for opportunity and necessity motivation at 51.6 percent (63); followed by income security and financial success at 13.9 percent (17); achievement, challenging, and learning at 12.3 percent (15); independence and autonomy at 10.7 percent (13); family and roles at 6.6 percent (8); and others at 4.9 percent (6). The data were gathered using a survey questionnaire, and a direct interview was conducted to further explain the instrument's contents. SPSS was used to examine the data collected. Informed consent was initially discussed with them, and the data gathered would be treated with confidentiality.

Table 2. Demographic Profile
(N=122)

Profile	Frequency	Percentage
Gender		
Male	30	24.6
Female	92	75.4
Course		
Business	31	25.4
Information technology	12	9.8
Education	42	34.5
Senior High	37	30.3
Motives		
Opportunity and Necessity Motivation	63	51.6
Achievement, challenge, and Learning	15	12.3
Independence and Autonomy	13	10.7
Financial Success and Secured Income	17	13.9
Family and Roles	8	6.6
. Others	6	4.9

2.3 Data Analysis

In ordinal regression analysis, a series of assumptions must be made before analyzing the data in SPSS. The initial presumption is that the independent variables must be continuous, ordinal, or categorical, whereas the dependent variable is assessed at the ordinal level. If independent variables are ordinal, they should be treated as continuous or categorical. The variables in this study have passed these first two assumptions. The dependent variables, entrepreneurial intention, entrepreneurial skills, and entrepreneurial mindset, were transformed into discrete variables with low, medium, and high levels.

A multicollinearity test was conducted since a logistic regression analysis is sensitive to significant correlations between independent variables. The method also applies to dependent variables. Tolerance and Variance Inflation Factors were measured to validate the assumption. In examining multicollinearity problems between variables, the assumption is validated.

In Table 3, the tolerance values were all more than 0.02. They were as follows: 0.853 for age, 0.929 for gender, 0.759 for the course, 0.876 for reasons, 0.709 for an entrepreneurial mentality, and 0.760 for entrepreneurial skills. Age, gender, course, motives, entrepreneurial attitude, and talents all had VIF values of 1.172, 1.410, 1.316, 1.142, and 1.317, all of which were less than 10. Multicollinearity assumptions for this study were validated.

Table 3. Results of Multicollinearity Assumptions

Variables	Tolerance	VIF
Age	0.853	1.172
Gender	0.929	1.410
Course	0.759	1.316
Motives	0.876	1.142
Entrepreneurial Mindset	0.709	1.077
Entrepreneurial Skills	0.760	1.317

Parallelism is another essential assumption in ordinal regression analysis. The chi-square test was performed to satisfy the assumption of parallelism. The following table shows the results.

Table 4. Parallelism Assumptions Results
Entrepreneurial intention as a dependent variable

Model 1	-2 Likelihood (-2LL)	x^2	df	p
Null Hypothesis	118.824			
General	116.709	2.115	6	0.909

Entrepreneurial skill as a dependent variable

Model 2				
Null Hypothesis	172.456			
General	162.483	9.973	12	0.618

Entrepreneurial mindset as a dependent variable

Model 3				
Null Hypothesis	174.440			
General	150.126	24.314	12	0.018

The chi-square test for models 1 and 2 (x^2 = 2.115, p > 0.05) demonstrates that the parallelism assumption is confirmed and tested. For model 2, x^2 = 9.973, p > 0.05. However, for Model 3, the p-value result is insignificant (x^2 = 24.314, p < 0.05). The outcome indicates that the parallelism assumption is valid, and the null hypothesis is confirmed. The result also demonstrates parity between each category of the dependent variables, entrepreneurial intention, and entrepreneurial competence. Though Model 3 did not pass this assumption, Ordinal Regression Analysis was still applied to all models.

3. RESULTS AND DISCUSSION

The results of the ordinal regression analysis are covered in this section. The 2-log likelihood (-2LL) values for the models developed without independent variables and those discovered with independent variables are shown in the analysis's model fitness information table.

Table 5. Model Fit Information

Model 1	-2 Log Likelihood	Chi-Square	df	p
Only the intercept	165.654			
Final	118.824	46.830	6	0.000
Model 2				
Only Intercept	235.354			
Final	172.456	62.897	12	0.000
Model 3				
Only Intercept	223.836			
Final	174.440	49.396	12	0.000

By comparing the model created with the independent variables to the baseline model without the independent variables, a substantial change could be seen in Table 5, Model 1 ($x^2 = 165.654 – 118.824 = 46.830$, $p < 0.05$), Model 2 ($x^2 = 235.354 – 172.456 = 62.897$, $p < 0.05$), Model 3 ($x^2 = 223.836 – 174.440 = 49.396$, $p <$ 0.05). The findings show that the dependent variable and the independent factors do have a relationship. The goodness to fit was examined at another stage. Pearson assesses the model's data fit using the chi-square and deviation statistics and the discrepancy between the actual and expected values.

Table 6. Goodness-of-Fit

Model 1	X^2	df	p
Pearson	86.395	68	0.066
Deviance	76.464	68	0.225
Model 2			
Pearson	183.067	188	0.588
Deviance	166.676	188	0.866
Model 3			
Pearson	179.741	184	0.575
Deviance	166.122	184	0.824

Examining table 6, Pearson's chi-square value for Model 1 ($x^2 = 86.395$, $p > 0.05$) and Deviance chi-square value ($x^2 = 76.464$, $p > 0.05$), Model 2 ($x^2 = 183.067$, $p > 0.05$) and Deviance chi-square ($x^2 = 166.676$, $p > 0.05$), Model 3 ($x^2 = 179.741$, $p > 0.05$), and Deviance chi-square ($x^2 = 166.122$, $p > 0.05$) were insignificant. The outcome indicates that the null hypothesis was confirmed and that the model accurately describes the data.

Pseudo-R^2 values evaluated the model's accuracy of fit. Measurement and evaluation of the strength of the relationship between the dependent and independent variables are the goals of pseudo-R^2. The most popular statistics are the McFadden, Cox-Snell, and Nagelkerke R^2 measures.

Table 7. Pseudo-R2 Value

	Cox and Snell	**Nagelkerke**	**MacFadden**
Model 1	0.319	0.364	0.183
Model 2	0.403	0.467	0.260
Model 3	0.333	0.391	0.213

As shown by Cox-Snell, Nagelkerke, and MacFadden statistics, the pseudo-R2 values for Model 1 were 0.319, 0.364, and 0.183, respectively, as shown in Table 7. The pseudo-R2 values for Model 2 are 0.403, 0.467, and 0.260, while those for Model 3 are 0.333, 0.391, and 0.213. The Nagelkerke value is considered even if the Cox-Snell pseudo-R2 value interpretation is complicated. These numbers demonstrate that the independent factors account for a significant portion of the dependent variable. The results were 36.4% for Model 1, 46.7% for Model 2, and 39.1% for Model 3. Although many additional factors may impact entrepreneurial goals, mentality, and abilities, they were only considered for the sake of this study, along with factors like age, gender, and course.

Independent variables are significant, as shown by the Wald test results. The logistic

regression study can be finished with no-biased and divergent parameter findings by testing the results using Wald statistics. The Wald exponential was obtained to interpret the model and determine the odds ratio.

Table 8. Expression of the Significance of the Model Parameters

A. Model 1

Variables		β	Wald	Odds Ratio	p
Entrepreneurial Intention	1 (Low)	1.724	6.236		0.013
	2 (Medium)	4.206	28. 407		0.000
Entrepreneurial Skills		1.078	10.137	2.93879	0.001
Entrepreneurial Mindset		0.782	4.948	2.18584	0.026

B. Model 2

Variables		β	Wald	Odds Ratio	p
Entrepreneurial Skills	1 (Low)	4.852	8.392		0.004
	2 (Medium)	8.716	22.183		0.000
Opportunity and Necessity Motivation		2.492	4.437	12.0854	0.035
Achievement, challenging, and learning		2.691	4.401	14.7464	0.036
No clear motive		0a			
Entrepreneurial Intention		1.195	12.429	3.30355	0.000
Entrepreneurial Mindset		1.076	8.520	2.93292	0.004

C. Model 3

Variables		β	Wald	Odds Ratio	p
Entrepreneurial Mindset	1 (Low)	3.247	4.658		0.031
	2 (Medium)	6.822	17.984		0.000
Business Students		1.789	8.079	5.98346	0.004
Senior High School (HUMMS)		0a			
Entrepreneurial Skill		1.114	8.826	3.04652	0.003
Entrepreneurial Intention		0.673	4.245	1.96010	0.039

Entrepreneurial intention is significantly influenced by entrepreneurial skills (p=0.001) and entrepreneurial mindset (p=0.026) for Model 1, as shown in Table 8. However, regarding predicting entrepreneurial intention, age, gender, course, and motivation were irrelevant. The interpretation according to the odds ratio is another method of investigating parameter significance. The likelihood of having a high level of entrepreneurial intention increases by 1.078 units for every unit increase in the entrepreneurial skill variable. When the odds ratio for entrepreneurial skills is considered, it can be observed that the odds ratio was 2.93879, which is greater than 1. The findings show that an increase of one unit in entrepreneurial skill multiplies the intention to start a business by 2.94. Also, the likelihood of entrepreneurial intention increases by 0.782 units for every unit higher in young entrepreneurs' entrepreneurial skills. A closer look at the odds ratio for the entrepreneurial mindset reveals that it was 2.18584, which is greater than one. Moreover, a one-unit increase in the young entrepreneurs' entrepreneurial mindset variable boosts the amount of entrepreneurial intention 2.19 times.

Results for Model 2 reveal that motives in engaging in entrepreneurial activities such as opportunity and necessity motivation (p = 0.035), achievement challenges, and learning (p = 0.036) were significant. The same results were also significant for entrepreneurial intention (p = 0.000) and entrepreneurial mindset (p = 0.004). A one-unit increase in opportunity and necessity motivation of young entrepreneurs increases the probability of entrepreneurial skills by 2.492 units more than those with no clear intention. The same goes for achievement, challenge, and learning

motivation, which will increase the probability of entrepreneurial skills by 2.691 units. Entrepreneurial intention and entrepreneurial mindset will also increase the likelihood of entrepreneurial skills by 1.195 and 1.076, respectively. When opportunity and necessity motivation, achievement, challenge, and learning are considered, the odds ratio was 12.0854 and 14.7464, which is greater than one. The result means that one-unit increase in opportunity and necessity motivation and achievement, challenge, and learning of the young entrepreneurs increases entrepreneurial skills by 12.08 and 14.75 times.

According to the study, business students are significant for Model 3 findings (p = 0.004). Moreover, results for entrepreneurial skills (p=0.003) and entrepreneurial intention (p=0.039) were significant. This study found that business students were 1.789 more likely than senior high school students to have a strong entrepreneurial mindset. When the odds ratio for the course variable is considered, it is clear that the odds ratio is greater than one. Business students had an entrepreneurial mindset of 5.98 times greater than senior high school students. However, the chance of having an entrepreneurial mindset and intention increases by 1.114 and 0.673 units for every unit increase in an entrepreneurial skill. A unit increase in entrepreneurial skills boosts entrepreneurial mindset 3.05 times, according to the odds ratio of 3.04652. A one-unit rise in entrepreneurial intention raises the degree of entrepreneurial mindset 1.96 times, considering the odds ratio of the entrepreneurial intention of 1.96.

According to research by [18], [19], [20], [21], and [22], having an entrepreneurial mindset and intention are positively correlated with starting a business. An entrepreneurial mindset has been identified as a key predictor of entrepreneurial intention. From [23]'s finding, individuals with a growth mindset are more likely to persist in entrepreneurial endeavors. This study also supports the claim that an increase in entrepreneurial mindset also

increases the level of the entrepreneurial intention of young entrepreneurs. Moreover, entrepreneurial knowledge or skills also increase the level of entrepreneurial intention. Entrepreneurial knowledge and skills positively impact entrepreneurial intention. The study's respondents are in school and have gained knowledge of abilities like planning, managing resources, and financial literacy through schooling. According to [24], business owners with entrepreneurial skills and knowledge see increased entrepreneurial intention and capital when running their companies. Certain skills are associated with higher entrepreneurial intention. [25] found that digital skills, in particular, are increasingly important for entrepreneurial success in the modern economy. Young entrepreneurs nowadays have been exposed to social media and other online platforms, where they can conduct entrepreneurial activities such as marketing and selling products. Maximizing their digital skills could result in more successful entrepreneurial ventures.

Looking at the results of Model 2, opportunity and necessity motivation enhances the degree of entrepreneurial skills of young entrepreneurs This contradicts the study by [26] that found that these motivations are linked to lower levels of entrepreneurship. Another researcher also supported the findings of this investigation. In times of high unemployment and economic recession, opportunity and necessity entrepreneurs will likely have higher average entrepreneurial skills [16]. The study also demonstrates that other forms of entrepreneurial motivation that enhance entrepreneurial abilities include achievement, challenge, and learning [27]. Self-determination theory has been applied to entrepreneurship, suggesting that intrinsic motivation leads to more sustainable entrepreneurial efforts [28]. According to different studies [29]; [30], starting and running a firm may result in changes in skill and motivation, and entrepreneurs may develop entrepreneurial abilities that affect their

motivation [17]. The motivation for most of these young entrepreneurs' engagement in entrepreneurial activities is to help their families and support their studies. These reasons could help unemployment problems in the community. As the phrase goes, "Necessity is the mother of invention", the way these young entrepreneurs find ways to have financial freedom and help themselves would see potential successful business owners in the province.

The field of study or the course can significantly influence entrepreneurial orientation. Business students' educational backgrounds directly influence their entrepreneurial intention [31]. [32] found that business students showed higher entrepreneurial intentions than those in other fields. [33] also noted that the effect of entrepreneurial education on entrepreneurial intention was stronger for business students. The result of this study also supports the claim that being a business student increases the entrepreneurial mindset. Business students' exposure to subjects related to entrepreneurship has widened their entrepreneurial subjectivity and enhanced their entrepreneurial mindset.

4. CONCLUSION

In the Philippines, a small amount of work is being done to examine youth entrepreneurship scientifically. So, this study closes this knowledge gap and advances our understanding of entrepreneurship, particularly that of young people. Younger generations' entrepreneurial traits have demonstrated such great potential for development. Thanks to social media platforms that support online entrepreneurship, many students are now more eager to participate in entrepreneurial activity, even on a small scale. According to the study's essential findings; entrepreneurial intention, abilities, and mindset are all indicators of one another in young entrepreneurs. One grows by one with every unit increase. Additional important aspects were the course, particularly the business students, motivations like

opportunity and necessity motivation, as well as their achievement, challenge, and learning.

Students are increasingly being exposed to technology at an increasing rate, which increases interest in entrepreneurial activity. Entrepreneurship is one form of self-employment that can aid in economic progress. The findings of this study advocate delivering entrepreneurial education classes to boost students' interest in entrepreneurship and increase their entrepreneurial skills, mentality, and intention. The adage goes, "Don't just give them fish; teach them how to fish."

The study shows interesting results that could boost and encourage entrepreneurship in the province, especially for the younger generation. The researcher suggests that the university conduct a feasibility study, review, and consider offering a course directly related to entrepreneurship. Entrepreneurial education could encourage more students to consider entrepreneurial ventures than directly being employed.

This study has a limitation. Perceptions usually differ from reality, and statistical problems like standard method variance and response trends may impact self-reported measurements. Yet, the study's findings confirm and refute those of other studies.

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Automatic Website Content Change Detection and Notification Using Image Processing

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Abstract

This research develops a web application called WatchNSend that allows users to automatically monitor websites and detects changes in website content using image processing techniques. The application is built in three modules. First, in the Setup Module, the user creates a monitoring job and specifies how they would like their website monitored. An Area of Interest (AOI) is selected by the user within the displayed webpage, and other job details are also set, such as the desired monitoring frequency. The application then saves the AOI image and job details for later use. The second module is the job module. This is where all job specifications and all job update information are stored. Also in this module, a timer controls mechanisms that monitor the specified update intervals of all jobs and initiate the third module accordingly. The third module is the comparison module. Here the application automatically collects a current copy of the job's AOI and then compares this new version of the AOI with the previous version, using two methods called the edge calculation and the overlay calculation. If content changes inside the AOI have reached a threshold set by the user, the application automatically notifies the user via e-mail. Results from multiple evaluations show that WatchNSend can monitor websites, detect and analyze changes, and notify the webmaster of the changes accurately and efficiently. WatchNSend is a reliable, robust, and easy-to-use tool that can save users time while keeping them current on website changes.

Keywords: Automatic Website Monitoring, Digital Image Processing, Image-based Monitoring, Change Detection

1. Introduction

Websites are indispensable tools that both the government and private sectors rely on for collecting, processing, and distributing their organization's information [1]. Two basic types of webpages are static webpages and dynamic webpages [2]. Static webpages remain as they are. They do not update automatically or in response to user actions. Static webpages are built with HTML and CSS and reside on a server. When a static webpage is requested by a user, the HTML file is sent by the server to their browser, which opens the page for viewing. In contrast, a dynamic webpage is developed not only with HTML but also with one or more programming languages such as PHP, C#, JavaScript, Ruby, or Python, and a dynamic webpage can update automatically in response to input from users or other data. A user can personalize a dynamic webpage, which can include interactive components such as a shopping cart or a form to fill out. Data for a dynamic webpage is stored in a database on the server and can be requested at any time, enabling the webpage to update dynamically according to user input or changes in the underlying data.

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Website content can change at any time, and many sorts of professions and fields need to be able to monitor various websites for changes. Timely knowledge of new updates to websites can be important or even critical [3]. In order to monitor one or more websites conveniently, users or organizations can avail of software that automatically performs Change Detection and Notification (CDN). As the name suggests, a CDN system automatically detects changes in webpages and notifies the user when there is a change [3]. Previous research in the field of website content change monitoring can be divided into two groups. The first group of CDN systems detects changes to text and HTML element tags. The second group of CDN systems detects changes by using image processing. An example of the first type of CDN system is when M. C. Shobhna [4] conducted exploratory research on webpage change detection systems between 2004 and 2013 using various methods such as BIODIFF, XML Tree Diff, CH Diff, and CX Diff, Level Order Transversal, Optimized Hungarian, Hashing Based Algorithm, Node Signature Comparison, Tree Traversing, and Document Tree Based Approach. Soobbha and Manoj found that a document tree-based approach gave the best performance. Their method relies on converting the content on a webpage to an XML structure. The XML structure generates nodes from the opening and closing tags of the HTML statements. When the system wants to monitor the website, it compares the parameters for each element. Regarding the second group of CDN systems, those that detect changes by using image processing, a review of current CDN systems by Mallawaarachchi, V. et al. [3] highlighted two examples from this group that are easy to use and flexible to the needs of users: Wachete [5] and VisualPing. Both systems offer a variety of monitoring options, including the ability to monitor multiple webpages, to monitor various types of content, to set a threshold percentage of changes that triggers notification, to adjust the frequency of monitoring, and to decide the frequency of notifications.

E. Fenton reported on the top 5 most popular Change Detection and Notification (CDN) tools for 2023 [6]: Visualping.io [7], Fluxguard [8], Sken [9], Pagescreen [10], and OnWebChange [11]. Fees charged for these services vary, depending on the number of monthly checks desired and other specific features. Limited free trials are also offered. The systems mentioned above are all provided from outside Thailand. In Thailand, there is currently no domestic developer or provider of this service. M. C. Shobhna [4] compared the specific features and detection modes of currently available CDN tools, including those mentioned by E. Fenton [6], and the specific features and detection modes of those five services are shown in Table 1.

Table 1. Comparison of functionality and detection modes of some popular CDN tools

CDN Tool	Functionality					Detection Mode		
	MSP	MMP	SSD	FICS	Notify	Visual	Text	HTML
Visualping.io [7]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fluxguard [8]	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Sken [9]	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Pagescreen [10]	Yes	Yes	Yes	Yes	Yes	Yes	No	No
OnWebChange [11]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes

SSD=Server side detection, MMP=Monitor multiple pages, MSP= Monitor a single page, FICS = Fixed Interval checks, and Notify = Email notification.

As of the end of March 2023, there were 354.0 million domain name registrations across all top-level domains (TLDs) [12], and the use of dynamic websites has only increased, including frequently updated websites such as news websites, online shopping websites, travel and accommodation websites, Wikipedia pages, and social media. When these webpages update information, users may want to be informed about changes to webpages immediately.

The current study develops a web application called WatchNSend that uses image processing techniques to detect changes in the content of a website and then sends notification of the changes via e-mail to the webmaster in order to reduce time spent monitoring the website in person. In the process, this study will disseminate the techniques involved in creating such an image-based system for those who want to develop website change detection and change

notification. This research can also serve as a guideline for the development of other sorts of related systems, such as GPS location monitoring systems using online maps, online appointment calendar change monitoring systems, and online retail product promotion change monitoring systems.

2. Materials and methods

The WatchNSend web application developed here for automatic website change detection and notification utilizes a variety of image processing techniques. The application is written mainly in PHP [13] , with some JavaScript and HTML as well. There is a client side and a server side. Figure 1 shows an overview of the processes that happen on each side. The three modules shown (Setup, Job, and Comparison) are described in detail in Sections 2.1–2.3.
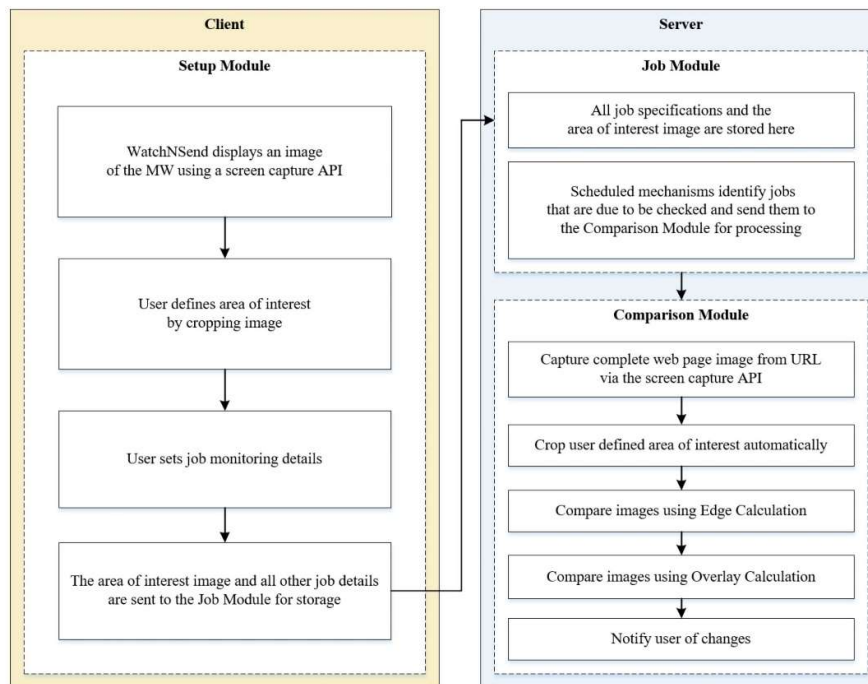
Figure 1. This overview shows the main processes inside the WatchNSend web application.
MW=monitored webpage, i.e., the webpage that the user wishes to monitor.

2.1 Setup Module

The Setup Module contains the steps for receiving job details from the user on the client computer. Each monitored webpage (MW) or portion thereof is one job. Users can add, edit, and check jobs in their job list using the WatchNSend website. Here are the steps.

2.1.1 WatchNSend displays an image of the MW using a screen capture API (Application Programming Interface).

The user is prompted to enter the URL of the MW. WatchNSend then uses the specified URL to go capture a current image of the MW. (A description of how this image is captured using a screen capture API appears in Section 2.3.1.)

2. 1. 2 The user defines the area of interest by cropping the MW image.

When the MW image appears in the display area, an adjustable rectangular selection tool will also be automatically activated for the user to indicate the Area of Interest (AOI). The AOI is the specific part of the image that the user would like to monitor. It can be designated to be anything from a small portion of the full image to the full image itself. The size and position of the selection tool are easy to adjust. The coordinates of the AOI chosen by the user are captured using JavaScript's Cropper command [14] and then saved as part of the data for the current job.

2.1.3 User sets job monitoring details

After selecting the AOI, the user specifies the frequency to check for changes, the threshold of change within the AOI at which the user would like to receive notification, and the e-mail address to which notifications should be sent. This threshold set by the user is referred to in this study as the notification threshold. The frequency to check for changes can be set to every 5, 15, or 30 minutes, daily, weekly, or monthly [15]. If the frequency is daily, the user can select the hour that they would like to check for changes. If the frequency is weekly, the user can select the day and hour to check. If the frequency is monthly, the user can select the date and hour to check.

2.1.4 Store the AOI image and all job details

Once the job monitoring details are complete, WatchNSend will immediately save a current copy of the AOI image as well as all the job details. This information will be used later to schedule checks for MW changes and to assess those changes.

2.2 Job Module

The Job Module resides on the server, and it has two functions: job information storage and identification of jobs that are due to be checked so that they can be sent to the Comparison Module for processing. Each of these functions is explained in detail here.

2.2.1 Job information storage

The Job Module is the storage area for all data on jobs, including all the job specifications that were inputted during the Setup Module, the original AOI image, and all information collected each time the MW is checked for changes. The first fetching of the AOI is initiated in the Setup Module when the new job is created, and all MW checks that follow are initiated by the timer function here in the Job Module.

2. 2. 2 Identifying jobs that are due to be checked and sending them to the Comparison Module

A system of timed mechanisms identifies jobs that are due to be checked. There are seven of these mechanisms, one for each possible frequency that users can specify for a job to be checked. Because these seven mechanisms are dispatched on a schedule to perform a designated task, they are called "JobFlights" here, like flights being dispatched from an airport. The seven JobFlights used in this study are shown in Figure 2. The 24-hour schedule by which the JobFlights depart, i.e., are run, is shown in Figure 3.

The Seven JobFlights in WatchNSend

JobFlight05 leaves every five minutes to query jobs that are checked every 5 minutes
JobFlight15 leaves every fifteen minutes to query jobs that are checked every 15 minutes.
JobFlight30 leaves every thirty minutes to query jobs that are checked every 30 minutes.
JobFlight60 leaves every sixty minutes to query jobs that are checked every 60 minutes.
JobFlightDay leaves every sixty minutes to query jobs that are checked daily.
JobFlightWeek leaves every sixty minutes to query jobs that are checked weekly.
JobFlightMonth leaves every sixty minutes to query jobs that are checked monthly.

Figure 2. These are the seven mechanisms called JobFlights that identify jobs due to be checked. The last three job flights in the list leave every hour in order to check for and respond to the user's preferred hour for checking changes.

24 Hour Schedule	JobFlight 05	JobFlight 15	JobFlight 30	JobFlight 60	JobFlight Day	JobFlight Week	JobFlight Month
00:00	Run #1	Run #1	Run #1	Run #1	Run #1	Run #1	Run #1
00:05	Run #2						
00:10	Run #3						
00:15	Run #4	Run #2					
00:20	Run #5						
00:25	Run #6						
00:30	Run #7	Run #3	Run #2				
00:35	Run #8						
00:40	Run #9						
00:45	Run #10	Run #4					
00:50	Run #11						
00:55	Run #12						
01:00	Run #13	Run #5	Run #3	Run #2	Run #2	Run #2	Run #2
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
23:00	Run #276	Run #93	Run #47	Run #24	Run #24	Run #24	Run #24
23:05	Run #278						
23:10	Run #279						
23:15	Run #280	Run #94					
23:20	Run #281						
23:25	Run #282						
23:30	Run #283	Run #95	Run #48				
23:35	Run #284						
23:40	Run #285						
23:45	Run #286	Run #96					
23:50	Run #287						
23:55	Run #288						

Figure 3. This is the 24-hour schedule by which the JobFlights depart, i.e. are run.

Operation of the JobFlights is managed by two things on the server: the Task Scheduler [16], which is part of Windows, and a set of seven PHP code scripts, one for each JobFlight type. The task scheduler is able to run the code scripts automatically in the background without opening a browser or any other program.

The seven JobFlight scripts vary by nature, with the most complex being the script for JobFlightMonth, because the user can select the monthly date and hour to check the job.

JobFlightMonth's actions will be explained here as an example, but the other six JobFlights operate similarly with their respective selection criteria. As mentioned above, JobFlightMonth leaves once an hour. Here is what happens. Every hour on the hour, the Task Scheduler automatically runs the PHP script specifically for JobFlightMonth. The script performs two important actions. The first action is to build a recordset of all job records that meet the criteria shown in Figure 4.

Recordset Criteria of JobFlightMonth

The job must be currently active.
The job must be specified to check monthly.
The job must be specified to check on the current date of every month.
The job must be specified to check on the current hour.

Figure 4. JobFlightMonth will pick up all records that meet these criteria.

Any records that enter the recordset defined in Figure 4 are due to be checked now. The second action of the JobFlight script is to take any records that have just been collected in the recordset and process them in the Comparison Module shown in Figure 1. The code that carries out the steps of the Comparison Module is here in the JobFlight script. If the JobFlight did not encounter any records to collect, the Comparison Module steps are not called.

2.3 Comparison Module

The job records delivered by each JobFlight need to have the current version of their monitored webpage (MW) captured and compared to the previously captured version. This happens in the Comparison Module, and the details of each step are described here.

2.3.1 Capture complete current webpage image from URL via screen capture API

This procedure relates to both capturing the initial webpage image of the MW during job initiation in the Setup Module and to capturing the current webpage image of the MW when a JobFlight has determined that the job is due to be checked for changes. WatchNSend utilizes a screen capture API to collect a current, complete screenshot of the user's monitored webpage. The underlying reason for using a screen capture API is that the application needs more than just a normal display of the MW as it would usually appear on a monitor. Many webpages are longer than the monitor display and use scrollbars to make the complete webpage accessible. An image of the full webpage that is complete and without any scrollbars will be referred to here as a Complete Webpage Image (CWI). Capturing a CWI is not a straightforward programming task because it requires installation of Selenium

software [17], which is also not a minor task. Various providers simplify this process by offering screen capture API services that collect and deliver CWIs for a small fee. Each API provider has different capabilities and different pricing. Three important performance criteria when selecting a screen capture API provider for an application like WNS are: the completeness of the webpage delivered, the accuracy of the webpage delivered, and the speed of delivery. Since WatchNSend uses PHP as its primary language for development, it also requires an API that supports PHP. Requests to the screen capture API are made through the GET or POST methods of PHP.

2.3.2 Crop user-defined area of interest automatically

When an updated, complete webpage image is acquired from the screen capture API, it is cropped automatically to the AOI using the stored coordinates of the AOI from the job record. JavaScript's Cropper command is used for this purpose as before. The AOI cropped from a current version of the web page is referred to as the Current Image (CI) , while the previously stored AOI is referred to as the Previous Image (PI).

2.3.3 Perform the edge calculation and the overlay calculation on the current image and previous image.

Whenever a webpage is checked for updates, both the CI and the PI are sent to feature extraction algorithm 1 to perform the edge calculation and the overlay calculation. Each of these two calculations compares the CI with the PI and provides a percent change between the two images. The two calculations complement each other because the edge calculation is best at detecting actual text

changes, while the overlay calculation is best at detecting changes in presentation of the text and changes in color.   Because these two calculations are used at the same time and

because they share some variables, they appear together in Algorithm 1. The steps in Algorithm 1 are described in detail here.

Step 1: Convert the CI and the PI to grayscale. These will be called the Grayscale Current Image (GCI) and Grayscale Previous Image (GPI).

Step 2: Find all the edge pixels of the GCI and GPI using the Canny Edge Detection algorithm [18]. These will be called the Edge (pixels of the) CI and PI (ECI and EPI)

Step 3: Count the number of edge pixels in the ECI and EPI.   These will be called the NECI and NEPI.

Step 4: Perform the Edge Calculation using Equation 1 [19].

$$\text{Edge Calculation result} = \frac{|NEPI - NECI|}{|NEPI|} \times 100 \tag{1}$$

Step 5: The Overlay Grayscale Image (OGI) is a construct that reflects changes between the GCI and the GPI. Create the OGI by calculating the OGI value of every pixel using Equation 2 [20].

$$OGI_{(x,y)} = (abs (GCI_{(x,y)} - GPI_{(x,y)}) + abs (GPI_{(x,y)} - GCII_{(x,y)})) \% 255 \tag{2}$$

If the intensity value of a given pixel has changed between the GPI and the GCI, the intensity of that pixel in the OGI will be greater than 0. If not, it will be 0.

Step 6: Use Otsu's thresholding method [21] to calculate the Otsu threshold value of the OGI. The result will be between 0 and 1, which corresponds to the grayscale pixel value range between 0 and 255.

Step 7: Convert the OGI image to a binary image (BOGI) using the Otsu threshold value calculated in the previous step.

Step 8: Count the number of white pixels in the BOGI (WBOGI).

Step 9: Perform the Overlay Calculation using Equation 3.

$$\text{Overlay Calculation result} = \frac{WBOGI}{M*N} \times 100 \tag{3}$$

Where: M is the Area Of Interest Image height

N is the Area Of Interest Image width

2.3.4 Select the calculation results

After the Edge Calculation and Overlay Calculation have been performed, their results, which both estimate the Percent Change (PC) between the CI and the PI, are compared, and the higher of the two numbers [22] is selected

to represent the PC for this MW check and referred to as the MWPC.

2.3.5 Notify user of changes

Once the MWPC is obtained, its value is compared with the Notification Threshold

originally specified by the user in the job record. If the MWPC is greater than or equal to the Notification Threshold, an email is sent to the user to notify them of changes. Whether or not the Notification Threshold is met, the following items are stored in the job history record after each MW check: the time of the MW check, the CI, the Edge Calculation result, the Overlay Calculation result, and the MWPC.

2.4 Experiments
2. 4. 1 Screenshot API service provider comparison test

The purpose of this test is to determine the best-performing screenshot API service from among those that are available at any given time, based on the three previously mentioned performance criteria: the completeness of the webpage delivered, the accuracy of the webpage delivered, and the speed of delivery. In addition to these three performance criteria, the Screenshot API service needs to be able to handle two basic kinds of webpage banners [23] : scrolling banners (simple banners that move with the rest of the webpage and can scroll out of sight) and static banners (banners that are fixed in position and do not move in response to scrolling). Six different screenshot API providers were tested, and a total of ten URLs were used for testing. Five of them have scrolling banners: https: / / th. wikipedia. org/ , https: / / www. kpru. ac. th/ index. php, http: / / omayo. blogspot. com/ , https://www.diald.nu.ac.th/th/clinic_calendar.php, https://store. steampowered. com/ ?l=thai, The other five have static scrolling banners: https: / / stackoverflow. com/ , https: / / www. w3schools. com/ , https: / / www. lazada. co. th/ shop/ skechers, https://shopee. co. th/ m/ super-brand-day, and https://www.deviantart.com. The test was run on an internet connection measured with Google Fiber [24] as having a download speed of 216. 8 Mbps and an upload speed of 53. 2 Mbps. The speed of actual image captures during the test was measured using PHP commands to record the time before and after the image capture. Test scores for the three performance criteria were normalized to values in the range of 0- 100 using the Min- Max Normalization Method [25] shown in Equation 4.

$$x_{scaled} = \frac{x - x_{min}}{x_{max} - x_{min}} * 100 \qquad (4)$$

In this normalization method, the highest score received during the test becomes 100 and the lowest score received becomes 0. All other scores fall between this minimum and maximum, and the proportions between the original scores are maintained. Results of the three performance criteria are normalized in this way so that they share a common unit and can be conveniently compared.

2.4.2 The AOI processing time test

The purpose of this test is to time how long the application takes to crop an incoming Screenshot API image down to the AOI and then perform both the Edge Calculation and Overlay Calculation on the AOI. To run the test, a timer is started in the application code when the MW image is received, and the timer is stopped right after the results of the two calculations are complete. This test used 70 sample images of the same starting size and cropped them in 7 different patterns (representing different size AOIs) . Each cropping pattern was applied to 10 images.

2.4.3 The comparison module test

The purpose of this experiment is to test the functionality of the comparison module and the ability of the Edge Calculation and Overlay Calculation to accurately detect content changes in the AOI. The experiment consists of 4 tests, each with an original image and four progressively changing update images, as shown in Figure 5. Each update image was compared to the original image of its test. In test 1, the amount of text changes. In test 2, the background color changes. In test 3, the text color changes. In test 4, the sequence of the text changes.

Figure 5. The image dataset used for the four tests that evaluate the functionality of the Comparison Module. In test 1, the amount of text changes. In test 2, the background color changes. In test 3, the text color changes. In test 4, the sequence of the text changes.

3. Results

3.1 Screenshot API service provider comparison test

The results of this test are divided into two figures. Figure 6 shows the results from scrolling banner webpages, and Figure 7 shows the results from static banner webpages.
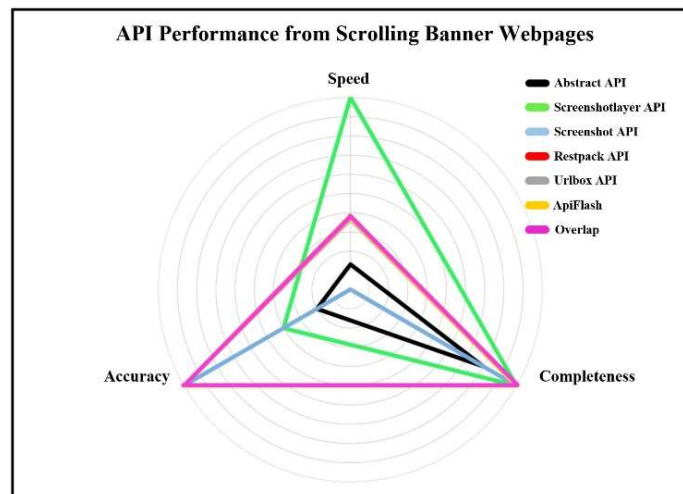
Figure 6. Results of the API performance test using scrolling banner webpages. Scores for the three criteria range from 0% (center point) to 100% (outermost ring). The last three providers in the list (Restpack, Urlbox, and ApiFlash) fully overlap as the pink triangle.

Figure 6 shows the three test criteria results (speed, accuracy, and completeness) displayed visually as a triangle for each provider. In the completeness category, Screenshotlayer, Screenshot API, Restpack, Urlbox, and ApiFlash all scored 100%, followed by Abstract API at 80%. In the accuracy category, Screenshot API, Restpack, Urlbox, and ApiFlash all scored 100%, but Screenshotlayer and Abstract API both had issues displaying Thai language content correctly. Finally, the average speed performance of Screenshotlayer was the best, followed by Abstract API, Restpack, Urlbox, ApiFlash, and Screenshot API.
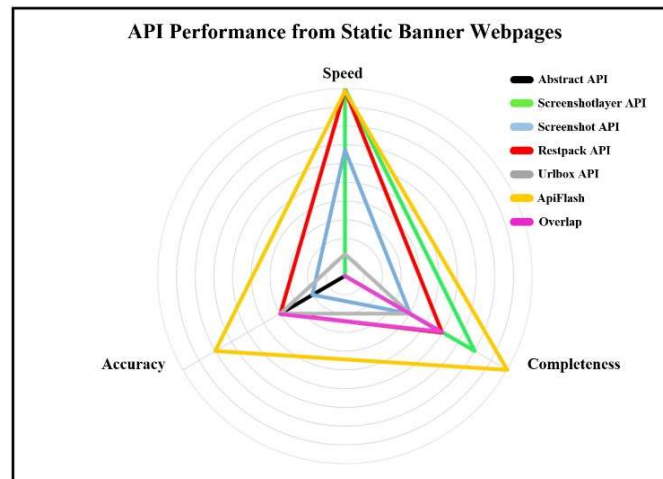
Figure 7. Results of the API performance test using static banner webpages. Scores for the three criteria range from 0% (center point) to 100% (outermost ring). The providers shown in black, green, and red (Abstract API, Screenshotlayer, and Restpack) share overlapping segments in the two pink lines.

Figure 7 shows that when using static banner webpages, the completeness criteria was led by ApiFlash with a score of 100%, followed by Screenshotlayer at 80%, and then the others. In the accuracy category, ApiFlash again performed best, this time with a score of 80%, with other providers trailing. The average speed score performance of Screenshotlayer was the best, followed by Restpack. After considering the results from both scrolling and static banner webpages, ApiFlash was chosen as the API provider for WatchNSend because ApiFlash can handle both types of banners and it scores an average of 86.01% on the three performance criteria.

3.2 The AOI processing time test

The results of this experiment to determine the time required to crop an incoming image to the AOI and then perform both the Edge Calculation and Overlay Calculation are shown in Figure 8.
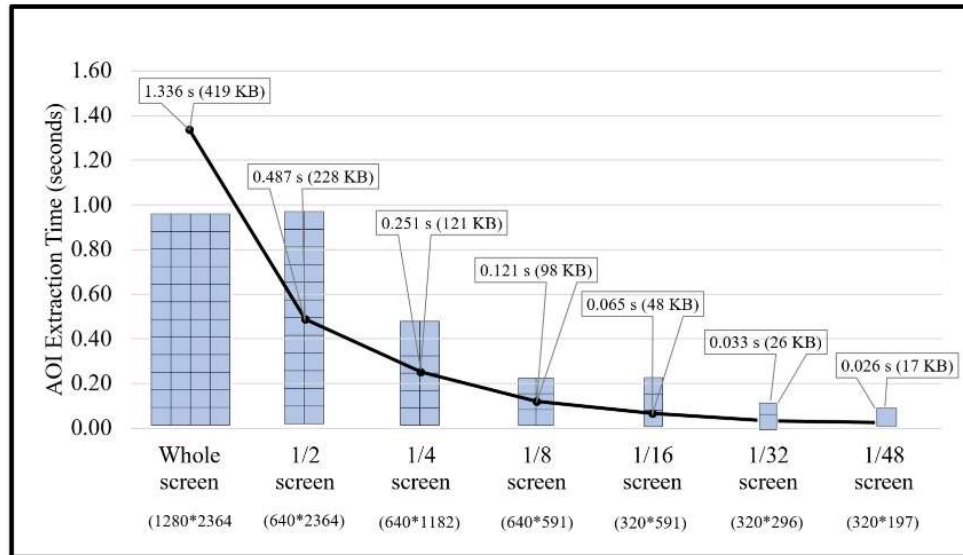
Figure 8. The time required to process various size Areas Of Interest (AOI)

These results show that the time required to process an AOI corresponds to the size of the AOI. The larger the AOI, the longer the processing time. The largest size took 1.336 seconds to process and the smallest took 0.026 seconds. The average processing time across all 7 sizes was 0.331 seconds, indicating that WatchNSend can process an average of 181 images per minute.

3.3 The Comparison Module test

The results of this test to investigate WatchNSend's ability to detect the four kinds of progressive image changes from Figure 5 using a combination of the Edge Calculation and Overlay Calculation are shown in Table 2.
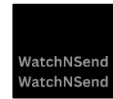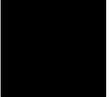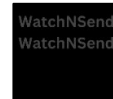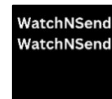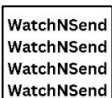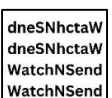
Table 2. The results of the Edge Calculation and Overlay Calculation for four kinds of progressive image changes from Figure 5, along with the Monitored Webpage Percent Change (MWPC)

Test	PI and CI Comparison	Edge Calculation Result	Overlay Calculation Result	MWPC
1	A compared to B	25.00	4.52	25.00
	A compared to C	49.99	9.05	49.99
	A compared to D	74.99	13.57	74.99
	A compared to E	99.98	18.10	99.98
2	F compared to G	Inf (0)	25.21	25.21
	F compared to H	Inf (0)	50.08	50.08
	F compared to I	Inf (0)	75.13	75.13
	F compared to J	Nan (0)	100.00	100.00
3	K compared to L	2.95	4.53	4.53
	K compared to M	5.91	9.07	9.07
	K compared to N	8.86	13.60	13.60
	K compared to O	11.81	18.14	18.14
4	P compared to Q	1.16	4.42	4.42
	P compared to R	2.32	8.84	8.84
	P compared to S	3.49	13.26	13.26
	P compared to T	4.65	17.69	17.69

Remember that whichever result from the Edge Calculation or Overlay Calculation is larger, that result is designated as the Monitored Webpage Percent Change (MWPC). In Table 2, the MWPC results for Test 1 and Test 2 are very tidy. They reflect that the progression of changes to the original image is approximately 25%, 50%, 75%, and 100%. The image differences in Test 3 and Test 4 were more difficult for the Edge Calculation and Overlay Calculation to evaluate, however the MWPC results for these two tests still reflect a steady and proportional increase, which is good. Users

of the application can be notified of these types of webpage changes by selecting one of the lower Notification Thresholds. In general, a high result for the Edge Calculation occurs when text changes on the MW. On the other hand, a high result for the Overlay Calculation generally occurs when the background color, text color, or text orientation change. Examples of the image results from each stage of the Edge Calculation and Overlay Calculation for the four Comparison Module tests are shown in Table 3.

Table 3. Examples of the image results from each stage of the Edge Calculation and Overlay Calculation for the four Comparison Module tests

Compared Image Pair from Figure 5	GPI	GCI	EPI	ECI	OGI	BOGI
A and C	WatchNSend WatchNSend WatchNSend WatchNSend	WatchNSend WatchNSend	WatchNSend WatchNSend WatchNSend WatchNSend	WatchNSend WatchNSend	WatchNSend WatchNSend	WatchNSend WatchNSend
F and H						
K and M	WatchNSend WatchNSend WatchNSend WatchNSend	WatchNSend WatchNSend WatchNSend WatchNSend	WatchNSend WatchNSend WatchNSend WatchNSend	WatchNSend WatchNSend WatchNSend WatchNSend	WatchNSend WatchNSend	WatchNSend WatchNSend
P and R	WatchNSend WatchNSend WatchNSend WatchNSend	dneSNhctaW dneSNhctaW WatchNSend WatchNSend	WatchNSend WatchNSend WatchNSend WatchNSend	dneSNhctaW dneSNhctaW WatchNSend WatchNSend		

GPI = Grayscale image converted from the color PI, GCI = Grayscale image converted from the color CI, EPI = Edge of the PI by Canny edge detection, ECI = Edge of the PI by Canny edge detection, OGI = Overlay Grayscale Image, and BOGI = the binary image from the OGI image using the threshold value.

3.4 Application Development

WatchNSend was developed into a web application with which users can easily create jobs to monitor and then view or update current or past jobs. There are two screens, and they are shown in Figure 9. Figure 9(A) is the Job Creation screen, where users can enter new jobs and specify the area of interest to monitor, along with other job details. Figure 9(B) is the dashboard screen where users can see an

overview of current and past/inactive jobs. By clicking on one of the jobs in the list on the left, the user can view the details of that specific job on the right and initiate changes if desired. Also in the dashboard job details is the monitoring history of the selected job, along with access to current and past notifications of webpage changes, which pop open when the notification icon is clicked (not shown).
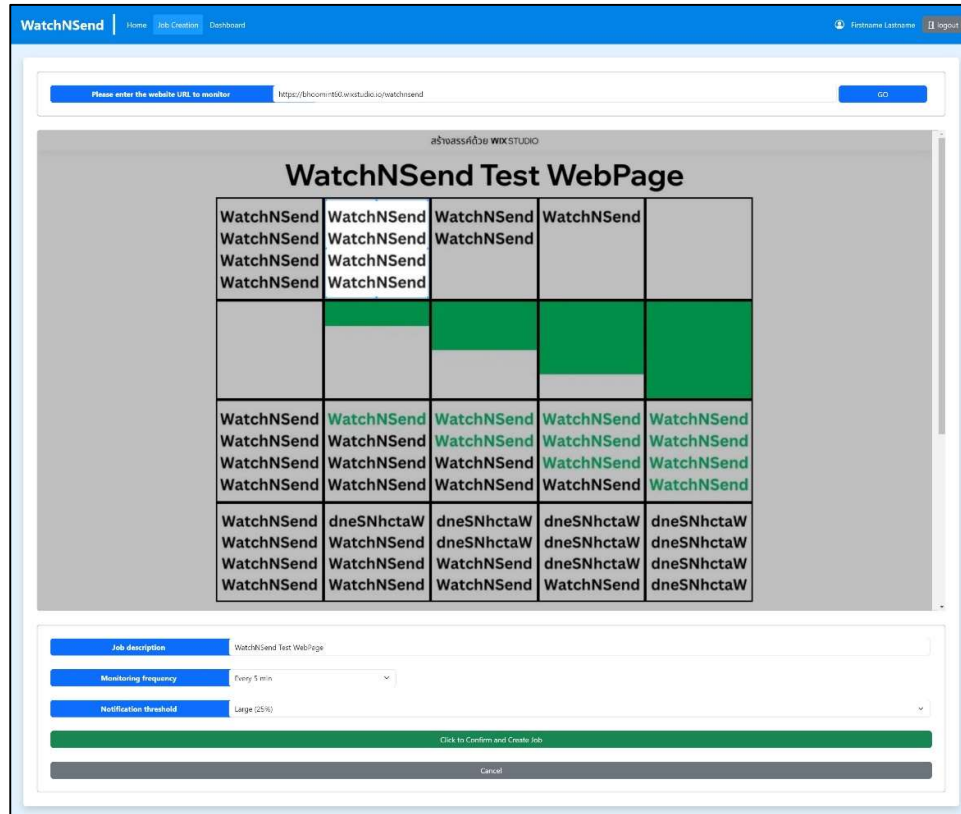
(A)
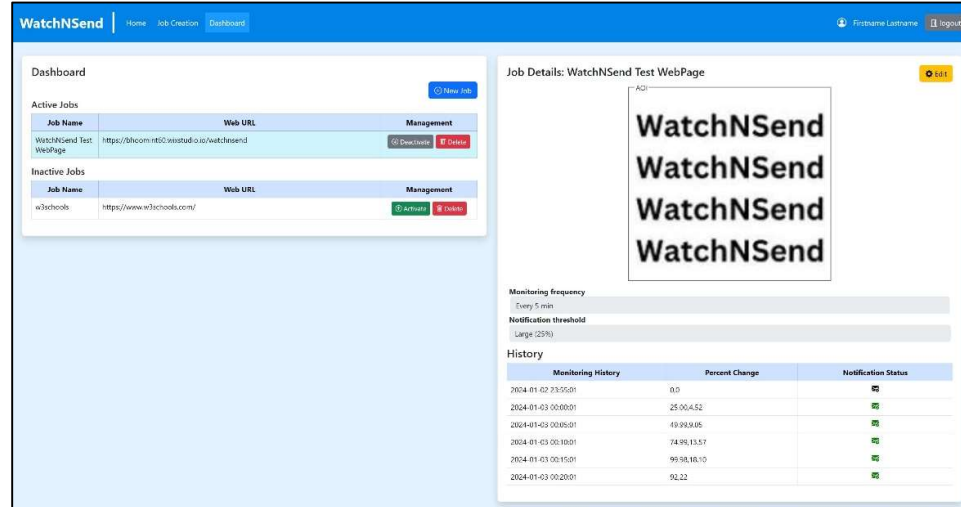
(B)

Figure 9. Sample screenshots of WatchNSend's (A) Job Creation screen and (B) Dashboard screen.

4. Discussion

Beyond its ability to accurately and efficiently detect webpage content changes, WatchNSend is also able to perform functions and detection modes on par with commercially available webpage monitoring tools, as shown in Table 4.

Table 4. The functionality and detection mode of WatchNSend compared with some other CDN tools

CDN Tool	Functionality					Detection Mode		
	MSP	MMP	SSD	FICS	Notify	Visual	Text	HTML
WatchNSend	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**No**
Visualping.io [7]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fluxguard [8]	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Sken [9]	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Pagescreen [10]	Yes	Yes	Yes	Yes	Yes	Yes	No	No
OnWebChange [11]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes

SSD=Server side detection, MMP=Monitor multiple pages, MSP= Monitor a single page, FICS = Fixed Interval checks, and Notify = Email notification

The six tools shown use different combinations of detection modes, but the one detection mode that most all of the tools have in common is the visual mode. The exact analytical methods of the other tools shown are assumed to vary; however, this information is proprietary and not available. Through the current research, the authors wish to disseminate a full example of how such a tool can be created, including robust scheduling and accurate detection. WatchNSend utilizes visual detection. Text detection and HTML tag detection predate the advent of visual detection, which functions broadly in this application to accurately detect changes to a webpage's text, its background color, its text color, or the direction of the text. Possibilities for future extension of this research include exploring novel algorithms for change detection beyond edge and overlay calculations, enabling detection of changes in HTML structure, delivering trend analysis to users, and conducting user studies to evaluate their experiences with WatchNSend.

5. Conclusion

The most distinguishing features of WatchNSend are its Edge Calculation, Overlay Calculation, JobFlights scheduling method, and use of Screenshot API. These features are written and combined using PHP, CSS, and JavaScript, which integrate well with the database, creating a flexible and user-friendly tool that can accurately perform an average of 181 website update checks per minute. WatchNSend's non-proprietary methods hold their own against commercial products, making WatchNSend an economical and expandable application for any individuals or businesses that need to monitor webpages in a convenient, reliable way.

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Analyzing Errors in Mathematics Problem-solving Among High School Students

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Abstract

This study explores the connection between math problem-solving skills and students' reading comprehension and analytical abilities. Problem-solving errors are common among elementary and high school students, notably in the Philippines, where math proficiency is subpar, emphasizing the need for enhanced problem-solving skills. This study examined errors made by 40 high school students when solving word problems and assessed how their reading comprehension and analytical skills affected these errors. Employing a quantitative correlational design, the study utilized standardized tests as its primary data collection tool. The data analysis involved various statistical measures such as frequency counts, percentages, mean, standard deviation, and chi-squared test for dependence to establish correlations. The findings unveiled that the majority of participants exhibited reading comprehension abilities at the instructional level and analytical abilities at the average level. Notably, the chi-square test results demonstrated a significant association between reading comprehension levels and the occurrence of problem-solving errors (Chi-square $(8, N = 40) = 22.371$, $p = 0.004$, contingency coefficient = 0.599). The errors mainly stemmed from difficulties in problem comprehension. The results underscore the need for focused reading comprehension interventions to improve students' math problem-solving skills. Furthermore, the study highlights the intricacy of cognitive processes in logical analysis, suggesting tailored support to address specific error patterns. In conclusion, this study offers insights into students' reading and analytical profiles and math problem-solving errors. It stresses the need for customized interventions to boost problem-solving skills and urges educators to address specific errors based on individual reading profiles. These results carry significant implications for improving mathematics education and enhancing teaching methods.

Keywords: error analysis, reading comprehension, analytical ability, problem-solving in mathematics, mathematics education

1. Introduction

Problem-solving skills hold paramount significance in the realm of education and have gained even greater prominence in contemporary society. These skills play an indispensable role in shaping students' abilities to grapple with challenges and are now more crucial than ever. The evolving demands of the workforce necessitate individuals who can adeptly identify and resolve complex issues across diverse contexts. In particular, problem-solving assumes a pivotal role in disciplines falling under the umbrella of science, technology, engineering, and mathematics (STEM). These fields routinely require individuals to analyze intricate problems, devise innovative solutions, and implement them effectively. As a result, fostering problem-solving capabilities in students has become a central objective in the field of mathematics education and one of the primary goals of teaching mathematics [1, 2]. Mathematics instruction should extend beyond mere rote memorization of formulas and algorithms and should help students learn how to apply

mathematical concepts and principles to real-world situations, equipping them with the tools necessary to address practical challenges [3, 4].

Nonetheless, notwithstanding the significance of problem-solving abilities, research has indicated that numerous students require assistance when it comes to tackling mathematical problems [5, 6]. Mistakes in problem-solving are not confined to particular concepts; instead, they manifest across a diverse spectrum of mathematical subjects [7, 8, 9]. Veloo et al. [10] conducted content analysis and found that specific math items, Standard Form, Linear Equation, and Line & Plane in 3 Dimension, were particularly challenging for students, with conceptual errors being the most common, followed by careless errors and problem-solving errors. Problem representation processes are essential for understanding and consolidating problem-related information, preserving mental images of the problem in working memory, and constructing a workable path to a solution, all aimed at forming a "cohesive mental representation of the problem scenario." Students often struggle with persistent and troublesome errors in algebraic problem-solving due to misconceptions developed during the transition from arithmetic to algebraic thinking [7] and errors related to incorrect prior knowledge and the formation of erroneous new knowledge during mathematics problem-solving [6]

Errors in problem-solving are common among elementary and high school students [11, 12, 13, 14]. In Turkey, Incebacak and Ersoy [15] conducted research in secondary schools, indicating that students struggle to solve mathematical problems. Tambunan [16] found that Indonesian students also faced difficulties when solving mathematical problems, while Kempert and colleagues' study [17] attributed students' deficiencies in problem-solving abilities to language barriers. Santos et al. [18] also found that nearly half of the respondents in a study exhibited unsatisfactory performance in translating worded problems due to carelessness, insufficient comprehension, interchanging values, and unfamiliarity with certain words.

Despite the pervasiveness of problem-solving errors and the pressing need to enhance students' mathematics performance, limited research has been dedicated to examining students' math problem-solving errors. The aforementioned data underscores the imperative for a more comprehensive exploration of students' math problem-solving abilities and a close scrutiny of the types of errors they make. This endeavor can assist educators in crafting suitable teaching strategies to address these problem-solving errors. To bridge this research gap, the present study analyzed errors in math problem-solving skills among high school students, taking into account their reading comprehension and analytical capabilities. The study employed Newman's Error Analysis framework to pinpoint various error categories, such as comprehension, transformation, process skills, and encoding errors. The findings from this study could be employed to develop targeted interventions aimed at enhancing students' problem-solving skills. By addressing students' mistakes, researchers can design more effective teaching methods, ultimately elevating the quality of mathematical education.

This study investigated the problem-solving errors exhibited by students as contributed by their reading comprehension and analytical abilities.

Specifically, this study answered the following questions:

1. What are the profiles of the participants in terms of age and sex, reading comprehension abilities, and analytical abilities?
2. What are the errors exhibited by the participants in solving mathematical problems?
3. Is there a significant relationship between the errors exhibited by the participants and their reading comprehension abilities?
4. Is there a significant relationship between the errors exhibited by the participants and their analytical abilities?

Hypothesis:
1. There is no significant association between the errors exhibited by the participants and their reading comprehension abilities.
2. There is no significant association between the errors exhibited by the participants and their analytical abilities.

2. Methods

Research Design

In this investigation, the quantitative research approach was utilized, with a particular focus on the descriptive correlational research design. The primary objective was to explore the connection between errors in problem-solving, reading comprehension, and analytical abilities of the student participants. Descriptive correlational research design facilitates the exploration and characterization of the associations between multiple variables and allows for the assessment of the degree of the relationship [19]. In this research, "error" refers to mistakes made by students during the process of solving mathematical word problems. These mistakes are classified into four types: comprehension errors (misunderstanding the problem), transformation errors (incorrectly converting the problem into a solvable form), process skills errors (errors in mathematical steps), and encoding errors (errors in writing or presenting the final answer).

On the other hand, "solving word problems" as operationally defined, is the ability to accurately understand, translate, process, and encode solutions to mathematical word problems, encompassing reading comprehension, analytical reasoning, and mathematical proficiency. "Error analysis" used in this study refers to a systematic process for identifying and categorizing students' errors while solving word problems. It provides insight into which stages of problem-solving (comprehension, transformation, process, or encoding) students struggle with. This study used Newman's Error Analysis to analyze students' errors through a structured scoring system.

Sampling

This study randomly selected forty participants from a population of 204 students in both grade 7 and grade 8, employing a stratified random sampling method according to Christensen et al. [20]. The research study was carried out throughout a carefully structured four-week period during the 2022-2023 academic year. This timeline was strategically designed to fit within the school's regular schedule, ensuring minimal disruption to students' ongoing academic activities. The study spanned various phases, including the administration of assessments, data collection, and follow-up interviews. Each phase was conducted in a controlled environment to maintain consistency across the sessions, allowing for accurate measurement of variables and ensuring that the integrity of the research process was upheld throughout the entire duration of the study.

Research Instruments

Three separate research instruments were used in this research. Initially, the Philippine Informal Reading Inventory (Phil-IRI) designed for high school students was utilized to evaluate the participants' proficiency in reading comprehension [21]. Phil-IRI was utilized to assess reading comprehension. It includes graded passages where students are required to read and answer comprehension questions. It was selected due to its widespread use in the Philippine education system and its established reliability and validity. Carter's Test of Logical Analysis [22] was also used to assess the analytical skills of the participants. This tool measures students' analytical reasoning without relying on specific mathematical content. It assesses students' abilities to approach problems logically and reason through situations with common sense. The test's internal consistency reliability (Cronbach's Alpha) has been established at 0.85 using pilot testing of 20 students not included in this study. Additionally, the accuracy of solving mathematical word problems was assessed using two standardized word problems extracted from the Regional Test Item Bank of high school mathematics. These word problems represented typical high school mathematics problems and were selected based on their alignment with the curriculum. The problems were validated by a panel of mathematics educators and underwent pilot testing to ensure their suitability for the student population. Newman's Error Analysis was utilized to determine the errors committed by each participant through a comprehensive scoring system and an interview conducted after administering the standardized word problems. These errors are categorized as comprehension errors, transformation errors, process skills errors, and encoding errors [23].

Data Analyses

The quantitative data collected in this research were analyzed using various statistical techniques to investigate the relationship between students' errors in solving word problems, their reading comprehension, and their analytical abilities. Descriptive statistics such as means, standard deviations, and frequency distributions were calculated for reading comprehension scores, logical analysis scores, and the frequency of each error type in Newman's Error Analysis. These provided an overview of the students' performance levels. The chi-square test for independence was used to assess the relationships between students' reading comprehension, analytical reasoning scores, and the frequency of different types of errors in problem-solving. The significance of these relationships was tested at a 95% confidence level. Contingency coefficient was computed to determine the strength of the relationships between the variables. This allowed the study to identify specific stages of problem-solving where students most likely struggled.

Ethical Consideration

This research placed significant importance on ethical considerations. Ethical clearance was sought and obtained from the ethics review board prior to commencing data collection. Participants were provided with a clear understanding of the objectives and nature of the study, and their informed consent and assent were acquired before their involvement. To safeguard the anonymity of respondents, unique codes were used instead of their actual names. Additionally, data security measures were implemented, restricting access solely to authorized personnel, thereby ensuring confidentiality.

3. Results and Discussion

Demographic Profile of Participants

The study included 40 students, with an average age of 12.63 years. The gender distribution consisted of 60% females and 40% males. This demographic snapshot provides context for the overall performance and error analysis across different groups.

Reading Comprehension Profiles

Participants were categorized into three distinct reading comprehension levels based on their performance in the Philippine Informal Reading Inventory (Phil-IRI): Instructional Level, Independent Level, and Frustration Level. These categories represent varying degrees of reading ability and were crucial in understanding the nature of errors students made when solving mathematical word problems.

A total of 21 (52.5%) participants were identified as being at the Instructional Level, with the majority being female (14 females and 7 males). Students at this level can read and comprehend text but often require assistance, particularly with difficult vocabulary or complex ideas. This represents the zone where readers can comprehend and engage with text with some level of support and guidance from a teacher or mentor [24]. This suggests that while these students are capable of understanding the material, they may still need guided support to fully grasp certain concepts. The higher proportion of females at this level suggests potential gender differences in reading development, though these differences may also be influenced by social or educational factors. Teachers working with students at the Instructional Level can use targeted strategies and scaffolding techniques to help them progress to higher levels of reading proficiency. This may involve guided reading sessions, vocabulary instruction, and discussions to enhance comprehension [25, 26].

The group in the Frustration Level included 10 (25%) students, with a slightly higher number of males (6 males and 4 females). Students at the frustration level struggle significantly with reading comprehension. Frustration Level is a category that typically represents the lowest level of reading comprehension proficiency [27]. They often face difficulty with decoding text and understanding key ideas, which can lead to disengagement or frustration. According to educational researchers [28], students at the frustration level might exhibit limited fluency, struggle with basic decoding skills, and show minimal comprehension of text. This level indicates that students may benefit from additional support, such as one-on-one tutoring or simplified reading materials, to improve their

foundational reading skills. The prevalence of males in this group may highlight a need for more targeted interventions for boys who struggle with reading.

Nine participants (22.5%), with more females than males, were classified as Independent Level readers. The Independent Level represents a stage at which readers can comfortably comprehend texts with minimal assistance [29]. Readers at this level are usually able to read fluently and understand the majority of the content without significant difficulties. They can read independently, making appropriate use of context and prior knowledge to grasp the meaning of a text. They are able to understand and engage with reading material, making them well-equipped to tackle more advanced texts. This group is generally more self-sufficient, relying on context clues and prior knowledge to make meaning from text. Research in literacy education indicates that students at the independent level tend to have a strong grasp of phonics and word recognition skills, enabling them to decode words accurately [30]. This level is considered crucial for fostering a love for reading and developing reading comprehension skills.

Analytical Ability Profiles

In addition to reading comprehension, the study assessed participants' analytical abilities using Carter's Test of Logical Analysis. The students were divided into three categories based on their performance: Exceptional, Average, and Below Average. A significant portion of the participants (40%) displayed exceptional analytical abilities, with 10 females and 6 males falling into this category. These students demonstrated strong problem-solving skills, suggesting that they were able to analyze and think critically about the tasks presented. These individuals likely excel in subjects requiring logical reasoning and may benefit from more advanced or challenging tasks.

On the other hand, 50% of the participants demonstrated average analytical abilities, with more females (13) than males (7) in this group. Students at this level are capable of analyzing information but may need occasional support to fully grasp complex concepts. They exhibit moderate proficiency in logical reasoning, which can be developed further through practice and instruction.

Only four students (10%) fell into the below-average category, with three males and one female. These students struggle with analytical tasks and require additional support to improve their logical reasoning skills. Targeted interventions, such as practice with structured problem-solving methods, can help these students develop their analytical abilities.

This result aligns with the idea that analytical skills can vary among individuals, with some demonstrating exceptional abilities [31, 32]. These findings underscore the importance of educational approaches and interventions designed to address the diverse needs of students in enhancing their analytical abilities.

Analysis of Problem-Solving Errors

The analysis of the Problem-solving Errors provided insights into the nature of errors made by participants across different reading proficiency levels—Instructional, Independent, and Frustration. The errors are classified into five distinct types: Comprehension Error, Transformation Error, Process Skills Error, Encoding error, and No error. Understanding the types of errors students make when solving word problems provides valuable insights into their cognitive processes and the challenges they face.

The most common type of error made by students in the Instructional Level in their reading abilities was related to process skills (20%), followed by comprehension errors (7.5%). This suggests that students at this level are capable of understanding the problem but struggle with executing the necessary steps to arrive at the correct solution. These errors could be due to misunderstandings in the application of mathematical concepts or difficulty in connecting the reading material to the problem-solving process. Educators can address these issues by focusing on teaching strategies that help students apply their knowledge effectively, such as using step-by-step approaches to problem-solving.

Most students at the Independent Level in reading made no errors (17.5%), indicating that they have a solid grasp of both the reading material and the mathematical concepts required to solve problems. However, there were still minor process skill errors (2.5%), suggesting that even highly capable students

can occasionally make mistakes, particularly when applying complex strategies. These students may benefit from being challenged with more difficult problems to further develop their skills.

Students with the Frustration Level in their reading ability exhibited a high percentage of comprehension errors (12.5%) and transformation errors (7.5%), indicating that they not only struggle to understand the text but also face difficulties in translating that understanding into a mathematical process. These errors are reflective of the frustration level's characteristics, where students often become disengaged when faced with tasks that they find overwhelming. Interventions for these students should focus on both improving their reading comprehension and providing clear, scaffolded instructions to support their problem-solving process.

Table 1. Reading comprehension profile and problem-solving errors

Reading comprehension profile	Problem-solving errors				
	Comprehension error	Transformation error	Process skills error	Encoding error	No error
Independent Level	0 (0%)	0 (0%)	1 (2.5%)	1 (2.5%)	7 (17.5%)
Instructional Level	3 (7.5%)	4 (10%)	8 (20%)	1 (2.5%)	5 (12.5%)
Frustration Level	5 (12.5%)	3 (7.5%)	2 (5%)	0 (0%)	0 (0%)

Association Between Reading Profiles and Problem-solving Errors

The analysis revealed a significant relationship between reading comprehension levels and the types of errors students made when solving problems (*Chi-square (8, 40) = 22.371, p = 0.004*). The null hypothesis *"There is no significant association between the errors exhibited by the participants and their reading comprehension ability"* was rejected. This suggests that a student's reading proficiency is closely associated with the kinds of errors they are likely to make in solving mathematical problems. For example, students with lower reading comprehension tend to make more comprehension and transformation errors, while those with higher comprehension levels are more prone to making process-related mistakes. The contingency coefficient of 0.599 further emphasizes the strength of the association between reading profiles and error categories. This value suggests a moderate relationship between the reading comprehension ability and the problem-solving errors committed by the participants. This result highlights the importance of addressing these specific areas in reading comprehension interventions in particular and in solving mathematical problems in general. The distribution of errors across reading profiles highlights the diverse challenges participants face at different proficiency levels. These findings emphasize the importance of personalized reading interventions that address specific error types based on individual reading profiles.

Association Between Analytical Ability and Problem-Solving Errors

The contingency table provided a comprehensive breakdown of the distribution of the types of problem-solving error among participants categorized by their level of analytical skills. This detailed analysis offered insights into the specific error patterns associated with each analytical skill level. In the "Below average" category, participants exhibited a simpler error pattern, with "Transformation Error" and "Comprehension Error" each accounting for 5% of occurrences.

Table 2. Analytical ability profile and problem-solving errors

Analytical ability profile	Problem-solving errors				
	Comprehension error	Transformation error	Process skills error	Encoding error	No error
Exceptional	2 (5%)	2 (5%)	3 (7.5%)	1 (2.5%)	8 (20%)
Average	4 (10%)	3 (7.5%)	8 (20%)	1 (2.5%)	4 (10%)
Below average	2 (5%)	2 (5%)	0 (0%)	0 (0%)	0 (0%)

The data also showed distinct error patterns based on analytical ability. Students with exceptional analytical skills made fewer errors overall, while those with average or below-average skills struggled more, particularly with process and comprehension errors. However, the relationship between analytical ability and error type was not statistically significant (*Chi-square (8, 40)* = 11.896, p = 0.156). This means that the null hypothesis "*There is no significant association between the errors exhibited by the participants and their analytical ability*" cannot be rejected. This suggests that while logical reasoning is important, it may not be the only factor influencing problem-solving errors. Educational strategies that combine both reading comprehension and analytical skill development may be more effective in improving students' overall performance. These findings underscore the complexity of the cognitive processes involved in logical analysis and suggest the importance of individualized support and instruction to address specific error patterns.

4. Conclusion and Implications

In conclusion, the study provides valuable insights into the demographic and academic profiles of the participating students. The majority of student participants fell into the instructional level category in terms of reading comprehension proficiency, indicating that they can comprehend texts with some guidance. This suggests the need for targeted strategies and support in vocabulary, sentence structure, and comprehension to help them progress further. In contrast, a notable proportion of students were classified as frustration-level readers, particularly among males, highlighting the challenges they face in understanding and engaging with texts. Interventions for this group should focus on building foundational reading skills and providing simplified materials. In terms of analytical ability, the majority of students exhibited an average level, while some demonstrated exceptional skills, and a smaller group fell below average.

The analysis of problem-solving errors revealed distinct patterns across reading proficiency levels. Notably, process skills errors were the most common type of errors,

suggesting challenges in applying reading strategies and skills in mathematical problem-solving. Comprehension errors were also prevalent, indicating difficulties in grasping deeper textual meaning when dealing with mathematical problems. The relationship between reading profiles and error categories was statistically significant, emphasizing the importance of addressing specific areas in reading comprehension interventions in order to improve the problem-solving skills of students in mathematics.

5. Suggestions for Future Research

Future studies could benefit from a longitudinal approach that tracks the development of reading comprehension and analytical skills over time. This would provide insights into how learners progress across different educational stages and the long-term impact of targeted interventions on reducing problem-solving errors. Additional research should also focus on exploring gender differences in both reading comprehension and problem-solving abilities. Understanding the underlying factors contributing to these differences could inform the development of gender-specific interventions aimed at improving performance across both domains.

Although reading comprehension and analytical skills play a significant role in solving mathematical word problems, other cognitive factors such as working memory, attention, and self-efficacy may also influence error patterns. Future research should explore these cognitive aspects to develop a more comprehensive understanding of the factors that impact students' problem-solving success. Future studies could likewise explore how socioeconomic status, school environment, and teacher quality affect both reading comprehension and problem-solving skills. This could help identify broader structural factors contributing to the academic performance of students, particularly those from disadvantaged backgrounds.

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