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Short Paper*

WebPy-BudgetAnalytics: Budget Monitoring and Analytic Support Tool for State Universities and Colleges

Adrian A. Rodriguez
Bicol University, Philippines
rodriguez.adrian0205@gmail.com
(corresponding author)

Michael B. Dela Fuente
Polytechnic University of the Philippines, Philippines
mbdelafuente@pup.edu.ph

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Abstract

Purpose - This study aims to develop a web-based budget monitoring system with an analytic support tool using a multiple linear regression model to enhance the financial management system of state universities and colleges (SUCs).

Method - It follows a descriptive and developmental design to answer the research problem and attain the objective of the study. The descriptive design is applied in the documentary analysis and administration of the survey using survey questionnaires. The developmental approach is applied in developing the web-based software, specifically, the Rapid Application Development (RAD) model.

Results - The study provided ways to address the present problems and difficulties with the current method of managing financial resources: (a) automating budget execution-related processes; (b) recording of budget execution in a central database; (c) real-time monitoring of budget utilization; and (d) projection and forecast of future budget requirements based on previous utilization records for budget planning and preparation.

Conclusion – The developed system is highly acceptable in terms of functionality, usability, reliability, maintainability, and efficiency in managing university financial resources based on user evaluation.

Recommendation - The system includes the following features for the recommendation to be implemented: (1) preparation and management of working financial plan (WFP); (2) preparation and management of sub-allotment; (3) preparation and management of obligation and utilization request; (4) preparation, management, and monitoring of Certificate of Availability of Funds (CAF) request; and (5) reports preparation, budget monitoring and projection of future budgetary requirements.

Research Implications – The study demonstrates how automation of processes and applying multiple linear regression enhance the management and monitoring of SUC financial resources.

Keywords – budget monitoring, multiple linear regression, analytic support tool, budget analytic, machine learning

INTRODUCTION

Business process automation with data analytics is used in banking, healthcare, online stores, and other business sectors to improve service performance and competitiveness. There are now developed systems that automate manual business processes and use machine learning (ML) algorithms to analyze data, identify trends, and assess risk, which will help administrators in organizations make informed decisions and meet their goals and objectives.

Some government agencies are also automating their processes and applying data analytics to improve governance and public service through simplified transactions, which also applies to budget management. The four unique steps or stages of the national government budgeting process are budget planning, authorization, implementation, and accountability. One must remember that budget is the foundation of every organization, business establishment, and government agency. Thus, it is necessary to track every detail of the budget execution to meet the organization's goals and objectives.

State Universities and Colleges (SUCs) budget comes from two sources: 1) from the national government through the General Appropriation Act (GAA) and 2) SUC's income from its operation. The office in SUCs that is in charge of keeping track of the allocation of appropriate funding for the delivery of services is the Budget Office. This office ensures that the funds are used for the purpose for which they were approved, subject to government accounting auditing rules and regulations.

The challenge in budget management is simplifying the preparation of a working financial plan, sub-allotment, obligation for GAA funds, utilization of income from its operation, and optimizing budget allocation and utilization, which is under the budget execution phase. Sometimes, SUCs underspend or have not met their targeted budget utilization rate because units within the SUCs cannot spend the allotted budget. There are also cases in some units that have budget deficits because of unforeseen expenditures. Preparing financial reports took days or weeks because consolidation among clusters or units is performed manually, which is prone to mistakes and errors even though a spreadsheet application aids it. In the manual budget execution procedure, more time is being spent, and the submission of reports is delayed. Budget personnel also had difficulties monitoring budget allotment against utilization as it was prepared and recorded manually.

The existing system SUCs use concerning budget management does not provide them with a centralized database and automated recording, updating, and tracking of budget execution transactions. The capacity of the existing system to visualize reports and identify trends is deficient, which is not helpful to SUC administrators in decision-making in meeting its primary final output (MFO) targets. They lack analytic support tools to take advantage of the available historical and present data that could provide a guide for decision-makers in budget management.

The study by Soegoto and Indra (2018) discussed that monitoring budget execution is not ideal if the budget planning and execution system is still done manually. Determining the amount of the budget consumed and left unused is challenging. These are the user needs and current flaws they had identified by conducting a systematic analysis of the existing manual system.

According to Stein and Rowe (1989), computerization makes it feasible to manage the budget in depth, with better precision, in more understandable ways, and in less time. Computerization will help organizations fast-track the preparation and consolidation of financial reports. Elita and Munggaran (2020) used a machine learning method called k-Nearest Neighbors to anticipate the state budget deficit in Indonesia. Machine learning plays a vital role in data analysis and identifying trends that will help administration officials make decisions regarding budget execution and management and optimize public funds.

Mohan and Sasikumar (2014) state that optimizing public funds allocation is challenging. Thus, to maximize the use of public funds, they created a decision support system for the budget distribution of R&D organizations.

LITERATURE REVIEW

Business Process Automation, E-Budgeting, and E-Governance

With the spread of the internet and information technology, the transition from paper-based processes to automated processes with the aid of technology is the new trend among organizations because of its contribution to transparency and accountability. Immaniar et al. (2019), Nugraha and Wibowo (2020), Oktaviani et al. (2019), and Nasution (2019) show the critical role of information technology in the budgeting process, specifically the e-budgeting where information is stored online because it promotes and increases transparency and accountability. This clearly shows that information technology will have a more significant impact in the future. Technology has emerged as an important organizational asset, particularly in automating operations. The public and private sectors are now in business process automation. According to Mohapatra (2012), Business Process Automation (BPA) is the coordinated use of computers, facilities, and human knowledge to produce the required outputs to maximize the process.

Implementing a budgeting system in government organizations is essential in implementing a budget. Soegoto and Indra (2018) discuss that it can lessen the chance that information will be produced with wrong data due to input errors. Gamayuni (2020) and Setyawan and Gamayuni (2020) also emphasized in their study that the budgeting system in government or e-budgeting increased the quality of local government financial reporting regarding planning, drafting, and realization of the local government budget. Sagita and Mariana (2017) said that using information technology in budget management can at least assist the government in suppressing official, political elite, and bureaucratic conduct to waste resources and decrease budget misuse and behavior related to corruption.

State Universities and Colleges are government academic institutions with three mandates: instruction, research, and extension. They have two funding sources: the General Appropriation Act and internal funds derived from the university's income, such as school fees. This government academic institution is expected to perform well by optimizing budget utilization through its expenditure program.

Financial and Budget System

A financial system is software for managing assets, income, and expenses. Wu (2020) states that a computerized financial management system examines the company's everyday activities. Additionally, it lessens the difficulty of the work and the workload pressure on the financial staff members.

A budget system is software used to manage, monitor, and track income and expenses. Both financial and budget systems are now available on different platforms. Hezretov (2021), Kazi et al. (2021), and Singh (2021) developed a budget mobile application that tracks personal income and expenses. Althnian (2021) also developed a rule-based personal financial management system that provides the user with actionable advice to make informed spending decisions and achieve their financial goals.

Web-based Monitoring System and Visualization

Automation can be in web-based technology. Mohapatra (2012) discussed that automation software could be a web-based tool properly architected for a web environment. Most systems nowadays are web-based. These are systems that use Internet technology to automate business processes. Saputro et al. (2020), De La Cruz (2019), Mleke (2020), Nallathiga and Sriram (2017), Prijayanti et al. (2020), and Namanya (2021) developed a web-based monitoring system for record-keeping, control, and data availability. Web-based monitoring provides timely data generation and helps administrators in decision-making.

Bartonek and Zagrovic (2019), Britzolakis (2020), Dhariwal et al. (2017), and Koulouras et al. (2018) used the web-based platform as a tool for data analysis and visualization. They used JavaScript library, Java, MS ASP.Net framework, Jquery, HTML/CSS, R, and Python. Python-based web development frameworks are now available for developing web-based projects. It can communicate with databases, execute queries, and run in a web environment.

Machine Learning and Data Analytics

The idea to improve the services offered does not stop in process automation. To aid administrators in making decisions, including machine learning in automated processes is also appropriate. Elita and Munggaran (2020) researched the usage of a machine-learning algorithm to forecast the state budget deficit in Indonesia. Employing the nearest optimal distance of the k-Fold Cross Validation procedure uses the K-Nearest Neighbors classification technique to estimate the state budget deficit. They applied machine learning to guide them in budget management to avoid budget deficits. Bergmann et al. (2020) highlighted how incorporating analytical methods seems predestined for budgeting. A favorable connection exists between business analytics and budgeting process satisfaction.

Multiple Linear Regression

Ojo et al. (2020) utilized multiple linear regression to analyze the relationship and predict using materials, time, and labor as variables for strategic decision-making given a limited budget. Shakhla et al. (2018) used multiple linear regression to study and document

the APPLE Incorporation stock price performance. Dhaval and Deshpande (2020) employed multiple linear regression to forecast short-term load in electrical power systems with input variables of temperature, due point, prior day load, and the preceding week's load.

K-means clustering and multiple linear regression were used by Omolewa et al. (2019) to evaluate the learner's academic performance. According to their study's findings, the main variables that may be utilized to predict students' academic achievement were their test, quiz, and assignment scores. Shafi (2023) also used the hybrid model using k-means clustering and multiple linear regression to predict household income in Malaysia.

METHODOLOGY

The study used a set of standards, shown below (Table 1), to determine how the system would be acceptable to the intended users. The criteria were based on the Software Quality Model of ISO, which was also adopted by Fahmy et al. (2012).

Table 1. Name Range for Identifying the Acceptability of the System

Range	Interpretation	Description
4.51 – 5.0	Highly Acceptable	Exceeds expectations in terms of the functionality and features of the suggested system.
3.51 – 4.50	Moderately Acceptable	Very satisfied with the functionality and usefulness of the suggested system.
2.51 – 3.50	Acceptable	Satisfied with the functionality and features of the suggested system
1.51 – 2.50	Fairly Acceptable	Satisfies a few of the expectations of the proposed system concerning features and usability.
1.00 – 1.50	Not Acceptable	The features and usability of the proposed system did not satisfy the expectations.

The study also used the following statistical tools, models, and techniques:

Multiple Linear Regression

Multiple Linear Regression was used to forecast future budgetary requirements. The datasets used were from the Financial Accountability Report No. 1 (FAR 1) quarterly report starting from March 2016. The identified attributes were period, year, month (by quarter), and utilization, which served as the independent variables, and the forecasted budget requirements were the dependent variables. The formula used was:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_i X_i$$

Where:

Y – dependent variable
β_0 – intercept
β_i – slope of X_i
X – independent variable

Mean Absolute Percentage Error

The Mean Absolute Percentage Error (MAPE) method was another data analysis methodology that was used in this study to assess the accuracy of future budget requirements forecasts or predictions for each unit, college, and campus in State Universities and Colleges provided by WebPy-BudgetAnalytics using previous actual data as the bases for actual assessing the accuracy (Equation 1).

$$M = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{At - Ft}{At}\right| \qquad \textit{Equation 1}$$

Where:

M = Mean
n = Actual size (number of times the summation of iteration happens)
At = Actual value
Ft = Forecast value

Mean Percentage

The average of the responses was calculated using the mean function, which determined the functionality with a functional completeness indicator, the reliability with a time-behavior and capacity indicator, the usability with a learnability, operability, interface design, and accessibility indicator, the maintainability with a modifiability indicator, the testability indicator, and the efficiency with a measure of how well the system worked with the users. The formula used was (Equation 2):

$$\text{M} = \frac{\sum x}{n} \qquad \textit{Equation 2}$$

Where:

M = Mean
$\sum x$ = Sum of all the responses
n = Total number of responses

To determine the verbal interpretation, the value generated after calculating the means of each item in the second portion of the survey questionnaire was compared with the values in Table 2.

Table 2. Name Range for Identifying Level of Agreement in Terms of Recommendation for Improvement and System Features

Scale	Range	Verbal Interpretation
5	4.51 – 5.00	Strongly agree
4	3.51 – 4.50	Agree
3	2.51 – 3.50	Neither agree nor disagree
2	1.51 – 2.50	Disagree
1	1.00 – 1.50	Strongly disagree

Software Tool

Python was utilized to create the system since it is frequently used for machine learning and can now be used to develop web-based solutions. The system was web-based because the target university had campuses in other municipalities and provinces. The system used machine learning, specifically a multiple linear regression model, to forecast future budgetary requirements, which served as an analytic support tool that will help the university budget planning and utilization.

The system prototype development followed the Rapid Application Development (RAD) model, the procedures of which are as follows: (a) requirements planning, (b) RAD design workshop, and (c) implementation. Requirements planning includes the following: (1) checking of the availability of data, cost, and period for development; (2) conduct of surveys, consultation, and interviews (for current workflows); (3) identification of scope and (4) analysis of related materials and studies. RAD design workshop includes database design, database development, and system development. The implementation part also provides testing, installation, acceptance evaluation recommendation, and system implementation.

Figure 1 below illustrates the budget monitoring and analytic support tool system architecture. It depicts the system architecture of the budget monitoring and analytic support tool.

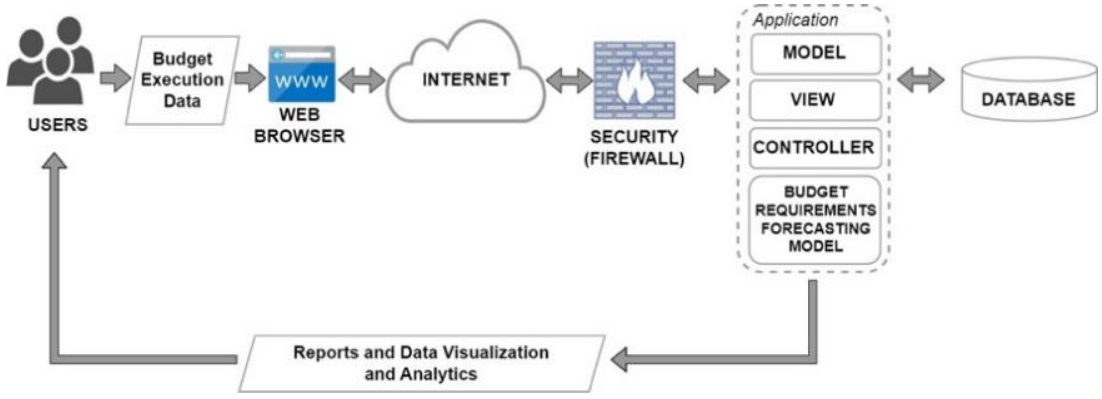

Figure 1. Budget Monitoring and Analytic Support Tool System Architecture

The system runs in a web browser. All the inputs and outputs were processed in the web browser. For the data storage, the database system that was used to store the data

was PostgreSQL. Apache was also used as the application's web server. The system was accessible through a private and public network (internet). An uncomplicated Firewall (UFW) was used to secure the application. The application contains the framework for processing transactions and the forecasting model.

The forecasting model for budget requirements is shown in Figure 2. The predicted quarter and previous budget utilization data were the model's inputs. Data preprocessing, including data preparation, cleaning, reduction, and transformation, is done on historical data to fit a model. The dataset was fitted into the model using Pandas data frames. It is a two-dimensional data structure where data is arranged in rows and columns in a tabular fashion.

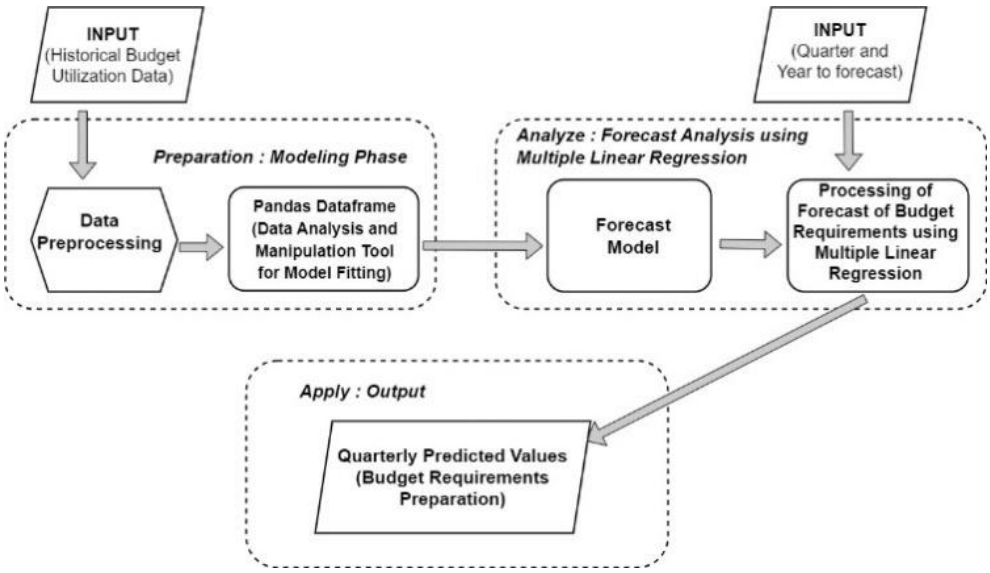

Figure 2. Budget Requirements Forecasting Model

The datasets used in the model were the budget utilization data under the Maintenance and Other Operating Expenses or MOOE object of expenditure from March 2016 to June 2022. The Mean Absolute Percentage Error is the data analysis technique used to assess the forecast model's accuracy. Additionally, Lin et al.'s (2011) study, which employs Lewis' (1982) MAPE model evaluation criteria, was used to evaluate the forecast model. The results are displayed in Table 3.

Table 3. MAPE for Model Evaluation

MAPE (%)	Forecasting Power
> 50	Weak and inaccurate forecasting
20 - 50	Reasonable forecasting
10 - 20	Good forecasting
< 10	Highly accurate forecasting

Table 3 presents the MAPE for model evaluation. After the assessment of the accuracy of the model, it can now be used for analysis and forecasting of budget requirements. The forecasted data were used for budget planning and sub-allocation.
The process flow for the forecast model using multiple linear regression started with the datasets that act as the model's inputs, which were the first step in the procedure.

The datasets went through preprocessing, which entailed cleaning, reducing, and transforming the data for model fitting. The model was created and then trained using training datasets. After training, the mean absolute percentage error was used to gauge the model's accuracy. Following the accuracy check, the next phase was prediction and testing, which required the input of a quarter to be forecasted. The predicted values were then in the following step.

RESULTS

The following results in Table 4 were based on the 5-point rating scale based on Table 1. Table 4 summarizes the respondents' level of acceptance of WebPy-BudgetAnalytics.

Table 4. Respondents' Level of Acceptance of WebPy-BudgetAnalytics

Criteria	Mean Response	Interpretation
Functionality	4.72	Highly Acceptable
Reliability	4.67	Highly Acceptable
Usability	4.57	Highly Acceptable
Maintainability	4.60	Highly Acceptable
Efficiency	4.73	Highly Acceptable
Overall	**4.66**	**Highly Acceptable**

Table 5 exhibits the datasets used for the analytic tool with the expected result, which was implemented using a multiple linear regression model. The independent variables were year, month (per quarter), period, and utilization, while the dependent variable was the quarterly budget requirement.

The period attribute or variable served as the sequence guide for the analysis using the Multiple Linear Regression Model algorithm. The datasets in Table 4 came from the financial reports specifically for the Maintenance and Other Operating Expenses (MOOE) expenditure.

Table 5. Datasets for WebPy-BudgetAnalytics Analytic Tool with Forecast

Period	Year	Month	Utilization	Budget Forecast	Absolute Percentage Error (APE)
1	2016	3	1,879,197.59	1,303,999.79	31%
2	2016	6	4,550,430.30	4,030,025.52	11%
3	2016	9	4,094,006.20	4,514,426.40	10%
4	2016	12	10,476,365.91	10,094,483.24	4%
5	2017	3	2,033,840.66	2,206,196.30	8%
6	2017	6	4,609,296.58	4,932,222.03	7%
7	2017	9	6,322,448.35	5,416,622.91	14%
8	2017	12	12,083,326.89	10,996,679.75	9%
9	2018	3	4,065,703.85	3,108,392.81	24%
10	2018	6	6,164,570.75	5,834,418.54	5%
11	2018	9	8,414,352.74	6,318,819.42	25%
12	2018	12	3,889,464.02	11,898,876.26	206%
13	2019	3	5,067,132.42	4,010,589.31	21%
14	2019	6	8,276,347.48	6,736,615.05	19%
15	2019	9	9,801,907.71	7,221,015.93	26%
16	2019	12	10,184,024.78	12,801,072.27	26%
17	2020	3	5,340,280.75	4,912,785.92	8%
18	2020	6	4,316,511.05	7,638,811.56	77%
19	2020	9	4,379,428.00	8,123,212.44	85%
20	2020	12	15,534,184.52	13,703,269.28	12%
21	2021	3	5,212,287.56	5,814,982.33	12%
22	2021	6	9,847,040.10	8,541,008.07	13%
23	2021	9	7,607,363.05	9,025,408.95	19%
24	2021	12	21,932,480.96	14,605,465.78	33%
25	2022	3	4,475,682.37	6,717,178.84	50%
26	2022	6	9,392,109.09	9,443,204.58	1%
27	2022	9	-	**9,927,605.46**	-
28	2022	12	-	**15,507,662.29**	-
29	2023	3	-	**7,619,375.35**	-
30	2023	6	-	**10,345,401.08**	-
31	2023	9	-	**10,829,801.96**	-
Sum of APE					756%
MAPE					29%

DISCUSSION

Table 4 summarizes the respondents' level of acceptance of WebPy-BudgetAnalytics. According to the respondents, the data shows that efficiency is highly acceptable, which ranked first and received an overall mean score of 4.73. The next rank is

functionality, with an overall mean score of 4.72 and a verbal interpretation of highly acceptable. The third in rank is reliability, which received an overall mean score of 4.67 and a verbal interpretation of highly acceptable. The second to the last rank is maintainability, with an overall mean score of 4.60 and a verbal interpretation of being highly acceptable. The least in rank is usability, with an overall mean score of 4.57 and a verbal interpretation that is highly acceptable. Overall, the developed system obtained a rating of 4.66, which the respondents considered highly acceptable for WebPy-BudgetAnalytics.

Table 5 shows the tabular presentation of the actual utilization, budget forecast, and absolute percentage error. The actual utilization came from the first quarter of 2016 to the second quarter of 2022 (period 1 to 26). Following the projection pattern generated by the Multiple Linear Regression Model resulted in the forecasted budget requirements per quarter from the third quarter of 2022 to the third quarter of 2023 (period 27 to 31). These results were used to prepare a budget plan to lessen the possibility of deficit and overspending.

The absolute percentage error or APE data is from periods 1 to 26. The data in the APE were used to test and measure the forecast accuracy of the model. The forecast model Mean Absolute Percentage Error was 29% with an interpretation of reasonable forecast based on Table 3.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results, the researcher arrived at the following conclusions: 1) There was no standard system or centralized database for the preparation, recording, updating, and monitoring of budget allotment and utilization. Regarding the budget plan, the usual basis for preparation was the previous budget and utilization. It is therefore concluded that the characteristics and performance of the existing process are still manual, though aided by a spreadsheet application. The manual process is only good when the amount of data and the number of transactions is limited to what an ordinary employee can handle; 2) Real-time monitoring of budget utilization and projection and forecast of future budget requirements based on previous utilization records for budget planning and preparation will contribute to the improvement of the existing process, 3) The following system features be included in the system: (a) preparation and management of working financial plan (WFP), (b) preparation and management of sub-allotment, (c) preparation and management of obligation and budget utilization request, (d) preparation, management, and monitoring of Certificate of Availability of Funds (CAF), and (e) reports preparation, budget monitoring and projection of future budgetary requirements; and 4) The researcher concluded that the WebPy-BudgetAnalytics is highly acceptable in terms of functionality, usability, reliability, maintainability, and efficiency.

The researcher arrived at the recommendations in light of the findings and conclusions of the study that the system be implemented in the university because of the

positive results of the users' evaluation in which the functionality, reliability, usability, maintainability, and efficiency are highly acceptable to the intended users.

IMPLICATIONS

The study's implications in terms of development and use of machine learning, especially multiple linear regression in web applications, are doable using Python programming language. Another opportunity is to improve the management and utilization of budgets in state universities using WebPy-BudgetAnalytics.

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DECLARATIONS

Conflict of Interest

The co-author has seen and approved the study's contents, and there are no conflicts of interest.

Informed Consent

A consent form was provided to the respondents to be informed of their rights and get their consent during the data gathering.

Ethics Approval

The University President approved the request to collect some data or information by distributing and facilitating survey questionnaires to identified respondents.

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Author's Biography

ADRIAN A. RODROGUEZ is from Sto. Domingo, Albay, Philippines. He was a graduate of Bachelor of Science in Computer Science at Bicol University in 2009. He is a graduate of Master in Information Technology (MIT) degree from the Polytechnic University of the Philippines. He is connected to Bicol University in the Philippines currently designated as System Administrator with a permanent position as Information Technology Officer I and a Bids and Awards Committee Technical Member for ICT-related goods and services.

MICHAEL B. DELA FUENTE is currently an Associate Professor at the College of Computer and Information Sciences, Polytechnic University of the Philippines, Manila. He was the former Chairperson of the Department of Computer Science from 2009 to 2017 and currently held the position of Laboratory Head since October 2021. His research interests are in telemedicine/telehealth, intelligent systems, e-learning and mobile learning, game-based learning and gamification, augmented reality and hyperreality, assistive and adaptive technologies, and language processing, particularly in sign language, and translation systems.