Short Paper*

Grey Literature Review of the Undergraduate Theses of the Bicol University Computer Science Program

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Abstract

Purpose – The purpose of this research is to examine the undergraduate thesis methodology, programming languages, and databases utilized to create thesis projects. The study's findings will open a wide range of researchable topics and will usher in new trends in computer science. There will be new insights in developing and proposing thesis proposals which will introduce various applications of a prospective research study.

Method – The manuscript from 2005 to 2019 served as initial information with the name of students, advisers, and panel members. The titles are converted into lowercase characters for easy categorization utilizing the features MS Excel transposition method and PivotTable. Special symbols like dash, colon, parentheses, slash, and apostrophe are removed to provide a list of common words. Standard frequency count and categorization of special project titles were used to count per year, filter, and categorize the titles according to keywords.

Results – The study showed that students are familiar with different methodologies, programming languages, databases, types of development, and application tools in writing special projects. Most projects are inclined toward a desktop application that uses Visual Basic as the programming language.

Conclusion – In software development, they used application tools to support the development process of the applications, and they used open-source tools. The type of study or research dictates the right decision in choosing the right methodologies to meet the study's objectives. They used tools to improve their design, convenient interaction with programming languages, and practical wise for faster development.

Recommendations – The results will be an opportunity to expose and explore computer science researchable areas, especially theories and concepts of computing. The study results shall serve as Manuscripts that are valuable assets of the institutions and should be preserved.

Research Implications – Capstone initiatives significantly contribute to the government, academia, business, cooperatives, religious institutions, and private groups. Approximately 60% of capstone projects are directly related to or have resulted in information systems for the organization. This advancement significantly affected the ITE program's directions, and the study established research options, including the capstone project's proposed research fields. Furthermore, supply excellent inputs to academic programs that will open new trends in researchable domains. Once students begin to submit capstone projects, this may have an impact on the research fields of the IT degree program.

Keywords – grey literature, academic manuscript, computer science, methodology, research topics

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INTRODUCTION

The Higher Education Institution (HEI) has been producing many undergraduate thesis and dissertation manuscripts. All of these are archived in libraries and in faculty rooms which are mostly found in unpresentable places. These manuscripts are a

collection of minds and ideas who are experts in the field. And most of these have the potential for publication which may open opportunities or improve the curriculum agenda of an institution. Today's technological innovation involves the increasing hybrid in nature, combining traditional techniques with elements.   The fourth industrial revolution impacted people or students with a sense of privacy, ownership, patterns, and time devoted to working and developing their skills, meeting people, and nurturing relationships (Schwab, 2016).

The collection of data from thesis or dissertations informed maintenance, performance, and other issues, then analyze the data which identifies patterns and insights from thesis methodologies. The Internet of Things is one of the key components of Industry 4.0, characterized by connected devices (Marr, 2018) that students are already doing in their mobile and web applications.

Grey literature (GLs) is an important source of information. These include reports, conference papers, and academic papers (i.e., thesis and dissertations), among others. The GLs can contribute to systematic reviews and meta-analysis though they are not routinely published in commercial journals or indexed in conventional bibliographic databases (Paez, 2017). Systematic reviews are an important tool in the analysis and dissemination of results. However, the important issue that needs to be addressed in a systematic review is whether results from GLs should be included, how it should be searched, and how they will be retrieved for evidence synthesis (Adams et al., 2016).

In 2004, the College of Science was established pursuant to BOR Resolution 75, which combined the BS Biology of BUCAS, BS Chemistry of BU-RSTC, and BS Computer Science of Computer Science Institute constituted the established Bicol University College of Science (BUCS). Today, BUCS has five (5) departments: CSIT, Biology, Chemistry, Physics, and Mathematics. The Bachelor of Science in Computer Science (BSCS) is under the CSIT department.

Every semester, more or less 300 students enroll BSCS program. The BSCS with two (2) blocks and the number of possible potential and initial figures to enroll for a thesis project will depend on the groupings for each thesis topic. As part of IT Education, game development, web development, mobile development and analysis or any development aligned with BSCS, the researcher examines the documents for each thesis to determine if the theories and concepts in computing follow the CHED CMO.

The study aims to analyze undergraduate capstone projects of the BSCS program of Bicol University along with methodologies with programming languages and databases used in developing capstone projects. The study's results shall provide sound inputs to academic programs, which will open new trends in researchable areas. More importantly, faculty members shall have an insight into setting the thesis projects and introduce diverse applications of technology potential research.

LITERATURE REVIEW

Grey literature is a valuable data source for large-scale review syntheses (Godin et al., 2015). However, several aspects of grey literature make systematic searching challenging. There are limited resources for this search and no `gold standard' for rigorous systematic grey literature search strategies. The research of Godin (2015) covers the systematic review search strategies used to perform a case study systematic review of grey literature on recommendations for school-based breakfast programs in Canada. Data on the organization, year released, who created them, target audience, goal/objectives of the document, sources of evidence/resources cited, meals mentioned in the guidelines, and recommendations for program delivery were retrieved. Their research provided a realistic and relatively stable strategy for identifying web-based materials in the grey literature using systematic search tactics. The search approach we created and evaluated is adaptable to locating various forms of grey literature from other fields and addressing various research queries (Godin et al., 2015).

A student's research output, such as a senior undergraduate thesis, is a way to develop an individual's research abilities. A formal thesis is considered an integral part of the degree or course completed by the student. It also explores the consistency of expectations of institutions, supervisors, and students. This includes titles, methods for subject learning outcomes, and dissertation guidelines based on school handbooks (Stappenbeld, 2019).

The research study of Aloufi et al. (2021) The evaluation looked at trials that involved student nurses and assessed therapies for stress, anxiety, and depression. From 2008 through 2018, the review includes experimental papers published in English. Based on their results, various helpful therapies are available to nursing students experiencing stress, anxiety, or depression. Mindfulness therapies had the greatest sample sizes and the highest levels of evidence and transcended stress, anxiety, and depression. A concerted strategy for building the body of evidence might aid future research (Aloufi et al. 2021).

The examination of grey literature contains extensive experiential knowledge that can supplement the material described in peer-reviewed journals. The research of Spagnolo and Lal (2021) they were doing reviews on global health/global mental health themes should think about including grey literature search tactics in their reviews. This may not only assist in acknowledging the research or dissemination reality of many but also in producing findings that corroborate and expand on those published in peer-reviewed journals (Spagnolo & Lal, 2021).

The advantages to being gained or learned during a review of a project, thesis, or current study. Weaver et al.'s (2016) study, which is all about the benefits of peer review, investigates the link between the implementation of a four-course writing-intensive capstone series and improvement. The findings of this study reveal an improvement in

student performance in rubric-scoring areas related to science literacy and critical thinking abilities (Weaver et al., 2016).

According to Santos (2018), using verbs in searching reviews has increased their attitude toward writing. Using corpus linguistics techniques, the search capability may be expanded using the larger corpus.

According to Hoffmann and Doucette's work on reviewed citation analysis, when assessing the age of cited resources, the researcher should compute the citation age as an alternative to the publication date. The study looked at some aspects of the strategy, whereas others were believed to be more thorough. It was also discovered that there are things to consider that must be properly selected and explored to achieve the study objectives. If the researchers aim to utilize the citation results primarily to expand local knowledge, they should employ an approach consistent with local practice. (Hoffmann & Doucette, 2012)

In the scoping reviews of Munn et al. (2018), there is currently little evidence for this relatively new technique of evidence synthesis. When synthesizing evidence, guidance is provided on using a systematic review or a scoping review strategy. The goal of this article is to explain the differences in indications between scoping reviews and systematic reviews, as well as to give advice on when a scoping review is (or is not) suitable. It is advised to keep a database of thesis titles to minimize subject repetition. Additionally, provide outstanding inputs to academic programs that will spark new trends in researchable sectors. Students' submission of capstone projects may influence the IT degree program's study topics.

METHODOLOGY

The department faculty in charge obtained the initial list of project titles. These include the list of titles from 2005 to 2019 with the name of students, advisers, and panel members. These served as a baseline for analysis to compare and cross-check the proposed and actual titles. The titles are converted into lowercase characters for easy categorization utilizing the features MS Excel transposition method and PivotTable. Special symbols like dash, colon, parentheses, slash, and apostrophe are removed to provide a list of common words. The generated words shall become the basis to determine the word frequency count.

The standard frequency count and categorization of special project titles were used to count the number of theses per year and filter and categorize the titles according to keywords. Clustering was done to present research implemented from different locations, programming used, and platforms used. The data shown in Table 1 was used for analysis.

Table 1. Summary of Titles per year	
Year	*Number of Titles*
2019	13
2018	19
2017	13
2016	10
2015	23
2014	28
2013	33
2012	40
2011	21
2010	47
2009	17
2008	23
2007	81
2006	34
2005	3
TOTAL	**405**

The study employed data preprocessing techniques, including data cleaning, data integration, data transformation, and data reduction to speed up the data preparation process (Sivakumar & Gunasundari, 2017).

RESULTS

A total of four-hundred five (405) manuscripts titles from 2005 – 2019 were retrieved and analyzed. These manuscripts are gathered from the library, storage room, and CS/IT department faculty room. Contents are classified based on methodologies, programming languages, databases, type of development, and application tools used in developing the system.

Two (2) categories of methodologies in software development—heavyweight and lightweight. Heavyweight methodologies are known as traditional methodologies, which focus on detailed documentation, inclusive planning, and extroverted design. Lightweight is referred to as agile methodologies and concentrates on short iterative cycles and rely on knowledge within a team (Khan et al., 2012).

In the study, it was observed that software development life cycle (SDLC), rapid application development (RAD), and Chris Crawford are the most popular methodologies used (Figure 1). The SDLC is one of the most popular methodologies in system development commonly used for web projects, applications, and services (Raj et al., 2014).
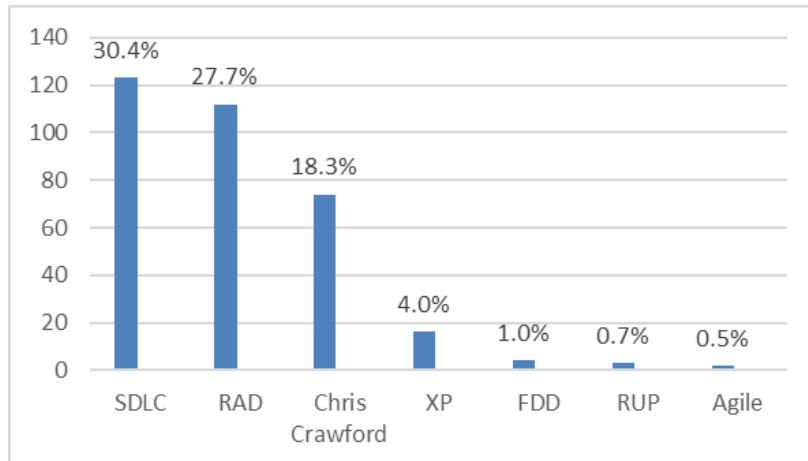
Figure 1. Popular methodologies used in capstone project from 2013 – 2019

The RAD model is popular and common in game development. This prioritized rapid prototyping and quick adjustment during the development process.   The RAD methodology allows fast implementation in the development in a real environment (Daud et al., 2010), which students preferred in developing the project. In 2013, Chris Crawford's methodology became popular among students' thesis because of the trend in game development. Game development is the art of creating games and describes the design, development, and release of a game. It may involve design, build, testing, and release. In creating a game, it is important to think about the game mechanics, rewards, player engagement, and level design (Game Development, 2019). A study suggests that the post-production phase needs further attention (Aleem et al., 2016) to monitor the progress and problems encountered by the application so that fine-tuning could be developed and deploy patches if necessary.

Other methodologies used in the design and development of the application are extreme programming (XP), systems development life cycle (SDLC), and feature-driven development. These methodologies served as a structure to produce quality software product delivered on time within the allocated budget and with client acceptable requirements (Kumar & Bhatia, 2014).

Common Programming Languages

Programming language (PL) in a special project is very important when choosing the right or perfect match for the project that fits the requirements of a specific topic. Figure 2 shows the most programming language used from 2005-2019. Most of them used Visual Basic or 26.7% applied for desktop applications because Visual Basic programming language is very good for novice developers' best starting experience (Saymote, 2014). 24.7% uses Java for desktop application, web development, and game application. Java is an open-source and powerful PL object-oriented and platform-independent that can run on any machine as long as there is a java runtime environment (JRE).

The PHP Hypertext Preprocessor (PHP) also gained popularity as the scripting language.   PHP is best suited for web development application because of the flexibility and power to embed the features of HTML for better user interfacing; about 14.3% uses PHP scripting language. There are also programming languages used in hardware design best suited for projects related to system software, device drivers, client applications, and game applications. Examples of these languages include C language, C++, C#, and C#.NET, using different versions.   An effective software development environment needs different tools to automate the development tasks, boost productivity by reducing the setup and increase speed (Bulajic et al., 2013).   These frameworks include Eclipse, Netbeans, Macromedia, Android Studio, Unity, and others.
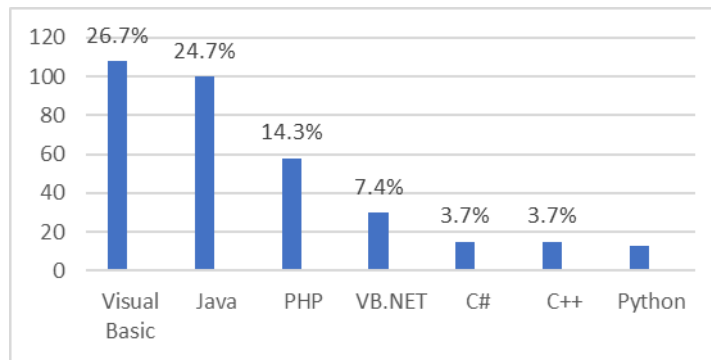

Figure 2. Common Programming Language Used in Application Development

Commonly Used Database

Algorithm-based research and computer science principles are the suggested thesis areas by the Commission on Higher Education (CHED). For computer science, the use of the database is secondary compared to programs (like BSIT) focusing on information system development, including web development and desktop application systems. As shown in Table 2, the majority, or 68.6%, wherein the database is not a requirement. This is because some theses are standalone, game or mobile application which does not require a database, unlike information system topics where databases are mostly needed due to their multiple-user access. However, those projects which require databases prefer MySQL, MS Access, SQL/Lite, ADODB, and MS SQL. These databases have unique command query sequences suited to the type of application.

Table 2. Commonly Used Database in System Development

Database	Count	Percentage
None	278	68.6%
MySQL	94	23.2%
MS Access	16	4.0%
SQL/Lite	8	2.0%
ADODB	4	1.0%
MS SQL	2	0.5%

Many of the thesis projects are developed in a desktop application. A desktop application is a system that can be installed on a single computer (laptop or desktop) and used to perform specific tasks. MySQL and desktop applications like information systems are the best combinations for IS development, especially when applied using a XAMPP web server solution. The XAMPP distribution gained popularity and is currently installed on millions of servers worldwide. Thus, developers (like students), especially in thesis projects, this could be an opportunity because it is a free, easy-to-download, and open-source, cross-platform web server that consists of Apache HTTP server, MySQL (now MariaDB) database and interpreters for scripts (Bazghandi, 2006). MySQL can be used for possible big transactions or can handle big amounts of data. Other database servers are SQL/Lite, which is mostly used in mobile applications, ADODB (1.0%) is a database wrapper library used in Visual Basic and other Microsoft products (Sklar, 2004); and MS SQL (0.5%) server, a proprietary system developed by Microsoft which does not allow any file manipulation while running (DNSstuff, 2020).

Type of Application Development

Most of the theses being reviewed are classified according to their application type. Figure 3 shows that desktop applications had 44.4%; before the growing internet popularity worldwide, desktop applications were the main development in computer systems from about 2005 to 2012. Desktop applications have a good interaction with standalone computers. They are easy to start development without the need to set up the network infrastructure and are free from connectivity problems. The information technology maturity is fast changing, and combining game applications which have 17.3%, and mobile applications, about 12.6%, has been the trend in thesis among students from 2013 to 2019 because of the popularity of smartphones or gadgets. Most students have mobile or smartphones with them, and they explore different technology or operating systems from the usual operating system used on our personal computers. Game development gained acceptance as an engaging and motivating tool for computer science students. Mobile games are easier to program and make it more feasible for students to develop games as part of their undergraduate experience (Kurkovsky, 2014). The web application has 16.5%, and it must run and test on a local server that can be accessed over the network. Web applications have become part of an academic curriculum, and teaching a web development course to computing students is challenging because of rapidly changing technologies (Yue & Ding, 2004) and some students will incorporate their knowledge in projects and some open-source leading-edge web technologies.
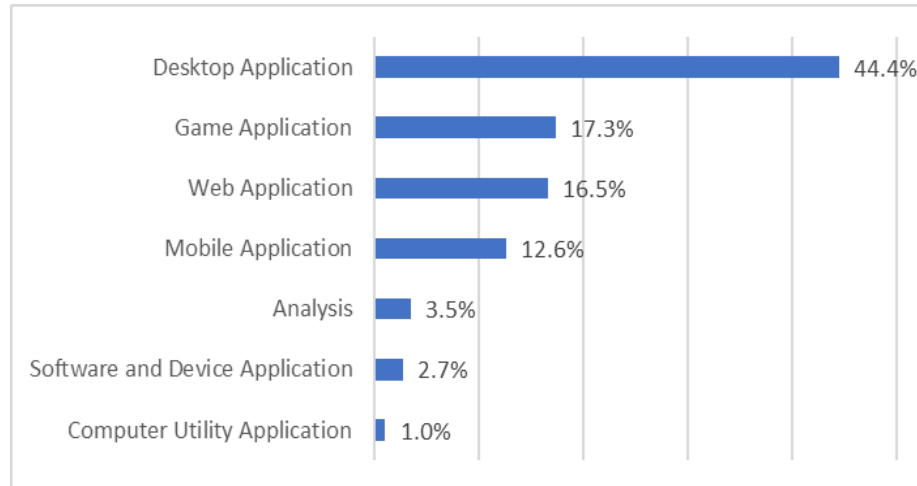
Figure 3. Application types that are mostly developed

Framework and Integrated Development Environment (IDE)

There are thesis projects that use frameworks and IDE to support the development process. The majority of 87% of these projects used hard coding techniques, which means developers directly embed the data into the source code, as shown in figure 4. In most cases, this technique is primarily used by developers who want flexibility with the source code or are somewhat unfamiliar with the framework environment.

The Eclipse IDE is also used. This tool is used in mobile or game development using the programming language Java and Python and provides developers with information throughout the development (Layman et al., 2008)). The reason for using IDE is that it is an effective tool technology in programming applications in support of IDE-based products that provide open application programming interfaces (desRivieres & Wiegand, 2004) that support integration development. Some use JDK or Java Development Kit as a support tool in Java. The Android Studio tool is for mobile development with the OS (Operating System) Android supported by Android SDK Manager. However, Table 4 shows mobile application has 12.6% doesn't mean that they used Android Studio, in such Eclipse is another option for mobile development. Another tool is Unity which is used for developing 3D objects or even 3D games, and this tool is supported by the programming language C or C++. The most basic Web prefetching technique (Davison, 2002)) and tool in web development is HTML which is also embedded with tools like Javascript, Cascading Style Sheets (CSS), etc. OpenCV also became part of the tool being used even though some students are new to computer vision. This tool is used for image processing and developing a real-time computer vision application.
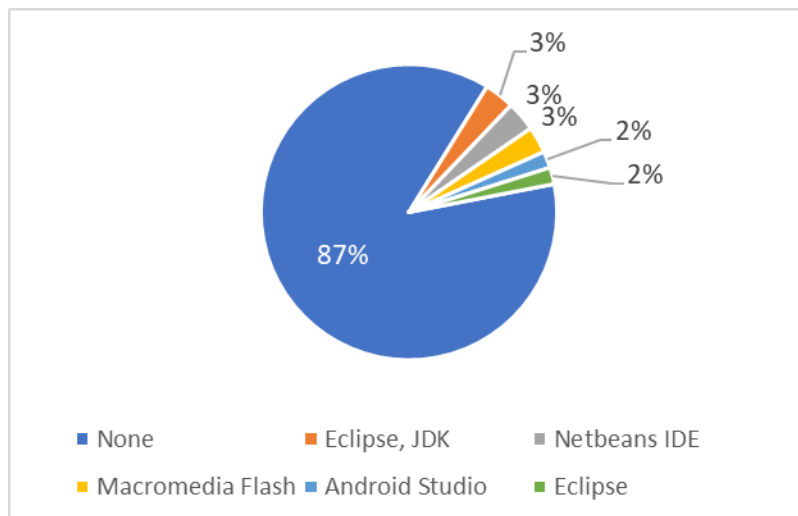
Figure 4. Common Frameworks and IDE used

Technology nowadays is becoming so vast, and computer science is one of the technical seeds for the latest technology (TECHSPARKS, 2020); this generation has many problems to solve (Kearney, 2020) with the help of computer science students. There is always a bright outlook for computer science graduates with the highest demand, whatever the field of expertise they may afford in any industry. Technology has been growing exponentially over the past years (Frot, 2021), and the future topics for the next generations would include the combination of artificial intelligence and robotics. The Internet of Things (IoT) is the main source or backbone of connectivity of objects and devices where the collection and transfer of data without human interaction (TECHSPARKS, 2020). Industries are investing big amounts of money and resources into artificial intelligence research, which can be another opportunity for students in their field of research. The computer-assisted education can be a possible trend for the succeeding years for those students with learning disabilities that can provide personal instruction and enable students to learn at their own pace (Frot, 2021) whereas, in the past decades, it was called Computer Aided Instruction (CAI). Big data analytics has been also in demand for research where companies make use of the datasets they have to personalize and improve services, and in 2019, some students already starting to do analysis type of research like gathering trending data from tweets of the netizens and developing an analyze with statistical analysis by using the NLP (Natural Language Processing). Students interested in computer security will be a trend for the next decade because the world is focused more on big data, and data protection is needed for the growing strand of computer science.

CONCLUSIONS AND RECOMMENDATIONS

There are 405 BSCS capstone project titles retrieved from 2005 to 2019. Some manuscripts are in good condition, and some are not. However, the good thing is that they are all textually readable and in a safe and secure place. The methodologies used

are all appropriate to their thesis, even though selecting the proper methodology for a certain topic is difficult. Their type of study or research dictates the right decision in choosing the right methodologies to meet the objectives of their study. Since most of them develop a game and android applications, they used techniques and selected tools that could be suitable during the development.

In software development, there is a need for help using application tools to support the development process of their applications. The tools and programming language they used are all open-source applications. They used tools to improve their design, convenient interaction with programming languages, and practical wise for faster development.

Based on the CHED CMO as of 2006 and revised CHED CMO as of 2015 that BS Computer Science students are required to complete a thesis that is focused on the theories and concepts of computing in the form of scientific work. The thesis topic should have an investigation problem that can be solved using Computing. All the theses titles are anchored with the CHED CMO; perhaps that game development was one of the main trends from 2013 – 2019; it's one of the challenges that games can also be part of learning theories about digital game-based learning (Chris Johnson). Aside from game development, the top thesis topic is mobile or android development; since Smart Phones have changed the world with this technology, and which most people in the country have smartphones, it has become the motivation for students to be updated when it comes to the new trend of android technology. The students have the skills in modern technology like coding, data processing, mobile development, web development, and network security.

Based on the findings, it is recommended that the special projects thesis consider other researchable areas, such as theories and concepts of computing. As a recommendation, since computer science focuses on the development of system software and they are using tools, and different frameworks for their development but the algorithms they used are not well discussed. For further and upcoming research projects, students should focus on computer science principles such as on latest trends in Computer science like Mobile Computing Systems, Expert systems, Intelligent systems, computer visions, parallel computing, cloud computing, natural language processing, pattern recognition, and data mining, image/signal processing, and emerging technologies. With this possibility, computer science topics can avoid duplication of ideas or topic titles. Old topics can be recycled and improved by applying the latest trends.

IMPLICATIONS

Undergraduate theses are great providers of valuable information to academic institutions, they may give new avenues and opportunities for technology application and research. The research projects are directly linked to analyzing existing algorithms and

have produced applications. And with these contributions, transactions, and processes have become more manageable, and opportunities have been exposed.

This advancement significantly affected the ITE program's directions, and the study established research options, including the CHED capstone project's proposed research fields. Moreover, supply excellent inputs to academic programs that will open up new trends in researchable domains. After students begin to submit capstone projects, this may have an impact on the research fields of the IT degree program. Most significantly, this will provide faculty members with insights into developing capstone projects and motivate them to bring different technological applications.

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DECLARATIONS

Conflict of Interest

The authors declare no competing interest in this study.

Informed Consent

Not applicable since this study does not involve human participants.

Ethics Approval

Not applicable since this study does not involve human participants.

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Dr. Jayvee Christopher N. Vibar is an Assistant Professor and Systems Programmer at Bicol University, Legazpi City where he teaches both in graduate and undergraduate courses. He oversees the university-wide central payroll system software that he developed. He is known for his balanced academic and coding competence. He is a graduate of computer science at Computer Arts and Technological College (CATC), Legazpi City, and later finished his Master of Information Systems at the University of the Philippines Open University (UPOU), Los Baños, Laguna. He completed his Doctor in Information Technology at the Technological Institute of the Philippines (TIP), Quezon City. His research activities can be seen through his ResearchGate portal, where lately he published IEEE international research at Nanyang Technological University, Singapore, and Shah Alam, Malaysia. You can reach him at jcnvibar@bicol-u.edu.ph.