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FOREWORD

Greetings!

Ultima InfoSys : Jurnal Ilmu Sistem Informasi is a Journal of Information Systems which presents scientific research articles in the field of Information Systems, as well as the latest theoretical and practical issues, including database systems, management information systems, system analysis and development, system project management information, programming, mobile information system, and other topics related to Information Systems. ULTIMA InfoSys Journal is published regularly twice a year (June and December) by Faculty of Engineering and Informatics in cooperation with UMN Press.

In this December 2025 edition, ULTIMA InfoSys enters the 2nd Edition of Volume 16. In this edition there are seven scientific papers from researchers, academics and practitioners in the fields covered by Ultima Infosys. Some of the topics raised in this journal are: Extraction of Class Candidates from Scenario in Software Requirements Specifications, Unlocking Sales Insight through Business Intelligence and ERP, Analyzing Factors Influencing Flow Experience in Battle Royale Games: A Case Study of Free Fire MAX, Utilizing a Data Warehouse to Analyze the Effects of Sales Type, Product Type, and Price on Net Profit in an F&B Outlet, An Exploratory Study of Video Game Pricing in the Southeast Asian Market, Stasiun Pengisian Kendaraan Listrik Umum (SPKLU) Model Using GIS and Machine Learning, and Needle Stick Injury Report Application Design at XYZ Hospital in Tangerang.

On this occasion we would also like to invite the participation of our dear readers, researchers, academics, and practitioners, in the field of Engineering and Informatics, to submit quality scientific papers to: International Journal of New Media Technology (IJNMT), Ultimatics : Jurnal Teknik Informatics, Ultima Infosys: Journal of Information Systems and Ultima Computing: Journal of Computer Systems. Information regarding writing guidelines and templates, as well as other related information can be obtained through the email address ultimainfosys@umn.ac.id and the web page of our Journal here.

Finally, we would like to thank all contributors to this December 2024 Edition of Ultima Infosys. We hope that scientific articles from research in this journal can be useful and contribute to the development of research and science in Indonesia.

December 2025,

Monica Pratiwi, ST, MT.
Editor-in-Chief

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Extraction of Class Candidates from Scenario in Software Requirements Specifications

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***Abstract*— The development of a software application involves a comprehensive process of defining and documenting software requirements. Among various modeling activities, sequence diagrams serve a vital role in illustrating dynamic interactions among system components. However, manually constructing these diagrams from natural language Software Requirements Specifications (SRS) is often labor-intensive, inconsistent, and prone to human error, especially when the text is complex and unstructured. This study focuses on automating the extraction of candidate elements specifically classes, subclasses, and attributes from the scenario sections of SRS documents. These sections are typically written in narrative form and are rich in behavioral information. The proposed method integrates Natural Language Processing (NLP) using Bidirectional Encoder Representations from Transformers (BERT) for contextual embeddings and a Support Vector Machine (SVM) classifier to categorize each noun phrase accordingly. Two datasets, SIData and SILo, with distinct domain characteristics and writing styles, were used to evaluate the system's performance. While the system demonstrates the feasibility of the approach in identifying relevant elements, limitations such as low precision and false-positive rates highlight the need for further refinement in classification accuracy, generalizability, and semantic understanding of entity relationships. These challenges present opportunities for future work, including improvements in preprocessing strategies, data augmentation, and the use of ontologies for domain-specific consistency.**

Index Terms—*Software Requirement Specifications; Class Diagram; Sequence Diagram; Class Extraction; UML; Natural Language Processing; SVM; Scenario; Scenario in SRS;*

I. INTRODUCTION

The Unified Modeling Language (UML) has long been used as a standard way to describe how software systems are structured and how they behave. As noted by the Object Management Group (OMG), UML acts as a general-purpose visual language that helps various stakeholders understand and communicate the system's design elements. Among the many diagrams in UML, class diagrams are typically used to show the system's static structure, while sequence diagrams focus more on how components interact over time. These diagrams are valuable not only for communication but also for documenting and maintaining complex systems throughout the development lifecycle.

In real-world software engineering, the Software Requirements Specification (SRS) is one of the most crucial documents [1]. It outlines what the system should be able to do covering both functional and non-functional aspects. Often, the SRS contains narrative scenarios to help convey system behavior in a more intuitive way. Converting these narratives into structured diagrams such as class or sequence diagrams is essential, but doing it manually can be time-consuming, prone to errors, and difficult to maintain especially when the system grows more complex [2]. method for classifying sentences in Software Requirements Specifications (SRS) using Natural Language Processing (NLP) techniques and BERT embeddings. Their work highlights the effectiveness of deep contextual representation in improving the understanding of requirement-related sentences in software documentation [3].

Several researchers have tried to address this problem. For example, Yang and Sahraoui [4] highlighted how tricky it is to convert natural language into UML because of the ambiguity and inconsistency of human language. Others, like Shweta et al [5], began experimenting with transformer models to get better at identifying diagram components in textual requirements. Malik et al. [6] used BERT to pick out specific entities from SRS documents, and Ferrari et al. [7] looked into how large language models (LLMs) could help generate sequence diagrams automatically. These efforts show that there's growing interest in using Natural Language Processing (NLP) to simplify software modeling. [8] Even so, a number of challenges remain. One of the biggest gaps is in extracting fine-grained elements like deciding whether a noun phrase refers to a class, a subclass, or just an attribute. This becomes even more difficult when the system relies on scenario sections, which are usually written in free-form narratives. These parts can be rich

in context but hard for machines to understand without deeper language processing.

That's where this study comes in. We propose a method to automatically extract useful UML entities specifically candidate classes, subclasses, and attributes from the scenario sections in SRS documents. To do this, we combine the power of BERT embeddings with a Support Vector Machine (SVM) classifier that assigns each noun phrase to the right category based on its context [9]. The idea is to create a rough structure that can later support the construction of sequence diagrams.

To see how well this method works, we tested it on two different datasets: SIData and SILo. The SIData and SILo datasets used in this study were specifically selected due to their completeness and availability of both Software Requirements Specifications (SRS) and corresponding class diagrams, which are essential for evaluation. The SIData dataset originates from an internal project related to environmental assessment systems, while SILo is derived from a logistics information system used in academic environments. Both datasets were obtained from the Department of Informatics, Institut Teknologi Sepuluh Nopember (ITS), Indonesia. The SIData dataset has more technical and domain-specific language, while the SILo dataset uses a more narrative tone, similar to how people describe scenarios in real-life situations. This contrast helps us see how flexible and reliable our method is across different writing styles. In our evaluation, we used common metrics like precision, recall, and F1-score to measure how accurately the system could identify and classify the elements. The results gave us useful insights into where the system performs well and where it still needs improvement.

II. METHODOLOGY

This section outlines the methodological framework employed to automatically extract class-related elements from scenario-based Software Requirements Specifications (SRS). The process consists of several sequential steps, beginning with the extraction of noun phrases from the scenario text using BERT embeddings, followed by classification of these phrases into class candidates. The extracted elements are then compiled and compared with ground truth data derived from corresponding class diagrams to evaluate the system's accuracy. Each step is designed to ensure a systematic and replicable approach for validating the effectiveness of the proposed method as can be seen in Fig 1.

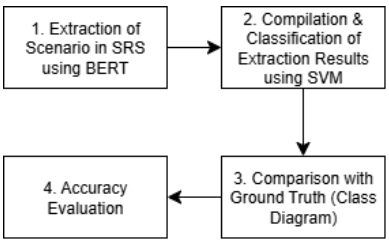

Fig. 1. Methodology

A. Extraction of Scenario in SRS Scenario using BERT

This stage focuses on capturing user interaction flows with the system as described in the functional requirements. Specifically, the research concentrates on processing only the scenario sections of SRS documents, as these are considered the most informative for identifying critical entities namely, classes, subclasses, and attributes which will later form part of the class diagram model [10].

The rationale behind focusing on scenarios stems from prior studies, which have shown that scenario narratives often encapsulate rich behavioral information essential for generating models such as sequence or class diagrams. In this study, the dataset used is stored in plain text (.txt) format. One example is a scenario excerpt from the SIData dataset, as shown in Fig. 2.

To extract relevant information, the text undergoes several Natural Language Processing (NLP) steps. These include noun phrase identification using the spaCy library [11], followed by embedding representations using BERT. These embeddings are then classified into predefined categories (class, subclass, attribute) using a Support Vector Machine (SVM) classifier. This hybrid technique aligns with recent advancements in contextual entity recognition, which have demonstrated high performance in extracting domain-relevant entities from unstructured documents. Implemented BERT models to classify of contextual embeddings and sequential modeling can yield strong classification performance on sentiment-based datasets [12]. In a comparative analysis, examined the influence of different pre-trained models on the accuracy of BERT for text classification, emphasizing the importance of selecting suitable base models to optimize performance in domain-specific tasks [13].

The extracted entities are then evaluated by comparing them with the reference class diagrams, which have been manually constructed and serve as the ground truth for this experiment.

That Monday morning, Ratna, the supervisor of Environmental Office, receipt a request from PT Pangkur for environmental assessment on their cafeteria. She immediately create an assignment for the environmental assessment. She assigned Yakub, the most experience field laboratory officer at the office. On the afternoon that day, Yakub open his SIData application and notice that there is a new assignment for him. He immediately prepared the necessary devices and materials and go to PT Pangkur. After arriving at the location, he immediately started the assessment. After getting the result, he took the time to create the assessment report via SIData. As soon as he submit the report, his superviser, Ratna noticed that the assignment has been completed. She is very satisfied with the quick response of Yakub.

Fig. 2. Scenario of SIData

B. *Compilation and Classification of Extraction Results using SVM*

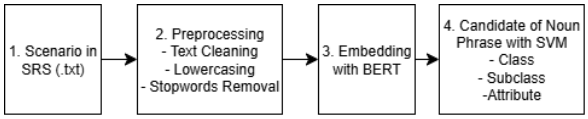

Fig. 3. Extraction Process

The preprocessing phase starts by cleaning the raw text to remove non-alphabetic characters, converting all words to lowercase, and eliminating stopwords. These are common techniques in Natural Language Processing (NLP) workflows, aimed at minimizing noise and improving the performance of later processing steps . After the text is cleaned, noun phrases are identified using spaCy's built-in linguistic features, which rely on part-of-speech (POS) tagging and syntactic dependency parsing to detect meaningful noun chunks.

Next, each identified noun phrase is transformed into a contextual embedding using a BERT model that has been fine-tuned specifically for the task of entity classification in software requirement texts. This fine-tuning process involves training BERT on manually annotated scenario data from SRS documents and appending a classification layer to label each noun phrase as a class, subclass, or attribute [14].

To improve categorization accuracy, these BERT-generated embeddings are then passed to a Support Vector Machine (SVM) classifier. The process consists of several sequential steps, beginning with the extraction of noun phrases from the scenario text using BERT embeddings. These embeddings are then fed into a Support Vector Machine (SVM) classifier to distinguish between valid and non-valid class candidates, as illustrated in Fig. 3. The extracted elements are then compiled and compared with ground truth data derived from corresponding class diagrams to evaluate the system's accuracy. Each step is designed to ensure a systematic and replicable approach for validating the effectiveness of the proposed method. This hybrid method leveraging deep contextual understanding from BERT alongside the robustness of SVM decision boundaries has been shown in previous studies to yield reliable results in entity classification tasks [15]. Support Vector Machine (SVM) approach to classif. The study confirmed the robustness of SVM in handling tasks with limited training data [16].

C. *Comparison with Ground Truth*

To assess the effectiveness of the proposed extraction method, an evaluation was conducted by comparing the extracted entities with a manually constructed class diagram, which serves as the ground truth. This comparison focuses on identifying matches between the predicted and actual elements, including class names, attributes, and subclass hierarchies.

To facilitate automated comparison, the reference class diagram was converted into a structured JSON format, enabling consistent parsing and element-wise alignment . The evaluation process then involves checking for the presence or absence of each predicted entity within the reference diagram.

Through this approach, the system's performance is quantitatively assessed, providing insight into its accuracy and relevance in identifying meaningful entities. Metrics such as precision, recall, and F1-score are used to measure how well the extracted results align with the expected outputs, thereby reflecting the practical applicability of the method in real-world software modeling tasks.

D. *Accuracy Evaluation*

The performance of the proposed extraction method is evaluated using a set of well-established metrics: accuracy**,** precision**,** recall**,** and F1-score. quantifies how many of the elements identified by the system are actually correct, while recall measures how many of the relevant elements present in the ground truth were successfully detected. The F1-score, serving as the harmonic mean of precision and recall, provides a balanced indicator of the system's ability to minimize both false positives and false negatives.

Beyond these core metrics, a descriptive statistical analysis is also performed to gain deeper insight into the model's performance. This includes calculating the minimum**,** maximum**,** mean**,** and standard deviation for each entity category namely class, subclass, and attribute [17]. The minimum and maximum values indicate the range of model performance, highlighting its best and worst outcomes across the evaluation. The mean reflects the central tendency, offering a general impression of accuracy across multiple test cases [18]. Meanwhile, the standard deviation captures the degree of performance variability, providing an indirect measure of the model's consistency and reliability when applied to datasets with differing linguistic characteristics.

Table 1. Confusion Matrix for Entity Extraction

Dataset	True Positive	False Positive	False Negative
SIData	2	27	18
SILo	3	24	9

The information extraction process using the BERT and SVM approach revealed that the overall performance of the system could not yet be classified as satisfactory. This is reflected in the evaluation metrics precision, recall, and F1-score which tend to be relatively low. Based on the evaluation results, the obtained performance metrics indicate the extent to which the system succeeded in accurately extracting information from the SRS documents, as presented in Table 2.

Table 2. Performance Evaluation

Dataset	Accuracy	Precision	Recall	F1-Score
SIData	4.2	0.069	0.10	0.250
SILo	8.3	0.111	0.25	0,157

To gain deeper insights into the classification performance of the BERT and SVM model across two datasets SIData and SILo a visual evaluation was conducted using a whisker plot. This diagram provides an intuitive overview of the distribution of three key metrics: precision, recall, and F1-score. Powers argues that common metrics (precision, recall, F1-score) can be misleading without understanding underlying biases. It explores alternative metrics like informedness and Markedness for a more principled evaluation [19]. This consolidates common performance metrics for classification and provides guidance on when to apply statistical significance testing [20].

For the SIData dataset, the plot reveals a tightly clustered boxplot within the lower range (below 0.10), highlighting the model's overall poor performance in identifying and categorizing entities accurately. Specifically, the model achieved a precision of 0.069, recall of 0.100, and F1-score of 0.082. The short whiskers in Figure 5 further reinforce this outcome, indicating low variance and minimal dispersion among prediction results suggesting that most classification attempts consistently performed poorly.

In contrast, the SILo dataset exhibits a broader distribution and noticeably improved metric values. The model attained a precision of 0.111, recall of 0.250, and F1-score of 0.157, with the whisker plot showing longer whiskers and a wider interquartile range. This implies greater variability in the model's performance and a modest improvement in its ability to generalize across different types of textual structures. Although the overall precision remains relatively low, the wider distribution reflects the model's potential to more effectively capture relevant phrases in less rigid, narrative-style documents such as those in the SILo dataset.

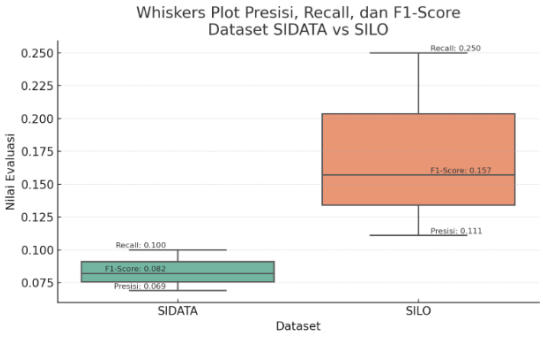

Fig. 5. Whisker Plot of Dataset

The observed differences in performance distribution between the two datasets can be attributed to their inherent linguistic characteristics. The SIData dataset generally features more informal and context-dependent phrasing, which introduces ambiguity and challenges in accurately identifying and classifying entities. In contrast, the SILo dataset is composed of more structured and repetitive terminology, often found in formal technical documentation, which aids in improving classification consistency. Furthermore, disparities in the total number of noun phrases, as well as the syntactic clarity of those phrases, play a significant role in influencing the classification performance across both datasets.

III. RESULT AND DISCUSSION

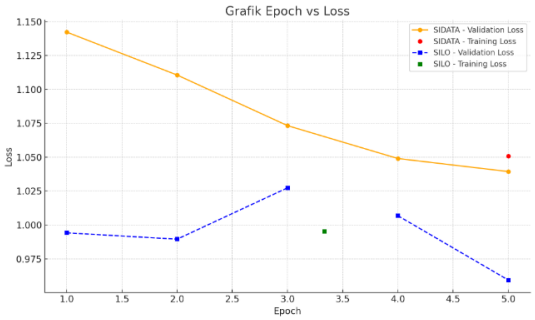

Fig. 6. Training loss of Dataset

The figure above illustrates a comparative analysis of training and validation loss curves observed during the BERT fine-tuning process across several epochs, using the SIData and SILo datasets. The orange line depicts the validation loss for the SIData dataset, which demonstrates a steady decline from epoch 1 through epoch 5. This downward trend suggests a stable and consistent learning process. The red dot, positioned at epoch 5, represents the training loss at that stage, providing a benchmark for evaluating how well the model has learned.

On the other hand, the blue line, which corresponds to the SILo dataset, shows a more erratic validation loss trajectory. Notably, there is a temporary increase in validation loss at epoch 3 before it eventually decreases

to its lowest point at epoch 5. The green dots indicate training loss values captured at various epochs, offering further insight into the model's convergence behavior. This fluctuation suggests that the SILo dataset presents greater variability or complexity, which may challenge the model's ability to consistently internalize training patterns.

Table 3. Training Log of SIData

Epoch	Iteration	Training Loss	Validation Loss
1.0	2	-	1.1422637701034546
2.0	4	-	1.1105989217758179
3.0	6	-	1.0732616186141968
4.0	8	-	1.048999309539795
5.0	10	1.0507	-
5.0	10	-	1.0393873453140259

Table 4. Training Log of SILo

Epoch	Iteration	Training Loss	Validation Loss
1.0	3	-	0.9941515326499939
2.0	6	-	0.9894852042198181
3.0	9	-	1.0273746252059937
3.3335	10	0.9951	-
4.0	12	-	1.0067888498306274
5.0	15	-	0.9593325257301331

Tables 3 and 4 display the detailed training logs of the BERT fine-tuning process for both SIData and SILo datasets, including the training loss and validation loss values across various epochs and iterations. For SIData (Table 3), the validation loss shows a consistent decline from epoch 1.0 to epoch 5.0, indicating a steady learning curve. The lowest validation loss, 1.039837435140259, was achieved at epoch 5.0 with 10 iterations, while the only recorded training loss value was 1.0507 at epoch 5.0 with 1 iteration.

In contrast, Table 4 illustrates the SILo dataset's training progression, where validation loss exhibits more fluctuation. Despite a slight increase at epoch 3.0, the validation loss eventually decreased to its lowest value of 0.9593325257301331 at epoch 5.0 with 15 iterations. The training loss was recorded at epoch 3.3335, reaching 0.9951. These variations reinforce the earlier observation that SILo's data complexity affects the stability and convergence of the model during training.

In this evaluation, the program demonstrated a significant dependence on the characteristics of the dataset. For the SILo dataset, which contains more natural and narrative-style text, the system exhibited better performance in information extraction. Conversely, for the SIData dataset, which is more formal and includes many technical terminologies, the system's performance declined considerably. This indicates that the system's generalization capability across various document styles is still limited and requires further improvement through increased training data variation and more refined classification methods. These results suggest that the model is better at identifying entities in datasets with certain structural and editorial patterns, though enhancements are needed both in the labeling process and in the classification architecture to ensure more stable and accurate performance across diverse data types.

Based on two scenario-based tests using different datasets, there is a clear tendency for the system to perform better when the data exhibits a more natural and explicit structure. This is evident from the stronger results observed on the SILo dataset, which utilizes operational descriptive narratives, as opposed to the SIData dataset that employs a more rigid and technically formatted language. The model tends to extract entities more effectively from sentences resembling everyday human communication. For instance, in the SILo dataset example: "After completing the payment, Ratna printed a receipt and handed it over to Yakub. ... Ratna sent Yakub to the warehouse. Yakub immediately went to the warehouse," the system could accurately extract entities such as *Yakub*, *receipt*, and *warehouse* due to the narrative structure. In contrast, a sentence like "AssignmentForm consists of various attributes such as SamplingID, TestingDevice, and SampleType which are stored in MasterData" from the SIData dataset proved more difficult to process due to its dense, technical form and lack of explicit actor interactions.

Such discrepancies contribute to unstable system performance, as reflected in the fluctuating precision, recall, and F1-Score values across the two datasets. It is crucial to recognize that the alignment between extracted results and ground truth data does not rely solely on the presence of entity names (e.g., attributes), but also on the contextual accuracy specifically, the correct class hierarchy to which those elements belong. For example, while the attribute *invoiceNumber* may appear in the extraction output, if it is assigned to the class *Payment* or *Receipt* instead of *Invoice* (as defined in the reference data), the system fails to classify it correctly. Therefore, despite being lexically correct, such attributes are considered contextually invalid and are treated as False Negatives (FN) in the evaluation.

Similar misclassifications were observed for attributes such as *status* and *supplierName*, where the system extracted the correct term but linked it to the wrong class. Even when such attributes are extracted, if they do not match their intended contextual placement in the reference class structure, they are still categorized as classification errors contributing to FN rates.

During evaluation, anomalies were identified where entities matching the ground truth terminology were extracted but placed under incorrect class contexts. Examples include entities like *invoiceNumber* and *status*, which were correctly recognized but misclassified into inappropriate categories. These misalignments resulted in the entities being counted as False Negatives, indicating a deeper issue in the system's understanding of semantic relationships and hierarchical structures among components in the

document. This highlights the ongoing challenge of enabling the system to comprehend and preserve the semantic and structural fidelity expected in UML-based document analysis.

IV. CONSLUSION

This study proposed a method to automatically extract conceptual elements namely classes (object), subclasses, and attributes from scenario-based Software Requirements Specification (SRS) documents. The process involved several stages, including text preprocessing, noun phrase extraction using spaCy, contextual embedding using BERT, and classification with an SVM classifier. The extracted candidates were then compared with the ground truth in class diagrams to evaluate structural alignment and accuracy. Overall, the method demonstrates the feasibility of integrating NLP and machine learning techniques for supporting early-stage software design automation.

The result of the extraction process consists of conceptual elements such as objects, subclasses, and attributes, which are then compared with the reference structure in the class diagram to measure their alignment and accuracy. This research process began with the collection and conversion of datasets in the form of Software Requirements Specification (SRS) documents into a compatible format, followed by text pre-processing stages such as the removal of non-alphabetic characters, lowercasing, and stopword elimination. After the text cleaning phase, noun phrase extraction was carried out using the spaCy NLP model, which was subsequently processed using BERT vector representations and classified using an SVM classifier to map entities into classes, subclasses, and attributes. Qualitatively, the primary objective of this study was achieved, which is the development of a framework capable of processing SRS documents and producing outputs that can be directly compared. The developed program has successfully identified several entities from the text and classified them into categories of class, subclass, or attribute, albeit with limited precision. Quantitatively, the system performance was evaluated using precision, recall, and F1-Score metrics on two different datasets: SIData and SILo. The results show that the precision values ranged from 8.3% to 16.1%, with an average of 12.2%. Recall values ranged from 9.5% to 38.5%, with an average of 24%. The F1-Score, which reflects the balance between precision and recall, ranged from 8.9% to 22.9%, with an average value of 15.9%. These values indicate that, although the system has functioned according to its intended purpose, the accuracy and relevance of the extraction results still require significant improvement for practical application in software development.

Overall, the performance of the extraction system remains far from optimal, with low accuracy rates across both datasets. The model tends to produce high false positive (FP) rates and still fails to recognize a significant portion of entities present in the reference data.

For further study, a few specific improvements may help strengthen the method. One is refining the preprocessing step to handle camelcase terms, since these often include multiple meaningful parts. It may also help to include linguistic cues, such as Part-of-Speech (POS) tags or the position of a noun phrase in a sentence, which can guide more accurate classification. Adding training data through paraphrased or reworded sentences could improve generalization. Using domain specific glossaries or ontologies might also support better consistency when dealing with specialized terms. Finally, future evaluations should consider reporting performance separately for classes, subclasses, and attributes to better understand where the model performs well or struggles.

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Unlocking Sales Insight through Business Intelligence and ERP

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***Abstract*— In recent years, businesses have encountered heightened competitive pressures, inefficiencies in financial management, operational instability, and declining profitability. Empirical research indicates that organizations that have digitized their business processes are better positioned to enhance operational efficiency and mitigate the risk of insolvency. PT Dwi Family Investama, a company founded as a printing and offset business, has faced similar challenges. The reliance on manual methods for recording orders and invoices has resulted in decreased work efficiency, an increased likelihood of recording errors, and difficulties managing customer data. Consequently, this situation hampers the company's ability to formulate effective business strategies and make informed decisions. This study aims to develop a web-based Enterprise Resource Planning (ERP) system with a dashboard designed to facilitate organizational decision-making. By implementing a business intelligence decision support system, the company can transition to digitized business processes and acquire critical insights regarding its operational status based on current data. In this study, the agile development method was established with the Laravel and Streamlit frameworks. As a result, system implementation reveals a significant increase in company performance indicators, with metrics showing an improvement of 52.3% in performance post-implementation. In conclusion, the results of this study prove that web-based ERP and dashboards can overcome company problems with a modular hybrid architecture approach and provide a significant positive impact on company performance.**

***Index Terms*—Business Intelligence; Dashboard; Decision Making; Enterprise Resource Planning; Operational Efficiency;**

I. INTRODUCTION

In the modern world, technology has become an essential aspect of daily living. Indonesia's ICT Development Index (IDI) increased from 80.1% in 2021 to 82.8% in 2022, according to data from the Central Statistics Agency [1]. The continuous development of Indonesia's information and communication technology industry is reflected in this increase in IDI. The need for businesses to adopt digitalization is increasing along with the use of technology. Since technology has a big impact on employee performance, digitizing company operations can increase productivity and efficiency [2]. According to research, businesses that have embraced digitalization see faster growth in productivity per employee than those that have not [3]. Businesses can also get a competitive edge by having access to trustworthy, high-selectivity, and real-time data [4]. Setting objectives and formulating wise suggestions for the future can be facilitated by utilizing well-managed knowledge based on this data [5].

Previous study has proposed that employing a web-based ERP system has many benefits for businesses. This benefit includes more flexibility, better operational performance, and simpler processes that support documentation and reporting and support data-driven decision-making [6]. Moreover, study research has indicated that dashboards in ERP systems are becoming essential due to the growth of big data and the need for real-time analytics. By using data visualization in dashboard, the system can promote understanding, streamline complex information, and facilitate quick and accurate decision-making [7]. Advanced visualization tools also give businesses significant competitive advantages by enabling interactive analytics that reveal hidden patterns and trends [8]. Integrating interactive dashboards and business intelligence (BI) has proven to reduces information gaps and speeds up data-driven decision-making, as shown in a case study in a Portuguese port [9]. As a result, web-based ERP systems with strong dashboard capabilities improve operational effectiveness and facilitate more accurate decision-making across a variety of industries [10]. Additionally, research indicates that businesses that have digitized their operations are more likely to increase operational effectiveness and lower their chance of going bankrupt [11].

A case study from one of the Indonesian willing companies is used in this study. According to management and operational staff interviews and in-person observations, PT Dwi Family Investama is having difficulties since it relies on manual recording techniques for day-to-day operations. Despite handling huge orders, the offset and printing services company lacks a well-organized system for storing customer data. Due to low efficiency, haveise in recording

errors, and trouble tracking client information, the lack of digitalized activities has resulted in large financial losses as well as a delay in timely decision-making and effective business strategies. Without effective data management, the business is unable to know how it is operating, which restricts its capacity to plan and make wise decisions.

This research focuses on developing an Enterprise Resource Planning (ERP) system in the form of a web-based system integrated with an interactive dashboard. It brings an innovative approach by using an interactive Streamlit-based dashboard, which functions independently while remaining fully integrated within the Laravel-based ERP system. This hybrid approach provides more responsive real-time data visualization and improves user experience because all functions are provided in one platform. Moreover, independent separation of the dashboard from the ERP system facilitates development flexibility, enabling ease of customization and scalability. The system is intended to digitize operations and enhance organizational decision-making.

Unlike previous studies that focus solely on ERP systems or dashboard visualization as standalone tools, this research integrates both in a cohesive framework tailored to the needs of SMEs in the printing industry. This study aims to investigate the impact of ERP and dashboard implementation on the operational efficiency of the company, specifically in reducing manual recording errors and improving data-driven decision-making. The contribution of this research lies in demonstrating how the integration of a customizable dashboard within an ERP system can serve as a strategic tool for small enterprises to enhance efficiency, transparency, and responsiveness.

II. METHOD

The operational inefficiencies of PT Dwi Family Investama were addressed in this study using the agile development technique. Agile is chosen because it provides flexibility in handling shifting system requirements [12]. Moreover, Agile also enables close collaboration between developers and the organization throughout the development cycle [13]. To identify issues and determine the system's requirements, information was gathered through interviews and in-person observations of firm personnel. Every stage of the development process allowed for continuous input and improvement because it was iterative.

Laravel is chosen as the primary web development framework for the system's implementation in order to construct the ERP modules. In addition, Streamlit is utilized to produce analytical dashboards. Laravel is chosen because this framework has a strong MVC structure that facilitates structured and scalable programming [14]. On the other hand, Streamlit makes it possible to create interactive data visualizations that link straight to the same database, giving decision-makers access to real-time insights [15]. Streamlit was chosen over traditional JavaScript-based visualization libraries due to its ability to create highly interactive dashboards with minimal development overhead [16]. Its Python-based structure allows rapid prototyping and real-time updates, making it ideal for building dynamic, data-driven interfaces in a short timeframe [17].

This combination allows for a modular and integrated solution so that the development of web-based ERP and interactive dashboards can run optimally and be integrated without interfering with each other, thus providing flexibility in development.

III. RESULT AND DISCUSSION

A. *Requirement Analysis*

To systematically define and document the system requirements, thorough observations and structures are conducted. The managers of the business and the customer service are interviewed and observed to gain better understanding of the company situation and current problem. Important information about the current operational workflows and process bottlenecks was obtained from these exchanges.

The interview results showed that WhatsApp is currently used to process the majority of consumer orders. To negotiate and complete their orders, customers reach out to customer support agents. After the order is placed, invoice for the agreed-upon down payment is then created and forwarded to the client. After the down payment is paid, the manufacturing team receives the order information. A product sample is created and shown to the client as part of the quality assurance procedure to make sure it meets their requirements and expectations. The production process does not start until the sample has been formally approved. Finally, the logistics process for product shipment is then initiated when the customer completes the remaining payment balance. Figure 1 provides a graphic summary of this business process flow.

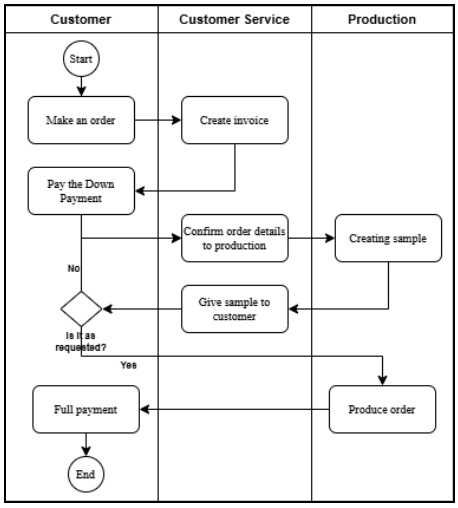

Fig. 1. Company's Order Business Process

In order to examine the current workflow and gain a better understanding of the business processes and related difficulties, observations and interviews were carried out. As shown in Table 1, the results will guide the creation of system features and functions that meet business requirements and describe how the suggested system resolves existing problems.

TABLE I. TABLE COMPARISON BETWEEN THE EXISTING PROBLEM AND THE SOLUTION PROPOSED

Existing Situation	Problems Caused	Proposed Solution	Benefit
Manual recording on a whiteboard.	Order data is lost or forgotten due to space limitations.	Web-based ERP for digital order tracking.	Improves operational efficiency and prevents data loss.
Reliance on WhatsApp for customer data.	Loss of important customer and order details.	Centralized customer data management via ERP.	Reduces data loss, builds trust, and improves customer relations.
Manual paper invoices.	High costs and lack of professionalism with no standard template.	Automated invoicing through the ERP system.	Cuts costs, enhances professionalism, and speeds up transactions.
Poor integration of customer and order data.	Difficulty making data-driven decisions.	Real-time analytical dashboard with ERP.	Enables faster, informed decision-making and boosts competitiveness.

As a solution to the problems listed in Table 1, this web-based ERP prototype is designed to accommodate the company's needs. The web-based ERP design includes six essential features such as dashboard, customer list, order manager, invoice center, product manager, and account manager. The dashboard facilitates company analysis through graphical representations. Furthermore, the customer list addresses data management challenges by centralizing customer information that previously relied on chat applications. Moreover, the order manager resolves issues of dependence on whiteboards for order tracking. Additionally, the invoice center automates invoice generation based on order data. The product manager ensures that companies can manage the products offered. Lastly, the account manager enables user access to the ERP system. Each feature encompasses various functionalities such as viewing data lists, accessing detailed data, creating new data entries, and updating existing data.

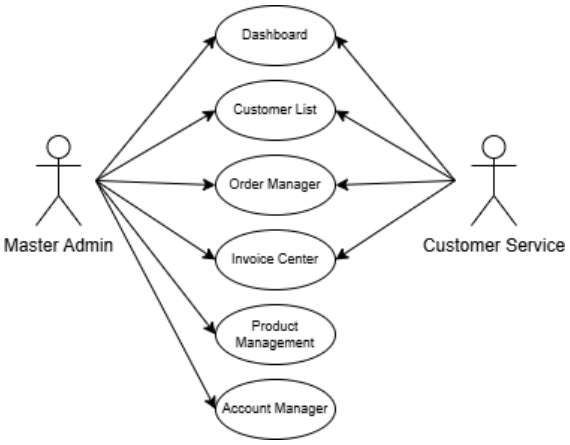

Fig. 2. Company's Order Business Process

The system will accommodate two types of users: customer service representatives and master administrators. Only the master administrator can access critical features like product management and account management, ensuring secure handling of sensitive configurations and user accounts. This access separation helps maintain data integrity and protects operational processes

B. Implementation of ERP Modules using Laravel

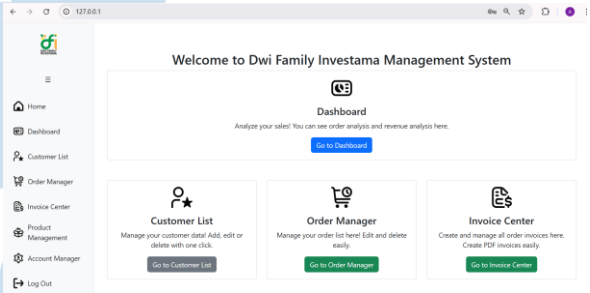

Fig. 3. Web-based ERP Prototype

The ERP system developed using the Laravel framework, chosen for its strong MVC architecture that promotes separation of concerns and structured code organization [18]. During development, Laravel's routing system enabled efficient mapping between user requests and backend logic. The separation is useful when managing features such as order input, invoice generation, and product listing.

Laravel's model layer was used to handle business logic and interaction with the MySQL database [19]. For instance, the order module linked order records with customer and product data using Eloquent ORM, simplifying database queries and maintaining relational consistency. Additionally, Laravel's built-in validation features ensured data integrity at the input level, reducing the risk of human error in form submissions [20].

Moreover, the Laravel's Blade templating engine also facilitated the rapid development of clean and maintainable UI components. It enabled separation between interface design and dynamic logic, which

allowed for easy updates based on iterative feedback during Agile sprints.

TABLE II. EXPLANATION OF EACH MODULE IN WEB BASED ERP

Modules	Description
Customer List	Centralizes customer records and eliminates reliance on messaging apps.
Order Manager	Digitally records orders, replacing manual whiteboard tracking.
Invoice Center	Generate structured invoices from order data, supporting partial and full payment logic.
Product Management	Manages the product catalog and recommendation price.
Account Manager	Manage roles and authentication, especially for admin vs. customer service separation.

C. *Analytical Dashboard Development using Streamlit*

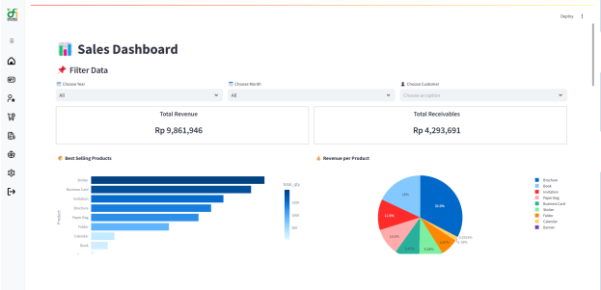

Fig. 4. Prototype Streamlit Dashboard

To complement the transactional ERP system, a web-based analytical dashboard was developed using Streamlit. Streamlit was selected for its ability to make an interactive and real-time dashboard based on database connection [21].

The dashboard connects directly to the same MySQL database used by Laravel, ensuring consistency and real-time data visualization. Streamlit's interactive components, such as multiselect filters and date range pickers, enabled users to perform customized analyses without the need for advanced technical skills. This proved particularly useful for managerial roles in the company, who needed immediate insights into sales, receivables, and customer trends.

Nine core visualizations were implemented, including revenue trends, product performance, customer rankings, and receivables breakdowns. These visualizations were dynamically updated based on user-defined filters and offered deeper understanding of business performance compared to traditional spreadsheet-based analysis.

D. *System Integration and Synchronization*

Despite being built using two different frameworks (Laravel and Streamlit), the ERP system and dashboard operate on a shared data foundation, namely a centralized MySQL database. This design choice allowed loose coupling between modules while preserving data consistency across components. The dashboard will be integrated directly into the web-based ERP by embedding iFrame. Thus, users can access all functions in one integrated web-based ERP.

To ensure synchronization, transactional data entered through the Laravel interface is immediately accessible to the dashboard. For example, when a new order is created and partially paid, the receivables chart on the Streamlit dashboard reflects the update in real time. This architectural setup supports real-time monitoring and decision-making without requiring additional data pipelines or synchronization scripts.

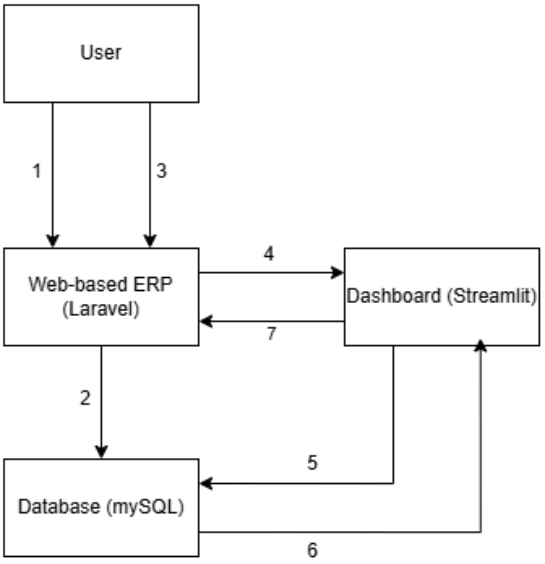

Fig. 5. System Architecture

The architectural overview of the system is illustrated in Figure 5. This architecture reflects the seamless integration between the web-based ERP application, the analytical dashboard, and the centralized MySQL database. From the user's perspective, all features appear to be unified within a single web-based platform. However, in practice, the analytical dashboard is a separate application built using Streamlit. Dashboard has been embedded into the ERP system interface to provide a cohesive user experience.

The following describes the flow of interaction within the integrated system.

1. Users interact with the web-based ERP system to input, update, or manage transactional data.
2. The ERP system processes the input and stores the corresponding data in the MySQL database.
3. When users navigate to the dashboard feature, they remain within the ERP interface.
4. The ERP application renders the Streamlit dashboard using an embedded iFrame component.

5. Upon loading, the Streamlit dashboard sends SQL queries to the shared MySQL database to retrieve relevant data.
6. The MySQL database responds with the requested data, enabling real-time access.
7. Streamlit dynamically generates visualizations and displayed within the ERP interface, ensuring a seamless transition between ERP system and analytical dashboard.

This modular yet unified integration architecture allows for system flexibility and maintainability. Specifically, it decouples the development of web-based ERP and analytical components, enabling independent iteration and updates. As a result, enhancements to the dashboard logic do not interfere with the ERP's core functionalities, and vice versa.

E. System Output and Performance Evaluation

Black box testing is carried out in this study to ensure that all system functions operate correctly [22]. Fifty-five test cases were developed to evaluate the system's functionality and completeness. The test includes validation from both the front-end and back-end systems. As a result, all test cases have been successfully executed, and the system passed the black box testing trials, confirming that it operates as expected and aligns with the defined requirements.

Following black box testing, performance is evaluated by comparing the company's performance metrics before and after the ERP system and dashboard are put into place. This involves a fifteen-question questionnaire addressing challenges like recording errors, transparency issues, data management difficulties, and inaccuracies. Customer service representatives and master administrators completed the questionnaire twice: once before (pre-test) and once after (post-test) system implementation. Five people will participate in filling out this questionnaire. Two of them are company owners who also oversee overall business operations, and the rest are customer service employees.

As detailed in Table III, the data collected is analyzed to determine the percentage change in performance indicators.

TABLE III. TABLE INDICATOR FOR EACH QUESTION

Indicator	Description	Score
A	Strongly Agree	5
B	Agree	4
C	Neutral	3
D	Disagree	2
E	Strongly Disagree	1

The total score for each respondent was calculated by summing the values of all selected answers [23]. Based on the questionnaire, the total score before system implementation is 146 as stated in Table 4. Moreover, the total score is increasing after the implementation system as shown in Table 5, resulting in 342 total score.

TABLE IV. TABLE SCORE BEFORE IMPLEMENTATION

Indicator	Score
Business Owner 1	22
Business Owner 2	31
Customer Service 1	31
Customer Service 2	31
Customer Service 3	31
Total Score	**146**

TABLE V. TABLE SCORE AFTER IMPLEMENTATION

Indicator	Score
Business Owner 1	72
Business Owner 2	67
Customer Service 1	68
Customer Service 2	70
Customer Service 3	65
Total Score	**342**

To find the highest score, use the following formula:

$$X = highest\ score \times (total\ questions \times total\ respondents)$$

In this case, the highest possible score for each indicator is 5, and 5 respondents answer 15 questions. Therefore, the calculation for the highest score is 375. Moreover, in order to interpret the company's performance, the following formula was used to calculate the performance percentage:

$$P = \frac{Score\ Answer}{Highest\ Score} \times 100\%$$

Based on the calculation, the company's performance value before the implementation of the system is calculated based on a score of 146, which amounts to 38.9%. In contrast, following the implementation of the system, the performance score significantly increased to 342, which corresponds to 91.2% of the maximum possible score

F. Review

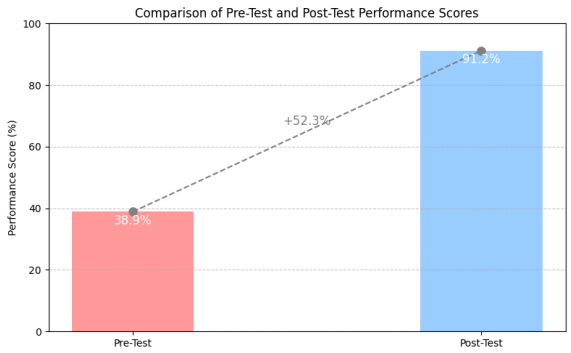

Fig. 6. System Architecture

The implementation of the ERP system and integrated dashboard resulted in a significant improvement in the company's operational performance. The improvement is reflected by a 52.3% increase in performance indicators post-implementation. This significant rise is not merely a numerical achievement, but also an indicator of the system's ability to address fundamental business challenges including data fragmentation, manual errors, and lack of process visibility.

In terms of efficiency, ERP system is successfully digitized and centralized key business functions. This transition eliminated reliance on manual tools that the company previously used, such as whiteboards and chatting apllication. The ERP system improved data traceability and enhanced organizational professionalism. Additionally, the analytical dashboard component further extends the system's value by enabling real-time insights into business metrics. The use of Streamlit allowed non-technical users, such as managers, to interact with complex data intuitively through dynamic filters and visualizations. This democratization of data access supports more agile, data-driven decision-making.

Beyond efficiency, the implementation of ERP system also enhanced transparency across the organization. Business information that was previously scattered can now be accessed centrally, ensuring all departments operate with consistent and up-to-date data. Moreover, the integrated dashboard helps provide real-time visibility of key business metrics. This shift has also strengthened the company's data-driven work culture, where decision-making increasingly relies on objective information rather than intuition.

The system implementation also has a positive impact on organizational responsiveness. With real-time access to operational and customer data, managers are able to adapt quickly to fluctuations in order volumes and operational challenges. Insights generated by the dashboard enable proactive responses, allowing the company to anticipate rather than merely react to issues. This responsiveness not only supports day-to-day operations but also lays the foundation for future technological advancements such as IoT-based process monitoring, AI-driven demand forecasting, and system-based supply chain management.

Feedback from management reported notable improvements in accuracy, ease of access to customer data, and overall agility after system implementation. The combined ERP and dashboard solution has effectively mitigated problems like data loss and manual tracking limitations.

IV. CONCLUSION

Research has been conducted to develop a dashboard in a web-based ERP prototype that addresses the issues identified at PT Dwi Family Investama. The resulting web-based ERP prototype features six key components such as dashboard, customer list, order manager, invoice center, product management, and account manager. Although web-based ERP and dashboards are developed in different frameworks, they are nevertheless integrated. The new system addresses the company's challenges by creating a centralized digital record-keeping system, reducing lost orders and customer data issues previously caused by manual methods. It also lowers operational costs by automating invoice generation and allowing data-driven decisions through an analytical dashboard, ultimately enhancing the company's competitiveness in the digital age

This research offers several notable contributions to both academic inquiry and practical ERP development. Firstly, it demonstrates a successful framework integration between Laravel and Streamlit, which originates from distinct technological ecosystems, PHP for transactional operations and Python for data analytics. By enabling these frameworks to interact seamlessly through a centralized MySQL database, the study presents a modular architectural approach that supports cohesive functionality without the need for middleware or third-party integration layers.

Furthermore, the adoption of Agile methodology within the development cycle highlights the adaptability and effectiveness of iterative implementation in microenterprise contexts. The ERP system evolved through continuous feedback loops involving actual users, ensuring alignment with real-world business processes and needs. This underscores the viability of Agile practices in resource-constrained environments, which are often underserved in traditional ERP research.

The system also represents a low-cost, yet high-impact ERP solution tailored for small-to-medium enterprises (SMEs), addressing a critical gap in ERP accessibility. By leveraging open-source technologies and a modular design, the prototype delivers essential functionalities without the expensive price typically associated with commercial ERP suites. As such, this study provides a scalable and replicable model for other SMEs facing similar operational and financial constraints.

Finally, this research also highlights evidence of an increase in company performance after implementing the ERP system and analytical dashboard. The significant increase of 52.3% in performance metrics post-implementation reinforces evidence the effectiveness of the system. Moreover, it also brought organizational impacts such as increased transparency and accountability in the work environment. Furthermore, this implementation also strengthens a data-driven work culture, where decisions are no longer based on intuition alone, but are based on objectives and real-time information.

Nevertheless, the prototype is not without limitations. From a security perspective, the system currently relies on standard authentication and has not yet implemented data encryption. Scalability is also a concern, as the prototype has only been tested in a small-scale environment and may require architectural adjustments to handle larger datasets or a higher volume of concurrent users.

For future research, it is recommended to enhance the system's security and integrate more ERP modules to support system functionality and provide a more comprehensive data source for the dashboard. Additionally, further exploration of dashboard customization based on employee roles could improve usability. Integrating AI-based analytics would also facilitate better data insights and support better-informed decision-making.

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Analyzing Factors Influencing Flow Experience in Battle Royale Games: A Case Study of Free Fire MAX

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***Abstract*—The rapid growth of the mobile gaming industry, particularly within the Battle Royale genre, has reshaped player engagement and competitive play. Free Fire MAX stands out by offering immersive gameplay supported by strong narrative driven elements. This study analyzes the influence of Game Design Factors (GDF) on players Flow Experience using a quantitative approach. Eleven factors Game Goals, Game Mechanism, Interaction, Freedom, Game Fantasy, Narrative, Sensation, Game Value, Challenges, Sociality, and Mystery were examined to identify which elements significantly contribute to psychological immersion. A structured questionnaire based on the Game Design Factors framework was distributed to active Free Fire MAX players aged 13–25 in Indonesia, using a five point Likert scale across 35 indicators. From 284 valid responses, 175 samples were retained for the main analysis. The methodology included Pearson validity testing, Cronbach's Alpha reliability testing, and classical assumption evaluations covering normality, multicollinearity, and heteroscedasticity. Multiple linear regression using SPSS was applied to determine the strongest predictors of Flow. The results indicate that Narrative, Challenges, and Mystery significantly influence Flow (Sig < 0.05), while other factors show no substantial effect. Narrative elements such as themed skins and crossover events enhance emotional involvement, Challenges improve immersion through balanced difficulty, and Mystery strengthens curiosity through hidden rewards and unpredictable events. Gender-based analysis showed no significant difference in Flow, suggesting immersion is consistent across genders. These findings reinforce Flow Theory and highlight key game design aspects essential for sustaining engagement in competitive mobile gaming.**

***Index Terms*—flow experience; game design Factors; free fire max; narrative; challenges; mystery**

I. INTRODUCTION

In recent years, the global mobile gaming industry has experienced significant growth, driven by rapid technological advancements, affordable smartphones, and increasingly accessible internet connectivity. This expansion has encouraged the emergence of various game genres that compete to capture and retain player attention [1]. Recent studies highlight that game engagement is increasingly shaped by design-driven immersion and reward structures that strengthen psychological ownership and sustained motivation [2], [3]. Among these, the Battle Royale genre has become one of the most dominant due to its competitive mechanics, social interaction, and immersive design elements. Free Fire MAX one of the leading titles in this genre has attracted more than 100 million monthly active users, particularly in Southeast Asia [4]. Its popularity is not solely driven by technical optimization but also by carefully structured game design elements that enhance player involvement and long-term engagement [5].

In mobile games, both narrative immersion and adaptive challenge systems have been identified as key determinants of sustained player involvement. Empirical evidence shows that perceived challenge significantly correlates with narrative immersion, enhancing player engagement [6], while unpredictable gameplay events and uncertain successes significantly enhance psychological investment and enjoyment, supporting sustained engagement [7]. Recent findings further emphasize that modern mobile game engagement is also shaped by design elements such as achievability and immersibility, which increase satisfaction, involvement, and continued usage intention among players [8]. Complementary meta-analytic evidence also demonstrates that content structure, interface clarity, and mechanical balance substantially influence enjoyment and behavioral outcomes across game genres [9]. Additionally, qualitative investigations involving professional game designers emphasize that maintaining equilibrium among narrative, mechanical systems, and player flexibility is essential for supporting adaptability and long-term game sustainability [10].

Despite its strong market presence, player engagement in Battle Royale games remains unstable and tends to fluctuate over time. Prior studies indicate that player motivation and flow are strongly influenced by design elements such as challenge balance, goal clarity, narrative depth, and interactive features [11].

However, most empirical research focuses on MOBA and RPG games, resulting in a research gap regarding how game design factors operate within Battle Royale environments [12]. Previous studies on titles like DOTA 2 and Valorant demonstrate that synergy between game mechanics, social interaction, and narrative is essential for sustaining engagement [5], [13]. Yet, systematic analysis of these factors in the context of Free Fire MAX remains limited.

To address this gap, this study aims to analyze the influence of Game Design Factors (GDF) on the Flow Experience of Free Fire MAX players using a quantitative approach. This research examines eleven design factors game goals, mechanics, interaction, freedom, fantasy, narrative, sensation, value, challenge, sociality, and mystery based on Shi and Shih's (2015) framework [14].

The population of this study consists of active Free Fire MAX players in Indonesia aged 13–25 years. A total population estimate of approximately 2–3 million potential players was identified based on regional user statistics, and 284 valid responses were collected through an online survey. After data cleaning, 175 samples were retained for quantitative analysis using SPSS, including validity, reliability, regression, and classical assumption tests.

Based on this background, the study addresses the following research question which Game Design Factors significantly influence the Flow Experience of Free Fire MAX players?. The findings of this study are expected to provide insights for developers seeking to optimize game design elements and strengthen long-term player engagement in competitive mobile gaming environments.

II. LITERATURE REVIEW

A. *Flow Experience Theory*

The concept of Flow Experience was first introduced by Mihaly Csikszentmihalyi (1990), describing a mental state in which individuals are fully absorbed and deeply engaged in an activity. In the context of gaming, flow refers to the immersive experience where players lose track of time and external distractions while focusing entirely on the game [11]. This optimal state occurs when the challenge of the game is well balanced with the player's skills, producing feelings of enjoyment, control, and intrinsic motivation.

Flow in digital games is characterized by several psychological dimensions, including deep concentration, a strong sense of control, enjoyment, reduced self awareness, and distorted perception of time. When these elements align, players enter a state commonly described as "being in the zone," where gameplay feels seamless, rewarding, and intrinsically motivating [11]. In highly competitive environments such as Battle Royale games, sustaining flow becomes essential for retaining players, as those who frequently experience this state tend to play longer and demonstrate higher loyalty toward the game. This highlights the importance of game design factors that maintain equilibrium between challenge and skill, ensuring that players remain engaged without feeling either overwhelmed or bored.

In this study, flow serves as the dependent variable, representing the level of engagement and satisfaction experienced by players during gameplay in Free Fire MAX. By quantifying flow, researchers can evaluate how effectively different game design factors contribute to immersive, enjoyable, and continuous play experiences.

Previous research has shown that flow experience can have both positive and negative implications in gaming contexts. On one hand, strong flow enhances game acceptance, concentration, and learning outcomes, particularly in educational or serious gaming environments [15], [16]. On the other hand, several studies suggest that intensified flow may increase the likelihood of problematic gaming behaviors, particularly within massively multiplayer online (MMO) genres [17]. Flow has been identified as a potential predictor of online gaming addiction, as persistent immersion may lead to compulsive play that becomes difficult to control [18], [19]. Thus, while flow is a desirable design outcome, maintaining a balance that encourages engagement without fostering harmful dependency is crucial especially in fast paced and reward driven games like Battle Royale.

Recent findings also suggest that escapism can function as a psychological pathway that strengthens flow-related experiences, particularly when immersive feedback systems and challenge structures effectively align with intrinsic player motivations. Empirical evidence shows that escapism not only enhances moment-to-moment enjoyment but also increases prolonged game use by reinforcing emotional immersion and perceived competence, thereby amplifying the conditions under which flow is most likely to occur [20]

B. *Game Design Factors (GDF)*

The Game Design Factors framework proposed by Shi and Shih (2015) identifies eleven key elements influencing player engagement and flow in digital games: Game Goals, Game Mechanism, Interaction, Freedom, Fantasy, Narrative, Sensation, Game Value, Challenges, Sociality, and Mystery. Each factor contributes uniquely to shaping the overall gaming experience.

- Game Goals define the objectives players aim to achieve. Clear and rewarding goals sustain motivation and provide direction.

- Game Mechanism refers to the structural rules, balance, and feedback system that govern gameplay.
- Interaction encompasses both player game and player-player communication that enhances social immersion.
- Freedom gives players autonomy to explore, customize, and make meaningful decisions.
- Fantasy provides escapism through imaginative settings and character design.
- Narrative delivers storylines and lore that emotionally connect players to the game world.
- Sensation emphasizes visual, auditory, and tactile stimuli that create excitement and realism.
- Game Value reflects perceived rewards, achievements, and satisfaction gained from playing.
- Challenges test the player's skill and persistence through progressively difficult tasks.
- Sociality involves cooperative or competitive play, fostering community engagement.
- Mystery introduces uncertainty, hidden features, or unpredictable events that maintain curiosity and anticipation.

Shi and Shih (2015) argued that a balance among these factors enhances player immersion and facilitates the emergence of flow. In the case of Battle Royale games, elements like Challenges, Sociality, and Mystery play a dominant role due to their competitive and unpredictable nature.

Prior studies have confirmed that well integrated game design factors significantly improve player engagement and retention [5]. Recent grounded-theory research on mobile game behavior further supports this view, demonstrating that multiple design features particularly challenge structures, reward systems, and narrative depth directly shape user behavior, motivational patterns, and sustained interaction within mobile gaming ecosystems [21].

III. Results and Discussion

A. Method

This study employed a quantitative research design using an online survey model to examine the influence of Game Design Factors on the Flow Experience of Free Fire MAX players. The survey instrument was adapted from the Game Design Factors (GDF) framework [17], consisting of 35 indicators distributed across eleven dimensions: Game Goals, Game Mechanism, Interaction, Freedom, Game Fantasy, Narrative, Sensation, Game Value, Challenges, Sociality, and Mystery. All items were measured using a five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." By adopting the GDF framework, this study systematically evaluates how each design component contributes to the emergence of Flow during gameplay.

The population of this study comprised active Free Fire MAX players in Indonesia aged 13–25 years. Based on regional usage statistics, the estimated player population ranges from 2 to 3 million individuals. A total of 284 valid responses were collected through online distribution via social media platforms. After data cleaning procedures, 175 responses were retained for statistical analysis to ensure data quality, remove outliers, and eliminate incomplete entries.

Data collection was conducted using a self-administered questionnaire delivered through Google Forms. The analysis procedures included: (1) validity testing using Pearson's product–moment correlation, (2) reliability testing using Cronbach's Alpha, and (3) classical assumption tests consisting of normality (Kolmogorov–Smirnov), multicollinearity (VIF and Tolerance), and heteroscedasticity (Glejser). Multiple linear regression was then applied to determine the significant predictors of Flow Experience. All statistical computations were performed using IBM SPSS Statistics.

B. Instrument Validity Test

Table 1 presents the results of the instrument validity and reliability testing for all constructs used in this study. Validity was assessed using Pearson's product–moment correlation by comparing the computed r-value of each indicator with the critical r-value of 0.148 (N = 175, $\alpha = 0.05$). The results show that all indicators exceeded the critical threshold ($r > 0.148$), indicating that each item is valid and suitable for further analysis.

TABLE I. Validity Test

Variables	Indicator	Pearson's r value	Critical R Value	C. Alpha
Game Goals	G1	0.596	0.148	0.749
	G2	0.535	0.148	
	G3	0.600	0.148	
Game Mechanism	G4	0.541	0.148	0.706
	G5	0.489	0.148	
	G6	0.543	0.148	
Interaction	G7	0.601	0.148	0.716
	G8	0.464	0.148	
	G9	0.550	0.148	
Freedom	G10	0.534	0.148	0.725
	G11	0.539	0.148	
	G12	0.575	0.148	
Gama Fantasy	G13	0.480	0.148	0.616
	G14	0.446	0.148	
	G15*	0.405	0.148	
Narrative	G16	0.664	0.148	0.776
	G17	0.608	0.148	
	G18	0.567	0.148	
Sensation	G19	0.492	0.148	0.739
	G20	0.533	0.148	

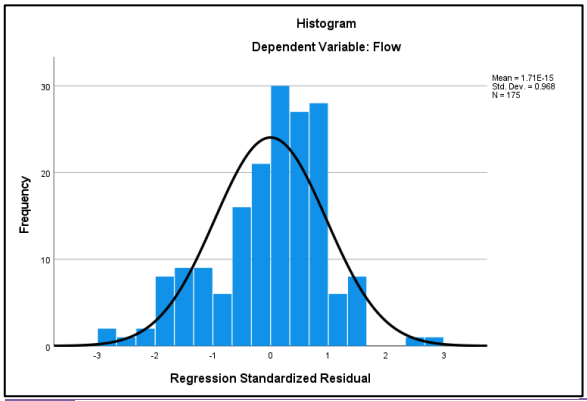
Variables	Indicator	Pearson's r value	Critical R Value	C. Alpha
	G21	0.679	0.148	
Game Value	G22	0.459	0.148	0.628
	G23	0.459	0.148	
Challenges	G24	0.503	0.148	0.667
	G25	0.377	0.148	
	G26	0.581	0.148	
Sociality	G27	0.552	0.148	0.718
	G28	0.490	0.148	
	G29	0.571	0.148	
Mystery	G30	0.433	0.148	0.604
	G31	0.433	0.148	
Flow	G32	0.488	0.148	0.796
	G33	0.650	0.148	
	G34	0.691	0.148	
	G35	0.619	0.148	

Furthermore, reliability was evaluated using Cronbach's Alpha for each variable. All constructs demonstrated acceptable internal consistency, with Cronbach's Alpha values ranging from 0.604 to 0.796, exceeding the minimum reliability criterion of 0.60. The Flow construct achieved the highest reliability (α = 0.796), followed by Narrative (α = 0.776) and Game Goals (α = 0.749), indicating strong measurement stability in these variables. Meanwhile, the lowest but still acceptable reliability was observed in the Mystery construct (α = 0.604), which remains within the acceptable threshold for exploratory studies.

Overall, the results confirm that all indicators in the Game Design Factors (GDF) and Flow Experience constructs are both valid and reliable, demonstrating strong psychometric quality and supporting their use in subsequent regression and classical assumption analyses.

C. Classical Assumption Test

To ensure that the multiple regression model meets the classical assumptions, a normality test was conducted on the standardized residuals derived from the Flow variable. The assessment utilized both graphical and statistical approaches. Fig. 1 presents the histogram of the regression standardized residuals, which illustrates a bell-shaped distribution with a mean close to zero and a standard deviation near one, indicating that the residuals are symmetrically distributed. Furthermore, Fig. 2 shows the Normal P–P Plot, where the plotted points closely follow the diagonal reference line without notable deviations or clustering patterns. This alignment demonstrates that the observed cumulative probabilities are consistent with those of a normal distribution.



In addition to graphical evaluation, the Kolmogorov–Smirnov test was conducted to provide statistical confirmation. The resulting significance value exceeded 0.05, indicating that the null hypothesis of normally distributed residuals cannot be rejected. Taken together, the graphical patterns and statistical results affirm that the regression residuals satisfy the normality assumption, allowing the subsequent regression analysis to be performed reliably.

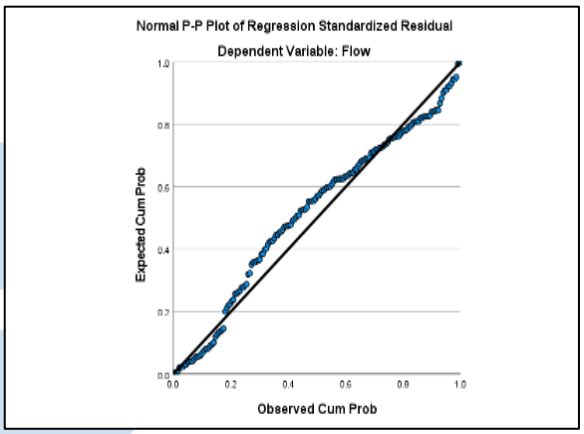


Fig 1. Normal P–P Plot of Standardized Regression Residuals

D. Descriptive Statistics

The descriptive analysis in Table 1 illustrates that all eleven Game Design Factors received relatively high mean values, ranging between 3.89 and 4.19 on a 5 point Likert scale. This indicates that players generally perceived the design elements of Free Fire MAX positively. Among these factors, Game Goals (M = 4.19, SD = 0.75), Challenges (M = 4.16, SD = 0.74), and Sociality (M = 4.18, SD = 0.71) recorded the highest mean scores, suggesting a consistent perception among players regarding the clarity of objectives, competitive engagement, and community interaction. The relatively low standard deviations (< 0.8) for most factors demonstrate that player responses were stable and homogeneous, implying agreement in how these elements were experienced.

Conversely, Narrative (M = 3.94, SD = 0.90) and Mystery (M = 4.03, SD = 0.89) exhibited slightly higher standard deviations, indicating greater variability in how players experienced these elements. This variability may stem from differences in players' interpretations of the game's storyline or exposure to limited time events and hidden features. Interestingly, despite the moderate means and higher dispersion, these two variables along with Challenges were found to significantly affect the Flow Experience in regression analysis. This suggests that elements capable of

evoking emotional, cognitive, and exploratory engagement tend to be more influential in sustaining Flow, even when perceptions vary among players. Although Game Goals and Sociality were rated highly by players, their lack of statistical significance suggests that perceived importance does not necessarily translate into deeper immersive flow.

These consistent mean values and stable deviations validate the reliability of the dataset, ensuring that the subsequent regression analysis reflects genuine player perceptions rather than random variability.

TABLE II. Descriptive Statistics.

Variable	Descriptive Statistics	
	Mean	*Std. Deviation*
GameGoals	4.1924	0.74908
GameMechanism	4.1600	0.76049
Interaction	4.1048	0.78691
Freedom	4.0838	0.83005
GameFantasy	3.8952	0.83647
Narrative	3.9448	0.90203
Sensation	4.0095	0.87204
GameValue	4.1514	0.83644
Challenges	4.1638	0.74095
Sociality	4.1829	0.71176
Mystery	4.0286	0.89333
Flow	3.7600	0.95380

E. Regression Analysis

TABLE III. Model Summary

Model Summary[b]			
R	*R Squere*	*Adjusted R Square*	*Std. Error of The Estimate*
0.788[a]	0.622	0.596	0.60610

a. Predictors: (Constant), Mystery, GamaFantasy, Narrative, GameGoals, Sensation, Freedom, Interaction, Sociality, Challenges, GameValue, GameMechanism
b. Dependent Variable: Flow

To identify which factors significantly affect the Flow Experience, a multiple linear regression test was conducted with Flow as the dependent variable and eleven GDFs as independent variables. The model produced an R^2 value of 0.622, indicating that 62.2% of the variance in Flow can be explained by the combined influence of the game design factors. This indicates a moderately strong explanatory power, suggesting that while GDFs explain a substantial portion of flow variance, other psychological or contextual factors may also contribute.

TABLE IV. Coefficients

Coefficients[a]				
Model	*Standardized coefficients Beta*	*Sig.*	*Tolerance*	*VIF*
(Constant)		0.554		
GameGoals	0.014	0.890	0.240	4.175
Game Mechanism	- 0.056	0.598	0.205	4.885
Interaction	0.141	0.140	0.257	3.894
Freedom	0.060	0.528	0.260	3.843
GameFantasy	- 0.128	0.061	0.499	2.003
Narrative	0.311	< 0.001	0.343	2.913
Sensation	0.096	0.262	0.320	3.126
GameValue	0.113	0.262	0.231	4.320
Challenges	0.341	< 0.001	0.231	4.333
sociality	- 0.180	0.053	0.272	3.675
Mystery	0.156	0.045	0.390	2.565

a. Dependent Variable: Flow

The regression results revealed that Narrative (Sig = 0.001), Challenges (Sig = 0.001), and Mystery (Sig = 0.045) had significant positive effects on Flow (Sig < 0.05). This finding indicates that the storyline, difficulty level, and hidden or unpredictable elements within the game play crucial roles in enhancing players' immersion and enjoyment. In particular, the Narrative aspect in Free Fire MAX is not limited to traditional storytelling but is creatively expressed through thematic collaborations, limited edition skins, and character based events. These collaborations often involving well known brands, anime series, or pop culture icons allow players to engage emotionally with the game world while expressing individuality through visual customization. As a Battle Royale game, Free Fire MAX integrates narrative elements dynamically within its seasonal content, transforming each event into part of a larger story arc that sustains player curiosity and attachment. This approach strengthens players' sense of identity and belonging in the game ecosystem, contributing significantly to the creation of a sustained Flow experience.

Among the significant variables, Challenges had the highest standardized beta coefficient ($\beta = 0.341$), indicating that the sense of challenge is the most dominant predictor of Flow among Free Fire MAX players.

F. Gender Based Flow Experience Analysis

This analysis was conducted to examine whether there were significant differences in the level of flow experience between male and female players in Free Fire MAX. Prior to the comparison of mean differences, a homogeneity of variance test was performed using Levene's Test to ensure that the data

variances between groups were homogeneous, thereby validating the assumptions required for the Independent Samples t-Test.

TABLE V. Independent Samples Test

Independent Samples Test				
	F	***Sig.***	***t***	***Sig. (2-tailed)***
Equal variances assumed	1.996	0.160	- 0.189	0.850

The results of Levene's Test for Equality of Variances indicated a significance value of 0.160 (> 0.05), confirming that the variances between male and female groups were homogeneous. This finding implies that the distribution of flow scores between the two gender groups was relatively even, suggesting that both male and female players exhibited similar variability in their engagement levels during gameplay.

Following this, the Independent Samples t-Test revealed a Sig. (2-tailed) value of 0.850 (> 0.05), indicating that there was no significant difference in the mean flow experience between male and female players. In other words, both genders demonstrated comparable levels of psychological immersion and engagement while playing the Battle Royale game Free Fire MAX.

These results align with previous studies suggesting that gender does not necessarily determine the degree of flow experience in gameplay. Instead, player engagement is more strongly influenced by game design factors particularly narrative depth, challenge balance, and elements of mystery that shape players' emotional and cognitive involvement during play.

G. Discussion

The findings confirm that Narrative, Challenges, and Mystery are key determinants of Flow Experience in mobile battle royale games. The results of the regression analysis show that the Narrative factor has a significant influence on players' Flow Experience (Sig < 0.05), indicating that the narrative dimension directly contributes to the level of psychological immersion while playing Free Fire MAX. Mechanistically, a strong narrative helps create emotional immersion by facilitating deep focus, a sense of connectedness, and player identification with the game world elements that align with the concentration and loss of self-consciousness aspects of Flow Theory. This finding is supported by Shi and Shih (2015), who asserted that narrative design can expand the game's context through symbolic, visual, and thematic experiences that influence player perception and motivation.

In the context of Free Fire MAX, narrative aspects emerge not only through the storyline or characters but also through thematic collaborations, limited-edition skins, and cross-franchise events. Collaborations such as with anime, artists, or global franchises function as narrative extensions, extending the story by connecting the game world to popular culture trends. This integration transforms cosmetic elements into storytelling devices that strengthen player identity, build emotional engagement, and create story continuity from one event to the next. This mechanism explains why narrative has a significant impact on Flow: players who feel symbolically "connected" tend to focus better, enjoy the game longer, and more easily enter a state of deep immersion.

In terms of implications, these results indicate that developers need to maintain and expand their narrative-driven content approach, particularly through collaborative events, themed battle passes, and consistent lore development. This approach has proven effective not only in improving Flow Experience, but also in extending the player engagement cycle in the highly competitive Battle Royale genre.

Regression results show that Challenges have a significant influence on players' Flow Experience (Sig < 0.05), confirming the crucial role of the balance between difficulty level and player ability in creating optimal engagement. From a Flow Theory perspective, a challenge-skill balance is a fundamental element that enables players to achieve a state of deep focus, increase persistence, and minimize frustration or boredom. When challenges align with individual abilities, players are more likely to experience a sustained sense of accomplishment and a clear goal orientation.

In Free Fire MAX, this balance is realized through various design systems. Ranked mode utilizes a skill-based matchmaking mechanism, ensuring players are continually faced with relevant challenges. Furthermore, dynamic arena conditions such as randomly changing safe zones, varying loot locations, and competitive pressure from other players create a game environment that demands constant adaptation. This aspect enhances strategic engagement and supports the development of a sustained Flow experience.

Elements of surprise, such as hidden missions, limited-rotation modes, and limited-time events, contribute to strengthening intrinsic motivation by adding a sense of novelty and anticipation of rewards. This aligns with progression design theory, which emphasizes that games need to demonstrate clear forms of achievement and make the journey towards those achievements feel meaningful [22]. The alignment between measurable challenges and a valuable progression system ensures players feel a real sense of progress, thus maintaining long-term engagement in the competitive Battle Royale ecosystem.

The results of this study indicate that Mystery has a significant influence on players' Flow Experience, indicating that curiosity and the desire to explore new

content are powerful motivational drivers in Battle Royale environments. In the context of game design, the construct of Mystery refers not simply to secrets or surprises, but encompasses various mechanisms that create structured unpredictability. This uncertainty fuels exploration, increases focus, and maintains player engagement as they are encouraged to continually seek out new information, unexpected rewards, or undiscovered plot developments.

In Free Fire MAX, Mystery is embodied through secret missions, unannounced collaboration events, hidden clues in teasers, and layered rewards that can only be discovered through active exploration. These elements create curiosity and stimulate exploratory behavior, encouraging players to engage with the game for longer. These findings align with recent research showing that level design patterns that encourage curiosity-driven exploration significantly increase player engagement and search behavior [23]. Furthermore, follow-up studies confirm that managed uncertainty acts as a motivational force that maintains long-term engagement, as players are continually driven to discover the next surprise [24].

Within the Flow Theory framework, elements of surprise and discovery increase selective attention and enhance enjoyment, encouraging players to remain in a state of optimal engagement [4]. The findings of this study demonstrate that an immersive narrative, balanced challenges, and mystery-driven exploratory elements form a critical combination for maintaining the Flow experience in modern Battle Royale games like Free Fire MAX. These results reinforce the validity of Shi and Shih's (2015) Game Design Factors framework, confirming that the alignment of emotional storytelling, adaptive challenge structures, and curiosity-oriented mechanics is essential to sustaining deep player immersion.

Furthermore, recent research in educational and esports contexts strengthens this conclusion by showing that well-designed game mechanics and narrative elements not only enhance engagement but also support higher-order cognitive involvement, strategic thinking, and skill development among players [25]. This suggests that the design principles effective in competitive mobile games parallel those observed in structured learning and esports environments, underscoring the broader cognitive and motivational impact of integrated narrative, challenge, and discovery-based game design.

IV. CONCLUSION

This study examined the influence of Game Design Factors (GDF) on the Flow Experience of players in the mobile Battle Royale game Free Fire MAX. The findings indicate that three factors Narrative, Challenges, and Mystery significantly contribute to the emergence of Flow, whereas Game Goals, Mechanics, Interaction, Freedom, Fantasy, Sensation, Value, and Sociality do not exhibit a meaningful effect. Narrative elements were found to enhance emotional involvement through collaboration-based thematic events, while Challenges supported Flow by maintaining an optimal alignment between player skills and task difficulty. The Mystery factor further strengthened engagement by encouraging exploration through hidden content and unpredictable in-game events. Additionally, the analysis revealed no significant gender-based differences in Flow, suggesting that immersive engagement is shaped primarily by design quality rather than demographic attributes. These findings reinforce Csikszentmihalyi's Flow Theory and align with Shi and Shih's (2015) GDF framework, emphasizing the importance of emotionally resonant storytelling, well-balanced progression systems, and curiosity-driven exploratory mechanics in sustaining long-term immersion.

Despite generating meaningful insights, the present study is subject to several limitations. First, the sample size, although adequate for statistical analysis, represents only a small fraction of the broader Free Fire MAX player base and may not fully capture the diversity of player experiences across Indonesia. Second, the data rely entirely on self-reported responses, which are susceptible to recall bias, social desirability bias, and subjective interpretation. Third, the study focuses solely on one Battle Royale game title, limiting the generalizability of results across different game genres or competitive environments. Fourth, the cross-sectional design restricts the ability to infer causal relationships between GDF and Flow. Additionally, the study did not incorporate behavioral or telemetry data, which may offer richer insights into actual gameplay patterns.

Future research may address these limitations by employing larger and more heterogeneous samples, integrating multi-method approaches such as in-game behavioral analytics, physiological measures, or experimental designs. Comparative studies across multiple Battle Royale titles or cross-genre analyses may further validate the robustness of the findings. Moreover, longitudinal research could explore how Flow evolves over time in response to game updates, seasonal events, or changes in competitive meta. Future studies may also investigate the mediating or moderating roles of psychological constructs such as escapism, emotional regulation, or personality traits to provide a more comprehensive understanding of Flow formation within modern mobile gaming ecosystems.

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Raaiqa Bintana providing expert guidance, supervision, writing review either in conception or writing processes.

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Utilizing a Data Warehouse to Analyze the Effects of Sales Type, Product Type, and Price on Net Profit in an F&B Outlet

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Abstract— The food and beverage (F&B) industry continues to expand amid increasing competition, making profitability analysis essential for effective decision-making. This study analyzes the effect of sales type, product type, and product price on net profit in an F&B outlet by utilizing a Data Warehouse to integrate and structure daily transaction data. The Extract, Transform, and Load (ETL) process ensure consistency and prepares the data for analysis, while multiple linear regression was used to evaluate the contribution of each variable. The results show that product price and sales type have a significant positive effect on net profit, indicating that higher prices and dine-in transactions generate greater profitability. Product type displays varied effects, with certain categories increasing net profit while others reduce it due to differences in demand patterns and cost structure. The regression model achieved an R^2 of 0.994, demonstrating strong explanatory power. Overall, the findings highlight the value of Data Warehouse based processing in improving financial analysis and supporting more accurate managerial decision-making in F&B outlet.

***Index Terms*— Data Warehouse; Sales Type; Product Type; Product Price; Net Profit**

I. INTRODUCTION

The food and beverage (F&B) sector is still expanding against a backdrop of severe competition [1]. Growth is stimulated by changing customer purchasing behavior, more businesses entering the market, and an expanding number of products on offer. Net income is also the primary indicator to evaluate how well existing business strategies or need to change them [2]. In the context of F&B outlet, the object of this research, analysis of sales type, product type, and price is crucial to determine the contribution of each aspect to net profit.

As daily transaction volumes at outlet increase, a system is needed that can manage operational data and transform it into useful business information for decision-making. In this regard, a Data Warehouse plays a crucial role. A Data Warehouse is a system that integrates data from various sources into a structured repository, supporting more effective business analysis and decision-making [3]. With a Data Warehouse, outlet management can monitor sales performance based on transaction mode, assess the contribution of each product type, and evaluate the impact of pricing policies on profits.

While numerous studies have been conducted on Data Warehousing and sales, most still discuss them separately. Data Warehousing research generally focuses on data integration and report generation but has not yet used the integration results to assess financial performance, such as net profit [3]–[5]. Furthermore, research on sales types is predominantly focused on digital sales [6], [7]. In contrast, research on product types and prices tends not to be linked to Data Warehouse utilisation or its impact on net profit [8], [9]. Therefore, research integrating analyses of sales types, product types, and prices within a Data Warehouse framework to evaluate their impact on net profit for F&B outlet remains limited.

Given that this topic has not been widely explored in previous research, this study aims to understand how sales types, product types, and prices affect net profit at a single F&B outlet. This study also evaluates how Data Warehouse utilisation can help process and present sales data in a structured manner, resulting in

clearer, more understandable analysis. Through this approach, the research is expected to provide business managers with deeper insights into the key factors influencing F&B outlet net profit.

II. LITERATURE STUDY

A. *THEORETICAL FRAMEWORK*

A Data Warehouse (DW) is an integrated data storage system that consolidates historical data from various sources and transforms it into meaningful information for business analysis [10]. Its presence permits business data regarding operations and transactions to gain more consistency, structure, and readiness when undertaking strategic assessments [3], which is aided by the Extract, Transform, and Load (ETL) method that guarantees data is cleansed and set up for analytical reporting [4]. In the F&B context, sales type refers to the transaction mode, such as dine-in, takeaway, or online ordering, and multichannel strategies have been shown to increase customer convenience, expand market reach, and improve revenue performance [6], [7], [12]. Product type categorising involves organising items based on shared features, which enables businesses to manage their products effectively, fine-tune their marketing approaches, and streamline the buying process for customers [8], [9]. Simultaneously, the pricing strategy has a direct impact on how much money is made per sales and the profit margin; raising prices can lead to higher earnings if the level of customer demand stays the same [13]. Net profit, which represents the earnings left over once all expenses, both those related to operations and those not, are subtracted [14], [15], is shaped by the mix of products offered, how prices are set. The methods used to sell, the type of sales, the product category, and the product's cost are key factors in judging how profitable food and drink businesses are.

B. *Research Hypothesis*

Based on the theoretical foundation and previous studies, the research hypotheses are formulated as follows:

a) H1: Sales type has a positive effect on the net profit of F&B outlet.
b) H2: Product type has a significant effect on the net profit of F&B outlet.
c) H3: Product price has a positive effect on the net profit of F&B outlet.
d) H4: Sales type, product type, and price simultaneously have a significant effect on the net profit of F&B outlet.

C. *Previous Research*

Although previous studies have examined Data Warehousing and ETL processes to improve data integration and reporting [3], [4], [5], these works do not extend their analyses to evaluate financial performance indicators such as net profit. Studies on sales type also tend to focus on online platforms and multichannel e-commerce environments [6], [7], which makes them less applicable to the operational characteristics of F&B outlet that rely on dine-in and takeaway transactions. Research related to product type and pricing strategies likewise treats these variables independently [8], [9], without integrating them into a single analytical model. Consequently, previous investigations have not concurrently assessed sales category, merchandise category, and merchandise cost utilising a Data Warehouse structure to ascertain their collective influence on total earnings, thus highlighting a distinct area of investigation explored in the current research.

III. METHODOLOGIES

A. *Research Type and Approach*

This research is quantitative in its explanatory approach, using multiple linear regression to establish associations between the variables and objectively consider independent variable effects on net profit. Research data obtained from transaction data on daily F&B outlet sales from October 1, 2024 to September 30, 2025. A total of 6.920 transaction records and stored in a Data Warehouse (DW) system for the sake of consistency of information and ease of analysis [11].

B. *Research Stages*

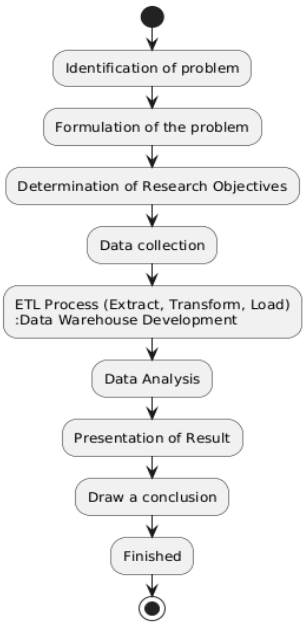

Fig 1. Research Stages

This study followed a structured research process comprising problem identification, objective formulation, data collection, ETL processing, Data Warehouse construction, data analysis, and conclusion drawing. Transaction data were extracted, cleansed, transformed, and loaded into a Data Warehouse to support regression analysis. The analytical stage included descriptive statistics, classical assumption testing, and hypothesis testing through multiple linear regression. The final stage summarised key empirical findings and interpreted whether sales type, product type, and price significantly influence net profit, highlighting insights valuable for data analysis and business decision-making.

C. Data Collection Sources and Techniques

The data for the study were collected from a daily transaction report F&B outlet sales types (dine-in and takeaway), product types (add-ons, coffee, matcha, dessert and main course), selling price, unit sold and margins. This data was then subjected to ETL in order to construct a Data Warehouse which contains data [16].

D. ETL Process and Data Warehouse Development

The development of Data Warehouse is done by ETL (Extract, Transform and Load) process to make sure that the transactions data are fully and reliably integrated. The ETL used contains below:

1. Extract (Data Extraction) step. Transaction data is provided in the form of daily screenshots from outlet: Excel reports that detail sales date, sales type, product type, price per unit, number of units sold and margin.

2. Transform (Data Transformation). It then performs normalisation of collected data and does the necessary tuning based on analysis requirements such as date, type of product, type of sales, selling price, number sold, sales value, COGS, and profit. The COGS reported in this study is derived from average cost data during the observation period. The dependent (net profit) is calculated as sales − COGS, serving as the net profit proxy (estimated revenue or gross margin) of the F&B outlet.

3. Load (Data Loading). Transformed data is subsequently inserted into the Data Warehouse in accordance with a star schema model with Fact_Sales, Dim_Product, Dim_Mode, and Dim_Date tables. This model facilitates multidimensional analysis of the impact of independent variables on net profit.

E. Research Variables

This study uses two variables: dependent and independent variables. Net profit is the dependent variable (Y), while sales type (X_1), product type (X_2), and price (X_3) are independent variables that influence it.

1. Dependent Variable (Y)
   Net profit, as the dependent variable, is used to measure the profit per transaction [15].

2. Independent Variable (X)

- X_1 (Sales Type): Includes dine-in and takeaway transaction methods to assess differences in sales characteristics and their impact on net profit.
- X_2 (Product Type): Includes add-on groups, coffee, matcha, desserts, and main courses.
- X_3 (Product Price): Indicates the product's selling price, which influences purchasing decisions and revenue generation [15].

F. Data Analysis Techniques

Data were analyzed to investigate the impact of sales type, product type and price on net profit at F&B outlet. The analysis consisted of descriptive, classical assumptions tests, and multiple linear regression with OLS. If heteroscedasticity existed, the robust standard error test (HC3) was applied to check the significance of the coefficient. Additionally, the hypotheses were tested by t-test, F-test, and R^2 (coefficient of determination).

1. Descriptive Analysis

Sum, mean, standard deviation, minimum and maximum were computed of price variables and net profit proxies. Categorical variables (product type and sales type) were given numerical codes in regression sessions, and described as counts in the exploratory data overview.

2. Classical Assumption Test

Classical assumptions are tested to confirm that the regression model meets statistical requirement for valid analysis [17]. A normality test measures the distribution of residuals, a multicollinearity test evaluates for collinearity between independent variables and homoscedasticity tests identify heteroskedasticity in the residuals. Moreover, the autocorrelation test shows that there is no residual correlation among observations themselves.

3. Multiple Linear Regression Analysis

Multiple linear regression analysis was employed to test simultaneously and partially of the influence of sales type (X_1), product type (X_2) and price (X_3) on net profit (Y) [18]. The regression model applied is presented as:

$$Y = \beta 0 + \beta 1\ X1 + \beta 2\ X2 + \beta 3\ X3 + \varepsilon$$

Where:
Y = Net Profit
β_0 = Constant
β_1, β_2, β_3 = Regression Coefficients
X_1 = Sales Type
X_2 = Product Type
X_3 = Price
ε = Error Factor

We used the Ordinary Least Squares (OLS) method to estimate the parameters. But heteroscedasticity may make the standard error of regular OLS wrong, which makes the t-test and F-test less accurate [19]. Therefore, if heteroscedasticity is detected, the analysis is supplemented with robust standard errors.

4. Robust Standard Error (HC3)

Suppose the heteroscedasticity test indicates that the residual variance is not constant. In that case, the OLS estimates are supplemented with robust standard errors. The variant used in this study is HC3 because, according to [20], it produces more stable and accurate standard errors than HC0–HC2. Therefore, the coefficient values are still estimated using OLS, while the coefficient significance is based on the robust standard errors from HC3.

5. Hypothesis Testing and Coefficient of Determination

Hypothesis testing is applied to test whether independent variables either partially or simultaneously have effect on net income. b) T-test This test is to see the effect of each individual variable. On the other hand, the joint effect of all independent variables is examined using an F-test to determine whether they simultaneously influence net profit [21]. $p<0.05$ expressing its significance. R^2: R^2 explains the variance of net income in relation to the regression model. An R^2 value closer to 1 would indicate that the sales type, product type, and price are better in explaining variations in net profit on studied F&B outlet.

IV. Result and Discussion

A. *Descriptive Statistics*

TABLE 1. DESCRIPTIVE STATISTIC OF RESEARCH VARIABLES

Statistics	Product Type	Sales Type	Price (Rp)	Net Profit (Rp)
Count	6.920	6.920	6.920	6.920
Mean	3,42	1,78	35.509,83	21.815,02
Std. Dev.	1,09	0,42	10.398,68	7.243,07
Minimum	1	1	5.000	3.750
Maximum	5	2	75.000	52.500

As seen in Table 1, the average value of 3.42 for the Product Type argument means that most of transactions are coming from moderate and high influential-product categories, respectively. The huge standard deviation of 1.09 means there is a considerable variation among product categories. For the Sales Type variable, a value of 1.78 for Mean indicates that the second sales method like dine-in is more often used. The low standard deviation of 0.42 shows that sales tactics are fairly consistent.

Variable Price on the average price of the product is Rp35,509 with a range of prices from (Rp5.000 to Rp75.000). The high standard deviation (Rp10.398) indicates differences in price exist between categories. Meanwhile, the average of Net Profit variable is Rp 21,815 and has a distinct minimum and maximum values. The high standard deviation of Rp7,243 reflects wide diversity in the level of profit among transactions.

TABLE 2. FREQUENCY DISTRIBUTION AND PERCENTAGE OF THE SALES TYPE VARIABLE

Sales Type	Frequency	Percentage(%)
1	1547	22.36%
2	5373	77.64%

As seen in Table 2, the distribution of the Sales Type variable is largest at 77.64%, coming from the second sales category (dine-in). Conversely, the first category (takeaway) only accounts for around 22.36% of all transactions.

TABLE 3. FREQUENCY DISTRIBUTION AND PERCENTAGE OF THE PRODUCT TYPE VARIABLE

Product Type	Frequency	Percentage(%)
1	412	5.95%
2	543	7.85%
3	3167	45.77%
4	1326	19.16%
5	1472	21.27%

As seen in Table 3, the variable product type demonstrates relative diversity of the distribution. Among the product categories, product category 3 (Matcha) has been selected for maximum time around 45.77% by the consumers of Product. Categories 5 and 4, with up to 21.27% (Main Course) and 19.16% (Dessert). Category 1 (Add On) and category 2 (Coffee), on the other hand contribute very little to total sales.

B. Classical Assumption Tests

The diagnostic tests in this study are normality test, multicollinearity test, heteroskedasticity test, and autocorrelation test.

1. Normality Test

The normality test was tested using the Jarque–Bera test in this analysis. The test results are:

TABLE 4. NORMALITY TEST RESULT

Statistic	*p-value*
1342.3758	0.000

According to the Jarque–Bera test in Table 4, the model's residuals have a test statistic of 1342.3758 with p-value = 0.000. It means we reject the null hypothesis of normally distributed residuals. The Q–Q Plot additionally supports the above evidence.

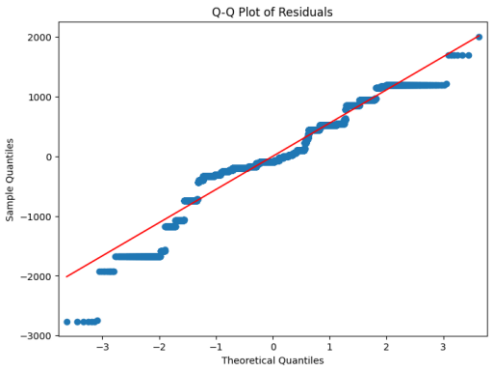

Fig 2. Q–Q Plot of Regression Residuals

Figure 2 shows the Q–Q Plot of the residuals generated from the multiple linear regression model. in performing regression analysis we use HC3 robust standard errors, which don't need normality of residuals for t-tests and F-test.

2. Multicollinearity

The Multicollinearity test was tested using the VIF (Variance Inflation Factor). The result presented in Table 5:

TABLE 5. MULTICOLLINEARITY TEST RESULTS WITH VARIANCE INFLATION FACTOR (VIF)

Variable	VIF
Price	21.712
Sales_Type_2	4.195
Product_Type_2	2.173
Product_Type_3	12.126
Product_Type_4	5.317
Product_Type_5	7.289

As seen in Table 5, several variables had quite high values. Particularly Price (21.71) and Product Type 3 (12.12) exhibited a high VIF. Other variables, Product Type 4 and Product Type 5, are in the moderate range (around 5–7), which is still acceptable. On the other hand, Sales Type 2 and Product Type 2 have low VIF values, so they do not pose a multicollinearity problem. Overall, despite several variables with high VIFs, the model remains usable.

3. Heteroskedasticity Test

In this analysis the Breusch-Pagan test was used to identify variance inconsistencies in this study. The results from the test were Breusch-Pagan=2384.4490 and F-statistic= 605.7219 with both having P-value of 0.0000. Since p-value is less than 0.05, it suggests that the model has heteroskedasticity.

In heteroscedasticity conditions like this, using the robust standard error (HC3) is an appropriate measure to measure bias in standard error estimates. This adjustment allows the t-test and F-test results to remain valid and reliable, allowing the regression model to provide more accurate and stable estimates.

4. Autocorrelation Test

The Durbin–Watson is used to assess autocorrelation in the regression residuals, The statistic obtained is 1.899, which is close to the ideal value of two and is within the acceptable range of 1.5 – 2.5. This indicates that the residuals are independent and the model is free from autocorrelation.

C. Result of Multiple Linear Regression Analysis

TABLE 6. MULTIPLE LINEAR ANALYSIS RESULTS

Variabel	Coef	Std. Error	z	p-value	CI 95% Lower	CI 95% Upper
const	815.6963	20.309	40.164	0.000	775.891	855.501
Price	0.6688	0.001	480.227	0.000	0.666	0.672
Sales_Type_2	22.4162	11.321	1.980	0.048	0.227	44.605
Product_Type_2	31.4707	30.215	1.042	0.298	-27.749	90.691
Product_Type_3	352.2875	39.382	8.945	0.000	275.100	429.475
Product_Type_4	-6756.7416	42.678	-158.319	0.000	-6840.389	-6673.094
Product_Type_5	-7693.9598	47.111	-163.314	0.000	-7786.296	-7601.623

Table 6 presents the result of multiple linear analysis used to identify the influence of each independent variable on Net Profit.

1. F-Test (Simultaneous Significance Test)

Based on the regression results using HC3 robust standard error in Table 6, the Prob(F-statistic) was 0.00. Since this value is below the 0.05 significance threshold, the null hypothesis (H0) is rejected and the alternative hypothesis (H4) is accepted, indicating that all independent variables collectively exert a significant effect on Net Profit in food and beverage (F&B) outlet.

2. Coefficient of Determination (R^2 and Adjusted R^2)

According to the estimation results, the R-squared statistic is 0.994 and the Adjusted R-squared is also 0.994. This means that the variables Sales Type, Product Type and Price explain 99.4% of the variation in Net Profit by the model.

3. t-Test (Partial Significance Test)

This t-Test is performed by contrasting the p-value of each regression coefficient with the 5% level of significance.

As seen in Table 6, Price variable has a 0.6688 coefficient with p-value = 0.000 this implies that Price has a significant effect in Net Profit. The positive value of the coefficient indicates that a unit rise in Price results as 0.6688 units growth in Net Profit, keeping all other variables unchanged. We also have the variable Sales_Type_2 (dine-in) which has a coef : 22.4162 and p-value 0.048 we can say that dine-in transaction has significant effect on Net Profit. Unlike the former factors, Product_Type_2 has a p-value of 0.298 significantly higher than the cut-off value and hence would have no impact on Net Profit. Meanwhile, Product_Type_3, Product_Type_4 and Product_Type_5 are shown to have strong effects in both univariate and multivariate models (p-value = 0.000 for all). Product_Type_3 has a positive coefficient value of 352.2875, meaning that this set has the potential to lift net profit relative to the base category. In contrast, large negative coefficients are derived for Product_Type_4 and Product_Type_5 (-6756.7416, -7693.9598).

In summary, the t-test results show that Price, Sales_Type_2, and Product_Type_3–5 significantly influence Net Profit, while Product_Type_2 does not.

D. Comparison of Research Results with Theory

Price, sales type, and product type were all found to influence net profit in this study. The effect of price is consistent with the literature, which states that higher selling prices can increase margins and lead to greater profits when cost conditions remain stable [13]. The differences across product types also align with the idea that each type has its own cost structure and demand level, resulting in varying profit contributions [12].

The impact of sales type, where dine-in produces higher net profit than takeaway, is also consistent with studies in the F&B field. Customer purchasing patterns and transaction behaviour often differ between sales modes, and these differences naturally affect the value of each transaction [23]. Overall, the findings support the existing theory that pricing, product mix and sales methods all play an essential role in shaping the profitability of F&B outlet.

E. Direction and Magnitude of Variable Influence

The regression results show that each independent variable impacts net profit in a different direction. Price has a positive and significant effect ($\beta = 0.6688$; $p < 0.001$), meaning that an increase in selling price leads to higher net profit. Sales type also has a significant effect, with dine-in transactions ($\beta = 22.4162$; $p = 0.048$) generating higher net profit than takeout transactions.

Product type exhibits varying impacts. Product Type_2 is insignificant, while Product Type_3 contributes positively to net profit ($\beta = 352.2875$; $p < 0.001$). Conversely, Product Type_4 and Product Type_5 reduce net profit ($\beta = –6756.7416$ and $\beta = –7693.9598$; $p < 0.001$), indicating lower profitability due to differences in cost structure and demand levels. Overall, only price and sales type showed a positive effect, while the impact of product type depended on margin characteristics and inherent cost structures.

F. Hypothesis Status (H1–H4)

The hypothesis testing in this work used robust regression findings (OLS–HC3). The evaluation was predicated on the coefficient size, the directional effect of each variable, and the p-value, supplemented by a concurrent test using the F-statistic.

1. Status H1 : Sales type has a positive effect on the net profit of F&B outlet

The estimation results show that Sales Type_2 (dine-in) has a positive coefficient of 22.4162 with a p-value of 0.048, indicating a significant effect on net profit. Therefore, H1 is accepted, and dine-in transactions generate higher net profit than takeaway.

2. Status H2: Product type has a significant effect on the net profit of F&B outlet.

The results show that Product Type_2 is not significant ($p = 0.298$), while Product Type_3, Product Type_4, and Product Type_5 are significant ($p = 0.000$). Because most categories show significance, H2 is accepted, indicating that product types contribute to variations in net profit.

3. Status H3: Product price has a positive effect on the net profit of F&B outlet.

H3 stated that price had a positive effect on net profit. The coefficient of 0.6688 with a p-value of 0.000 confirms a significant positive effect on net profit, therefore H3 was accepted. In other words, increasing prices was proven to increase net profit when other variables were held constant.

4. Status H4: Sales type, product type, and price simultaneously have a significant effect on the net profit of F&B outlet.

H4 stated that sales type, product type, and price simultaneously had a significant effect on net profit. The Prob(F-statistic) value of 0.00 indicates that these three variables collectively have a significant effect on net profit. Therefore, H4 is accepted.

V. CONCLUSION

After seeing the results of the processed data, this study concludes that Sales Type, Product Type and Price can be identified as significant factors affecting the Net Profit of F&B outlet on every increase of Rp. 1 related to an increase in net profit of around 0.6688 ($p < 0.001$), Sales Type 2 (dine-in) provides a higher net profit than its comparison category ($\beta = 22.4162$; $p = 0.048$), and Product Type 3 (matcha) increases net profit by 352.2875 ($p < 0.001$) while 4 and 5 decrease net profit by -6756.7416 and -7693.9598 ($p < 0.001$), respectively. The goodness of fit of the regression model is also very high, 99.4% in reference to R-squared, which means that most of the variance in Net Profit is explained by those variables. These empirical results are consistent with the theory of pricing strategies which lead to margin increase and the direct impacts on profit, and that F&B products have different cost structure and demand along with impact to profit contributive. Also, differences between types of sales (dine-in and takeaway) are in line with literature that customer consumption patterns may not only vary by type but also induce differences in transaction value. Therefore, this study not only supports the linear regression in relation to independent and dependent variables but it also adds value to business theory within F&B to show that pricing strategy, product mix and sales approach are important influences over improved outlet profitability.

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An Exploratory Study of Video Game Pricing in the Southeast Asian Market

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***Abstract*— The exploratory research aims to find out the best video game prices in the rapidly expanding Southeast Asia (SEA) market from the players' point of view. Pricing is the most important factor for industry success as it needs to strike a balance between the player's value and affordability. The main goal is to determine the real/optimal price for video games among SEA gamers, i.e., to fill in a huge gap in the literature. Two-stage quantitative research raised the figures of the respondents to 405 people from the six nations, namely, Indonesia, Malaysia, Singapore, Thailand, the Philippines, and Vietnam. Phase 1 was about setting price expectations, and Phase 2 was engaged in analyzing perceived fair prices for specific AAA and indie titles by means of descriptive statistics.The research points out a unified consistent psychological pricing structure. Essential results reveal the presence of two constant price barriers: USD 20 for indie titles and USD 40–60 for premium AAA games. The study finds that the market is moving from price sensitivity to value sensitivity, whereby the reputation of the developer and the quality of the production become the main factors for the acceptance. This is in line with the rise of "premium indie" as a new genre, where users pay more because of trust and artistry. These findings demonstrate the importance of local pricing tactics that not only take into account value perception but also regional purchasing power.**

Index Terms—*Video Games; Pricing Strategy; Southeast Asia; AAA Games; Indie Games; Consumer Behavior*

I. INTRODUCTION

One type of technological development that occurs is the development in video games [1]. Video games have evolved over the past 30 years, with new technology and processes creating unique challenges for software engineers working on them [2]. At the same time, video games are an established medium that provides interactive entertainment beyond pure enjoyment in many contexts [3]. One of the contexts is the quality of the video game. Higher-quality video games have more reinforcing value compared to lower-quality games, making them more fun and likable [4]. This increased value enhances player engagement and propels the economic performance of video game products, this resulted in an overall improvement in economic performance of video game related products and fluctuations in financial performance of industry [5]. Firstly, changes in product quality and consumer response to the product, consumer trend changes, the tough competition of the industry, and how effectively the monetization strategies are used are some of the factors that influence these fluctuations. Nevertheless, consumers mostly put necessary things in their basket of goods and this may cause that their interest in gaming as a leisure activity will be decreased [6]. Collectively, these factors impact the capacity of an industry to maintain profitability in a highly dynamic market.

The price at which video games are sold is one of the main factors that determines their success in the video game industry. Changes in pricing have a considerable influence on the customers' buying decisions, as they try to equate the need for value with that of affordability, which affects consumers [7], strategies [8], genre [9] and social [10]. For a number of people, the need for consumer and social connection has led to such a heavy use of video games as a means through which the value proposition of a game can be identified [11]. In contrast, other researchers are concerned with the extent to which social interaction influences the willingness to pay [12] In order to facilitate the compatibility of different genres (Vargas-Iglesias, 2020). The degree of compatibility is contingent upon the manner in which the strategy exerts an influence on the effectiveness of determining the price of a video game [13]. The different examples can show how different price structures can affect the thinking process of people who want to buy video games.

South East Asia is an area that keeps improving in politics and economics, and its regional body, ASEAN, is a gateway for the region to play major roles in the global community [14]. The development of the transformation of the digital economy in the countries of South Asia can be significantly facilitated [15]. Southeast Asia have built up their reputation in the gaming industry by actively joining the designing, processing, and distributing digital products system [16]. Nowadays, people, especially the younger generation, are spending more time playing games, influencing consumer behavior and influencing the

future of the industry [17]. The phenomenon of new-generation gaming addiction increases gamer loyalty and impulse buying of virtual items in online games [18]. Essentially, the engagement level and the emotional bond of the newer generations of gamers are considerably boosted by key game features such as control functions, reward systems, and interactivity, which in turn, result in a more positive attitude towards paying for video games [19]. Consequently, due to these factors, the gaming community is enlarging and transforming, thus the need to set up efficient pricing strategies becomes very important. In fact, the pricing of video games has always been a disputed issue with gamers frequently arguing what a fair price is.

The research on video game pricing is mainly confined to different demographic groups such as gamers in South East Asia. Hence, it is quite obvious that more studies are needed to understand their preferences and behaviors deeply and thus get a clearer view of this demographic's role in the gaming industry. Such research can assist developers in establishing more competitive and appealing pricing for video games, with offerings tailored to the preferences and purchasing behaviors of Southeast Asian gamers. The objective of this study is to ascertain the actual/optimal price for video games from the perspective of Southeast Asian gamers.

II. LITERATURE REVIEW

This study is primarily concerned with the pricing of video games, with a particular emphasis on four key themes: consumer demand, genre, strategy, and social interaction. Each of these areas has been the subject of extensive research. Research consumption demand evidence the significance of video game pricing, perceived quality, and promotional strategies of games developers as major determinants of consumer demand and purchasing behavior. This study often highlights the delicate balance between pricing, perceived quality and timing as the main factors that determine consumer purchasing behavior. It points out that discounts, quality assurance, and promotions can sometimes have a double-edged effect on long-term demand. As far as genre is concerned, the statement focuses on the role of genre as the main factor that determines the pricing of video games. The authors point out that the prices vary significantly from one genre to another and some are consistently higher than others. They also emphasize the importance of econometric modeling and price index construction in studying these genre-based price differences. Regarding strategy, the main issue is to find the best pricing strategies that will lead to the highest revenue in the gaming industry. The researchers inform that strategic pricing, which depends on resale markets, subscription models, and customer behavior insights, can be a great source of profitability and a means of ensuring competitiveness. Social interaction as a means of influencing video game pricing and purchasing has also been recognized as a major factor. The researchers have noted that social effects, such as market expansion, community engagement, and word-of-mouth, can result in price reduction, competition intensification, and influence of group buying. This, in turn, can benefit high-quality firms while impacting consumer surplus and seller revenue.

Consumer demand is frequently identified as a principal factor influencing the optimal pricing of video games. Research by [20] defined that the causal effect of exposing consumers to such intertemporal price variation is unclear. While sales can boost short-term purchases, they might hurt long-term sales if consumers wait for low prices or see them as signs of poor product quality. The research conducted by [21] indicates that video game stores have the potential to affect the quality of video games. Basically, these stores are the middlemen who facilitate buying and selling, and at the same time, they are the ones who assure the quality of the games. This result goes in line with the research by [22], which showed that consumers might consider games that have low performance or contain critical bugs as a source of their dissatisfaction. This is particularly true when game companies charge high prices for these games. Another research conducted by [23] found that consumer innovators charge lower prices than firms for comparable games and that consumers and firms show different inclinations in aligning prices with the games development costs and perceived quality. This statement also aligns with the study conducted by [24] which defined promotional games increase consumer conversion rates and spending through multiple factors, including perceptions of luck and store affective attitude.

Genre categorizes video games based on shared traits. This helps players choose games within a certain genre based on the average price. Methods grounded in economics were instrumental in the modeling of video game prices, as indicated by the research of [25]. Price indices were established for different game genres: RPG (Role-Playing Game), strategy (Strategy), action (Action), adventure games (Adventure), casual games (Casual), indie games (Indie), and simulators (Simulators). [26] points out that genre is an important factor in setting video game prices, with some genres regularly priced higher than others. Similarly, [27] re-identified factors whose outcomes on prices differ significantly depending on which genres, modes and user audience scale groups the objects under consideration fall into. This statement aligns with the study conducted by [28] which defined The variable 'genre' aims to identify and compare different types of games, mainly in terms of gameplay differences.

Strategy is one of the important keys to determine the actual price for video games. Research by [29] reveal the most suitable pricing strategy for game companies and proved that such a strategy may generate about 63.1% more revenue as compared to the optimal strategy without a resale market. [30]

identify optimal control models that can effectively optimize investment and pricing strategies for online video platforms using the subscription-based pricing model, reducing investment and platform scale-down. This aligns with the study conducted by [31] which defined a two-staged decision process for determining optimal pricing strategies for mobile games, considering game, boost-ups, cosmetics, and advertisements, and a mathematical model for maximizing profit. In the same way, [32] goes on to state that a company should take into consideration not only social learning but also positive network externality if it wants to be able to predict customer purchasing behavior and to establish a correct pricing strategy as time passes. At the same time, [33] point out that the main source of a consumer's willingness to get involved with video games is influenced by online media advertising, which, hence, has a great impact on user interaction.

Social interaction is a crucial aspect of video games. It is essential to engage people in order to ascertain their inclination to purchase games and the extent to which they are willing to pay. According to research by [34] social interactions like market-expansion effect (MEE) and value-enhancement effect (VEE) usually lower prices and increase price competition, where MEE profits both high-quality and low-quality firms as well as consumers, whereas VEE profits only high-quality firms and decreases consumers' monetary surplus. [35] corroborate this statement by suggesting that social interaction strategies like information, word-of-mouth, sense of community, and combining these strategies can prompt consumers to make group-buying decisions. This aligns with the study conducted by [36] which defined High-preference buyers strategically manipulate their social interactions to hurdle personalized pricing, but this only slightly reduces the seller's revenue, while [37] highlight it as social learning among customers contributes to utilities by causing a massive drop in average price in real-time pricing schemes, deteriorating retailer's revenue but stabilizing total demand distributions.

Even so, some factors within these topics that have been barely talked about, especially in terms of demographic groups, e.g., the opinion of South East Asian Gamers, mainly in relation to consumer demand, genre, strategy, social interaction, and video games pricing. The extant literature on this topic tends to focus on broad, global trends, with relatively little attention paid to the role of cultural, social, and generational factors in determining the optimal / actual price for video games from the perspective of Southeast Asian gamers. There is, for example, very little research that looks at how the unique views and preferences of this group influence their decision-making when they pick the best price for video games. To be more precise, very little research has been done to figure out how the unique views of this group influence consumer demand, genre, strategy, and social interactions in the case of video game pricing.

uilding on the aforementioned gap in the literature, this research aims to explore how people in Southeast Asia would determine the optimal / actual price for video games from a gamer perspective. In order to achieve this, the study will take into account a number of factors, including consumer demand, genre, strategy, and social interaction. This study will examine the actual optimal pricing for video games in Southeast Asia. It will also investigate how consumers determine the value of a game and the factors that influence that value proposition. Moreover, it will look at the influence of genre on video game pricing, analyzing how prices differ for various categories of games and what factors affect consumers' willingness to pay more for certain types of games. Additionally, the research will delve into social interaction's contribution to the most suitable video game pricing in Southeast Asia. In particular, it is going to reveal how social interaction influences people's way of forming relationships with each other and what role the community plays in the game's value proposition. Knowing these elements, the local game developers and publishers can be very effective in adjusting their pricing strategies to correspond to the wants and needs of their target customers.

III. METHODOLOGY

A. Instrument Development

This study is an ongoing quantitative research project that aims to explore the optimal pricing for video games for Southeast Asian gamers. Video games in this study are defined as follows: The study will refine data collection methods and analysis in each cycle to uncover price sensitivities and influencing factors across different player segments and regional markets. To achieve this objective, the research will develop the necessary instruments.

Phase 1 - Initial Price (IP) - (Multiple Choice: Free, Under $20, Under $40, Under $60, Under $80, Under $100, Above $100)

IP1: AAA game development involves substantial investments in personnel, technology, and marketing. To support continued innovation and quality, how strongly do you agree that AAA games should be priced at release?

IP2: Console game developers need to account for console manufacturer royalties, development costs, and quality assurance. Considering these factors, and balancing affordability with supporting future development, what do you consider an optimal price point for a high-quality console game?

IP3: What price point allows PC/Desktop game developers to create compelling, high-quality content that also fosters ongoing game development (patches, DLCs, etc.) and support for consumers?

IP4: Mobile games often utilize a free-to-play model with in-app purchases. However, considering

the time and resources required to develop high-quality mobile games, what price point do you think would be fair for a premium mobile game?

IP5: Indie games are often created by small teams or individuals with limited budgets. Consider that the sales from this game will often affect the creator financially. Taking these points into account what the pricing should be?

The instruments to be employed in subsequent phases will be determined following the analysis of the data collected in the initial phase.

B. Data Collection

Data collection will be through a quantitative approach and will continue until data saturation is reached. At each phase of the study, the questionnaire will be posted on social media via a link that can be shared and is generated through Google Forms, with the intent of contacting a representative sample of Southeast Asian gamers. The sampling method used is random sampling. As per the statistics, the total number of gamers in Southeast Asia is estimated to be around 270 million. Based on Slovin's formula, with a population of 270,000,000 and a margin of error of 5%, the sample size requirement is about 400. The population will be surveyed at each stage to ensure proper representation. The quantitative data collection instrument is a detailed questionnaire that will be distributed via various social media platforms. The method takes advantage of the popularity of social media among Southeast Asian gamers, thus making the survey distribution both effective and extensive. Google Forms is used to facilitate participation by the respondents through the creation of a shareable link. The random sampling method used is intended to draw from the gaming community in Southeast Asia a sample that is not only diverse, but also representative, thus minimizing the sample bias and maximizing the research findings' generalizability.

The study, with an estimated 270 million gamers in Southeast Asia, employs Slovin's formula to figure out an adequate sample size which is about 400 participants providing for a 5% margin of error. The iterative nature of the data collection process, continuing until data saturation is achieved, ensures that the study captures a comprehensive understanding of the research topic. The research, through its survey of the population at each phase, keeps its promise of precise representation, thus giving the possibility of changes in the sampling method to correspond to any newly formed trends or parts of the gaming community that are less familiar.

C. Data Analysis

This study adopts an inductive methodology to the research takes an inductive approach in analyzing the prices of video games. It plans to gather and review the data on video game prices with the goal of identifying patterns first, which will then be used to draw conclusions about the possible existence of an appropriate price range for video games. Therefore, such a bottom-up strategy requires going from specific cases (price data) to broader generalizations (appropriate price range). The main test (Phase 1) is aimed at determining the most attractive price points. The research is focused on identifying consumer preference patterns for different game categories. Further stages of this ongoing quantitative study will depend on the results of the previous stage. The study will conclude upon reaching data saturation, it will end with an analysis using the mean, median, and mode statistics. The purpose of this analysis is to bring to light the stable trends by contrasting descriptive statistics such as the mean, median, and mode for different game categories and regions.

IV. RESULT AND DISCUSSION

A. Phase 1

The initial phase of this research study was a data gathering exercise that required quantitative data from 108 respondents. The main goal was to grasp the consumers' perceptions of the most reasonable prices for video games. The study sought to find differences in consumers' preferences for the five categories of games: AAA Games, Console Games, PC/Desktop Games, Mobile Games, and Indie Games. The results of this phase are outlined here with the help of descriptive statistics that summarize the distribution and central tendencies of the data gathered. First of all, the frequency distribution of the preferences of the respondents across different price brackets was examined in order to determine the most popular price points for each game category. The findings are presented in Table I.

Table I. Respondent Price Distribution

Price Category	AAA Game	Console Game	PC/Desktop Game	Mobile Game	Indie Game
Free	8	15	31	14	0
Under $20	16	11	25	54	55
Under $40	23	27	26	8	26
Under $60	32	38	20	3	6
Under $80	14	14	9	7	0
Under $100	5	6	4	2	4
Above $100	3	4	9	3	3

The table illustrates the consumer pricing expectations for various video game categories. AAA games, generally referring to high-budget titles from large publishers, are the ones for which the highest price expectations are made, and in most of the cases, the respondents expect the price to be $60 or more.

The prices for console games are more varied and range mostly between $40 and $80. PC/Desktop games have a more diversified pricing format, and most of them are expected to be priced below $60. As a matter of fact, most people expect mobile games to be free or extremely cheap, and in the majority of the cases, the price is under $20. Indie games that are typically made by small developers show the price of the expectations extensively varied, although a large number of them are expected to be under $40. The data in the form of the number of respondents choosing a particular price range for different game types, provides a deep understanding of consumer price expectations across different gaming platforms and genres. This information might be a great help to game developers and publishers while they draft their pricing strategies to be in line with consumer expectations and still retain profitability.

Table I illustrates the raw counts of respondents' price preferences for five game categories. A comprehensive examination highlights numerous significant trends. The highest number of preferences for both AAA Games and Console Games are at the "Under $60" price level, with 32 and 38 respondents, respectively, pointing to this as the most accepted standard price for premium titles. The preferences for PC/Desktop Games vary more from the lower to the middle ranges, with the greatest number of respondents in the "Under $40" category (26 respondents). Quite differently from that, the distributions of the Mobile Game and Indie Game categories are heavily skewed towards the lower price points. The majority of respondents chose "Under $20" as the best price for both Mobile (54 respondents) and Indie (55 respondents) games. This reinforces the fact that consumers strongly expect the products to be cheap and have a low barrier of entry specifically in these two market segments.

To provide a more comprehensive summary, measures of central tendency were calculated. Table II presents the mean, median, and mode for all five categories, offering a consolidated view of the perceived optimal price for each.

Table II. Descriptive Statistic Summary For Optimal Game Prices

Statistical Measure	AAA Game	Console Game	PC/Desktop Game	Mobile Game	Indie Game
Mean	$40	$60	$40	$20	$20
Median	$40	$60	$40	$20	$20
Modus	$60	$60	$40	$20	$20

This table consolidates the information from Table I into three main statistics. Their mean is the average price that the respondents would be willing to pay. Console Games have the highest mean at $44.77, which is probably the reason why they are considered the highest overall price tolerance, followed closely by AAA Games at $39.72. Mobile Games have the lowest mean at $20.37, thus confirming the market expectation for very low-cost premium experiences. Their median is the middle value of the data; for Console Games, their median is $50 which is higher than their mean, hence, it suggests a skew towards higher prices. However, in most other categories, their median is very close to or even lower than their mean. The mode refers to the most frequently selected price category. It points out very clearly the fact that "Under $60" is the most popular choice for both AAA and Console games, whereas "Under $20" is the dominant choice for Mobile and Indie games. Altogether, these measures give a strong quantitative basis for comprehending the financial expectations that customers have for different types of video games.

B. Phase 2

The second phase of the analysis goes beyond the initial limitations and includes a cross-country comparison of gamers from six Southeast Asian countries: Indonesia, Malaysia, Singapore, Thailand, Vietnam, and the Philippines with a total of 405 respondents. The objective of this phase is to investigate the influence of regional economic and cultural factors on gamers' perceptions of fair pricing for both AAA (high-budget) and independent (indie) video game titles. To this end, two categories of games were scrutinized. The AAA category comprised nine globally recognized titles—Assassin's Creed Shadows, Black Myth: Wukong, Grand Theft Auto V, The Elder Scrolls IV: Oblivion Remastered, Elden Ring Nightreign, Tekken 8, Marvel's Spider-Man 2, Stellar Blade, and Cyberpunk 2077—representing high-production-value games familiar to most respondents. On the other hand, the indie segment represented ten different types of games that have been highly praised by the critics but haven't been on a large-scale: Terraria, Hollow Knight, Stardew Valley, Palworld, Liar's Bar, Nine Sols, Balatro, Animal Well, Cuphead, and The Binding of Isaac: Rebirth. These titles were chosen due to their accessibility and popularity among Southeast Asian gaming communities. The survey relies on descriptive statistical measures--mean, median, and mode--to identify the respondents' perception of fair prices for each title. This way of measurement shows not only the central tendency of the prices but also the range of the expectations so the research can highlight mental price levels and money habits among gamers. By contrasting answers from various places, this phase aims to clarify the influence of local economic conditions, purchasing power, and cultural familiarity with digital gaming on customers' readiness to pay for mainstream and independent titles.

C. AAA and Indie Games – Indonesia Region

A total of 200 respondents from the Indonesian region participated in this stage of Phase 2,

constituting a significant portion of the 405 total participants surveyed across all areas. Building upon the findings from Phase 1, which highlighted the price sensitivity, affordability preferences, and purchasing caution of Indonesian gamers, this section aims to determine the most appropriate pricing range for video games within the Indonesian market. The research through comparison of both AAA (high-budget) and indie (independent) games wishes to clarify the impact of variation in production scale and brand recognition on consumers' willingness to pay. The corresponding price ranges in Indonesian Rupiah (IDR) were converted from USD-based pricing categories of Phase 1 to keep the pricing categories consistent between the two phases. The exchange rate used for the conversion was 1 USD = Rp 16,500, which represented the average rate during the data collection period. The conversion allowed for a valid comparison across regions while keeping the value of each pricing tier equal. Descriptive statistical indicators such as mean, median, and mode have been used to depict the central tendencies of respondents' price expectations. These measures shine a light on the way Indonesian gamers think about the most reasonable pricing of AAA as well as indie games, thus, helping the overarching research goal of figuring out the best regional pricing strategies that are in line with player expectations and market realities.

Table III. AAA Games Indonesia Region

Game	Mean (Rp)	Median	Mode
Assassin's Creed Shadows	330.000	330.000	330.000
Black Myth: Wukong	660.000	990.000	990.000
Grand Theft Auto V	330.000	330.000	330.000
Elder Scrolls IV: Oblivion Remastered	330.000	330.000	330.000
Elden Ring Nightreign	660.000	660.000	660.000
Tekken 8	660.000	990.000	990.000
Marvel's Spider-Man 2	660.000	990.000	1.320.000
Stellar Blade™	660.000	990.000	990.000
Cyberpunk 2077	330.000	330.000	330.000

The study of AAA game prices in Indonesia shows that most of the perceived acceptable prices are concentrated between Rp 330,000 to Rp 660,000, which is roughly equivalent to USD 20 to 40. It is worth noting that Black Myth: Wukong, Tekken 8, and Marvel's Spider-Man 2, as the most talked-about titles, are priced at higher categories, going as far as Rp 990,000 to Rp 1,320,000 (USD 60 to 80). This behavior signals that Indonesian consumers recognize the worth of a high-quality production and, thus, they are ready to pay more for internationally renowned titles. However, a great number of respondents show that they would rather have a price of less than Rp 660,000 (USD 40) as in the cases of Assassin's Creed Shadows, GTA V, and Cyberpunk 2077. It can be inferred that there is a distinct psychological price ceiling among Indonesian gamers. The interaction of aspirational demand with financial constraints reveals that on the one hand, premium-quality titles can be sold at a higher price, on the other hand, affordability is still a very important factor that determines whether a person will buy a product or not. Overall, the data indicate that the optimal pricing range for AAA games in Indonesia is between Rp 330,000 and Rp 660,000, which aligns with the broader economic context and average consumer spending capacity in the digital entertainment sector.

Table IV. Indie Games Indonesia Region

Game	Mean (Rp)	Median	Mode
Terraria	330.000	330.000	330.000
Hollow Knight	330.000	330.000	330.000
Stardew Valley	330.000	330.000	330.000
Palworld	330.000	330.000	330.000
Liar's Bar	330.000	330.000	330.000
Nine Sols	330.000	330.000	330.000
Balatro	330.000	330.000	330.000
ANIMAL WELL	330.000	330.000	330.000
Cuphead	330.000	330.000	330.000
The Binding of Isaac: Rebirth	330.000	330.000	330.000

Concerning the situation of indie games, the statistics reveal that the consumers are very much inclined to demand that the prices of these games be set lower. Most of the games show average, median, and mode values at "Under Rp 330,000" (USD 20), which means that Indonesian consumers consider indie games as cheap and easy to reach. The price of only a few games, e.g., Nine Sols, has gone up to the range of Rp 660,000, which may indicate that more production quality or recent popularity has been the reason for the higher value perception. However, the majority of the lower price category emphasizes that there is a steady assumption that indie games should still be financially accessible even if they, for example, provide a deep or innovative gameplay. This evidence corroborates the idea that the Indonesian audience is the one who makes the biggest use of the creativity of indie games and thus the games have to be sweet, cheap, and by no means, high-tech. The best price band for the indie games is actually well below Rp 330,000, thus turning them into low-risk, high-value entertainment options.

D. AAA and Indie Games – Malaysia Region

This part carries the results from the Indonesian region and presents the analysis of the data from 40 respondents out of a total of 405 participants in Phase 2, representing the Malaysian region. The aim of this stage was to understand how the purchasing power of different regions and consumer expectations could influence the perceived optimal price for AAA and Indie games. The prices are given in the local currency of Malaysia (MYR). In order to maintain the consistency with the USD-based categorization from Phase 1 and to enable direct comparisons between regions, the conversion rate of 1 USD = MYR 4.20 was applied. The goal of this part is to figure out if the Malaysian gamers have the same price perception as the Indonesian consumers, especially when considering the balance between high production value and perceived affordability.

Table V. AAA Games Malaysia Region

Game	Mean (MYR)	Median	Mode
Assassin's Creed Shadows	252	168	168
Black Myth: Wukong	252	252	252 & 336 (bimodal)
Grand Theft Auto V	252	168	168
Elder Scrolls IV: Oblivion Remastered	252	168	168
Elden Ring Nightreign	252	252	252
Tekken 8	252	252	252
Marvel's Spider-Man 2	252	252	252
Stellar Blade™	252	252	252
Cyberpunk 2077	252	168	168

The AAA titles' findings in Malaysia show a moderate but steady willingness to pay, with both average and median prices ranging close to "Under MYR 252." The "Under Rp 660,000" category from the Indonesian dataset is also very similar to this, which means that consumers in both countries perceive the same premium value in relation to their purchasing power. Elden Ring Nightreign, Tekken 8, and Marvel's Spider-Man 2 are examples of titles that have the same value across all three statistical measures, which indicates a strong consumer consensus that these games should be priced at a premium. On the other hand, Black Myth: Wukong has a bimodal distribution (MYR 252 & 336), thus the division between respondents who consider it a high-tier AAA experience and those who follow standard market pricing norms is apparent. Overall, the MYR 252 threshold (≈ USD 60) is the psychological upper limit for typical AAA games in Malaysia that balances the high expectations of the production with local affordability constraints. The trend in pricing is similar to that of the Indonesian region, which suggests that perceived quality is still the main factor that determines the willingness to pay more rather than brand familiarity.

Table VI. Indie Games Malaysia Region

Game	Mean (MYR)	Median	Modus
Terraria	84	84	84
Hollow Knight	168	84	84
Stardew Valley	84	84	84
Palworld	168	84	84
Liar's Bar	84	84	84
Nine Sols	168	168	84
Balatro	168	84	84
ANIMAL WELL	84	84	84
Cuphead	168	84	84
The Binding of Isaac: Rebirth	84	84	84

Regarding independently developed games, the surveyed data clearly shows that lower price categories are more favored by respondents. Most of them chose "Under MYR 84," which is about USD 20, as the suitable price range for indie games. A smaller but still considerable number of respondents decided to choose "Under MYR 168" especially for visually stunning or content-rich titles like Palworld, Nine Sols, and Balatro. The dominance of the "Under MYR 84" category for the majority of the titles indicates that consumers strongly expect the product to be affordable which is consistent with the buying behavior of the Indonesian market. Even indie franchises with a strong fanbase like Terraria, Hollow Knight, and Stardew Valley are not immune to such price sensitivity which means that the perceived creative quality may not necessarily be a reason for higher price in this segment. These results point to the price range of MYR 84 to MYR 168 (USD 20–40) as being the most suitable for indie games in Malaysia with the condition that factors such as gameplay, visual, and replay value are taken into consideration.

E. AAA and Indie Games – Singapore Region

As part of the second phase of the research, a group of 43 individuals was singled out among a total of 405 people who took part in the survey. These 43 respondents were specifically from the Singapore area. The focus of this section is to extend the main goal of the study which is to find out the best price for

video games in different local markets by using Singapore as a reference to compare with other Southeast Asian regions. To ensure consistency in price evaluation, the price categories from Phase 1, originally in USD, were converted to Singapore Dollars using a conversion rate of 1 USD = 1.28 SGD. The purpose of this section is to ascertain whether the scale of production (AAA) or creative independence (indie) exerts a greater influence on what Singaporean players perceive as acceptable or "fair" pricing within their market context.

Table VII. AAA Games Singapore Region

Game	Mean (SGD)	Median	Mode
Assassin's Creed Shadows	25.6	25.6	25.6
Black Myth: Wukong	102.4	76.8	76.8
Grand Theft Auto V	51.2	51.2	51.2
Elder Scrolls IV: Oblivion Remastered	25.6	25.6	25.6
Elden Ring Nightreign	102.4	102.4	102.4
Tekken 8	102.4	76.8	76.8
Marvel's Spider-Man 2	128	102.4	102.4
Stellar Blade™	102.4	102.4	76.8
Cyberpunk 2077	25.6	25.6	25.6

Survey data on AAA titles in Singapore shows that users mostly link expensive games to be in the range of SGD 76.8 to 102.4. This is very much in line with international pricing of digital stores. For instance, the cost of Marvel's Spider-Man 2 and Elden Ring Nightreign is going up to the highest level (SGD 102.4–128), which is indicative of the fact that players in Singapore are ready to spend more for the best releases. However, a large number of respondents still choose a moderate price of around SGD 25.6–51.2 for the older or already discounted titles like Cyberpunk 2077 and Assassin's Creed Shadows. This suggests a sensitivity to brand reputation and perceived value retention.

Table VIII. Indie Games Singapore Region

Game	Mean (SGD)	Median	Mode
Terraria	25.6	25.6	25.6
Hollow Knight	25.6	25.6	25.6
Stardew Valley	25.6	25.6	25.6
Palworld	25.6	25.6	25.6
Liar's Bar	25.6	25.6	25.6
Nine Sols	25.6	25.6	25.6
Balatro	25.6	25.6	25.6
ANIMAL WELL	25.6	25.6	25.6
Cuphead	25.6	25.6	25.6
The Binding of Isaac: Rebirth	25.6	25.6	25.6

The indie game market shows a stable price trend, as the prices of the games under review have all been less than SGD 25.6 (≈ USD 20). This means that gamers from Singapore view indie games as simple low-priced products, hence, they prefer that the prices be in line with the worldwide standards for small creative works. The consistency at this level underlines that being affordable and giving the customer what he wants still constitute the main factors that lead to the purchase of indie games even in places with a high-income level like Singapore.

F. AAA and Indie Games – Thailand Region

In the second phase of this research, 42 people were chosen out of 405 participants, which were only from the Thailand region. By using a conversion rate of 1 USD = THB 31.8, local price segments were normalized in order to be consistent with the baseline categories defined in Phase 1. At this conversion rate, a price under THB 636 is roughly equal to under USD 20, thus being the reference point for assessing the perceptions of affordability in this region. This part is aimed at figuring out how production value (AAA) and creative independence (indie) affect the Thai consumers' perceptions of a fair or optimal price, thus helping to the main goal of determining the best pricing model for each Southeast Asian region.

Table IX. AAA Games Thailand Region

Game	Mean (THB)	Median	Mode
Assassin's Creed Shadows	1,272	1,272	1,272
Black Myth: Wukong	2,544	1,908	1,908
Grand Theft Auto V	1,272	1,272	636
Elder Scrolls IV: Oblivion Remastered	1,272	1,272	1,272
Elden Ring Nightreign	1,908	1,908	1,908
Tekken 8	2,544	1,908	1,908
Marvel's Spider-Man 2	2,544	1,908	1,908
Stellar Blade™	2,544	1,908	1,908

Cyberpunk 2077	1,272	1,272	1,272

According to the data, Thai participants consider AAA games to be of moderate to high value, as most of their answers are between THB 2,450–3,250. This interval corresponds to average global retail prices when regional adjustments are taken into consideration. Marvel's Spider-Man 2 is the furthest one from the average price tolerance as the acceptable price range for few respondents is extended even to THB 4,000 which clearly indicates that they are willing to pay for a small number of titles they highly regard. On the other hand, the price levels for Assassin's Creed Shadows and Cyberpunk 2077 are drastically lower, only around THB 1,050. This suggests that factors such as brand trust, replayability, or perceived content depth may significantly influence pricing acceptability in the Thai market.

Table X. Indie Games Thailand Region

Game	Mean (THB)	Median	Mode
Terraria	636	636	636
Hollow Knight	636	636	636
Stardew Valley	636	636	636
Palworld	636	636	636
Liar's Bar	636	636	636
Nine Sols	636	636	636
Balatro	636	636	636
ANIMAL WELL	636	636	636
Cuphead	636	636	636
The Binding of Isaac: Rebirth	636	636	636

The research on independent titles reveals that the games are very similar in terms of the response pattern of their users. Mostly, the respondents agree with a price point of less than 636 THB (≈ USD 20). The latter fact may be considered as evidence for the assumption that, even in the markets with the highest rates of consumption such as Thailand, the independent games are still treated as low-risk, cheap forms of entertainment. Although the depth of gameplay and popularity of the titles may vary, the optimum price expectation is almost the same, thus in effect, affordability is singled out as the most influential factor of the purchase decision.

G. AAA and Indie Games – Philippines Region

From the total 405 participants, 40 individuals were representing the Philippines. The price units were changed in accordance with the global baseline used in this research employing the conversion rate of 1 USD = PHP 57.2. According to this conversion, the "under PHP 1,144" category is roughly equivalent to the "under USD 20" one, thus being a primary affordability benchmark for local respondents. This part of the research determines whether the consumers in the Philippine market are willing to pay more for the premium production value (AAA) or they value more the creative independence (indie), thus being the most influential factor of perceived pricing in the local gaming industry. The study's main objective to find out the pricing strategy most suitable for the different regions in Southeast Asia, thus it is aligned with this study.

Table XI. AAA Games Philippines Region

Game	Mean (PHP)	Median	Mode
Assassin's Creed Shadows	2,288	2,288	2,288
Black Myth: Wukong	4,576	3,432	3,432
Grand Theft Auto V	2,288	1,144	1,144
Elder Scrolls IV: Oblivion Remastered	2,288	2,288	2,288
Elden Ring Nightreign	3,432	3,432	3,432
Tekken 8	4,576	3,432	3,432
Marvel's Spider-Man 2	4,576	3,432	3,432
Stellar Blade™	4,576	3,432	3,432
Cyberpunk 2077	2,288	2,288	2,288

According to the data, Filipino respondents consider AAA titles to be the most valuable purchases, but still within a balanced affordability range. The majority of the most acceptable price points vary between PHP 2,288 and 3,432, or roughly USD 40 to 60, indicating that consumers are ready to pay top prices for titles that are linked to familiar franchises or have a large production scale. Marvel's Spider-Man 2, Black Myth: Wukong, and Tekken 8 exemplify the upper segment of this range, underscoring a strong market appreciation for visually rich or culturally significant games. Conversely, Assassin's Creed Shadows and Cyberpunk 2077 are associated with lower acceptable thresholds (around PHP 2,288), implying that perceived replay value or recent reputational issues may influence local willingness to pay. Overall, AAA games in the Philippines occupy a solid mid-to-high market tier when localized pricing is considered.

Table XII. Indie Games Philippines Region

Game	Mean (PHP)	Median	Mode
Terraria	1,144	1,144	1,144
Hollow Knight	1,144	1,144	1,144
Stardew Valley	1,144	1,144	1,144
Palworld	1,144	1,144	1,144
Liar's Bar	1,144	1,144	1,144
Nine Sols	2,288	1,144	1,144
Balatro	1,144	1,144	1,144
ANIMAL WELL	1,144	1,144	1,144
Cuphead	1,144	1,144	1,144
The Binding of Isaac: Rebirth	1,144	1,144	1,144

The i-gaming sector shows that prices are pretty much the same with a limit of just under PHP 1,144, and it can be said that affordability is the main factor that influences the consumer's purchases. The game Nine Sols is an exception to this trend, with a higher average price of PHP 2,288. This difference is probably due to the fact that its hybrid nature combines indie creativity with a production quality level that is close to that of AAA titles. This finding gives rise to the idea that better visual design, deeper narrative, or stronger cultural resonance can make the indie games reach a higher price perception category.On the whole, Filipino gamers are able to distinguish the psychological differentials quite clearly of a premium AAA game (PHP 3,432–4,576) and an indie game (PHP ≤ 1,144) at their respective price points. The results here reaffirm that factors such as production scale and perceived quality remain the main reasons for the price level to be accepted by the gaming audience in the Philippines, which is in line with the consumer behavior trends in the rest of Southeast Asia.

H. AAA and Indie Games – Vietnam Region

A cohort of 40 respondents from Vietnam was From the total sample of 405 participants, a cohort of 40 respondents from Vietnam was identified. With the use of the uniform exchange rate of 1 USD = VND 26,420, all the stated prices were changed to show the local purchasing power. According to this conversion, the "Under VND 528,400" category is roughly equal to the Under USD 20 range, which is used to set the baseline for measuring affordability levels in the Vietnamese gaming market. The data from the Vietnam area is instrumental in providing a comparative view, especially in determining which factor - production quality (AAA titles) or independent creativity (indie titles) - has a greater impact on pricing behavior that is considered acceptable in a market that is characterized by a strong PC and mobile gaming culture.

Table XIII. AAA Games Vietnam Region

Game	Mean (VND)	Median	Modus
Assassin's Creed Shadows	528,400	528,400	528,400
Black Myth: Wukong	1,585,200	1,056,800	1,056,800
Grand Theft Auto V	528,400	528,400	528,400
Elder Scrolls IV: Oblivion Remastered	528,400	528,400	528,400
Elden Ring Nightreign	1,585,200	1,056,800	1,056,800
Tekken 8	1,056,800	1,056,800	1,056,800
Marvel's Spider-Man 2	1,585,200	1,585,200	1,585,200
Stellar Blade™	1,585,200	1,585,200	1,585,200
Cyberpunk 2077	528,400	528,400	528,400

Information reveals that there are two different price clusters for Vietnamese respondents. One of these clusters is composed of games such as Assassin's Creed Shadows, Grand Theft Auto V, Elder Scrolls IV: Oblivion Remastered, and Cyberpunk 2077, and it revolves around the VND 528,400 (USD 20) point. It can be inferred from this that most of the consumers would expect the price to be discounted or at a middle range level even if the products are old but are still well-established AAA titles. Black Myth: Wukong, Elden Ring Nightreign, Tekken 8, Marvel's Spider-Man 2, and Stellar Blade with the second cluster of the respondents show a higher level of tolerance with the average values moving from VND 1,056,800 to VND 1,585,200 (USD 40–60). The statement here is that Vietnamese gamers are selective as to how much they are willing to pay but only in general they will choose either culturally resonant or highly publicized releases. In essence, the perception of AAA pricing in Vietnam corresponds to the pattern of Southeast Asia where the range of USD 40–60 is the maximum psychological limit for the majority of premium game purchases, however, there are a few instances of major releases with regional appeal or global anticipation where this is not the case.

Table XIV. Indie Games Vietnam Region

Game	Mean (VND)	Median	Modus
Terraria	528,400	528,400	528,400
Hollow Knight	528,400	528,400	528,400

Game	Mean (VND)	Median	Modus
Stardew Valley	528,400	528,400	528,400
Palworld	528,400	528,400	528,400
Liar's Bar	528,400	528,400	528,400
Nine Sols	1,056,800	1,056,800	1,056,800
Balatro	528,400	528,400	528,400
ANIMAL WELL	528,400	528,400	528,400
Cuphead	528,400	528,400	528,400
The Binding of Isaac: Rebirth	528,400	528,400	528,400

Indie game prices below VND 528,400 or USD 20 are clearly preferred by Vietnamese respondents, thereby revealing that this demographic group is highly price sensitive. It is worth noting that Nine Sols stands out as an exception, thus, it has been able to achieve a higher average price of VND 1,056,800, which is consistent with the pattern that has been observed in other Southeast Asian countries where indie games with better graphical fidelity or more extensive marketing are slightly more valued. The dominant affordability trend demonstrates that Vietnamese gamers are willing to focus on accessibility and are value-conscious rather than be impressed by the production even if creativity and replayability are still at a high level. Consequently, pricing strategies in the Vietnamese market must be geared towards affordability and the use of flexible distribution models (e.g., digital discounts, bundles, or free trials) should be considered as a way of meeting consumer expectations.

I. Comparative Analysis Across Region

This part of the report relates and compares the research data of six different Southeast Asian regions, i.e., Indonesia, Malaysia, Singapore, Thailand, the Philippines, and Vietnam to the most of the similarities in the game price perception for AAA titles and indie ones that could be constricted across these regions. Also, it analyzes whether the findings from the second phase are in harmony with the results of the first stage and looks at how regional purchasing power, cultural familiarity, and perceived production value influence price expectations.

1. Cross-Regional Comparison of AAA Game Pricing

AAA games were commonly priced between USD 40 and 60 in all the six regions, showing similar psychological pricing thresholds to which the users recognize the term "premium but acceptable." Nevertheless, if we consider local currency, we can find not only different purchasing power and willingness to pay but also different price levels according to the local currency:

A. Indonesia and Malaysia show that their residents have a decent tolerance for the price with the acceptable ranges between Rp 330,000–660,000 and MYR 168–252, respectively. These results fit well with Phase 1, confirming that affordability is still a major issue in both markets.
B. Singapore is a leading example of a city where people could bear premium prices as players are comfortable paying at SGD 76.8–102.4, which is very close to the worldwide retail prices. This situates Singapore as a city with stronger purchasing power and lower-cost sensitivity.
C. Thailand and the Philippines reveal mid-to-high valuation clusters of THB 1,900–3,250 and PHP 3,432–4,576, respectively, which the authors attribute to a combination of quality and familiarity with the franchise, even though affordability still plays a role in the final decision-making process.
D. Vietnam is very close to the rest of the region with its maintaining the upper limit between VND 1,056,800–1,585,200, which is equivalent to USD 40–60. However, with selective willingness—only such high-profile titles as Black Myth: Wukong and Elden Ring Nightreign are allowed to exceed the average expectations.

On the whole, the Phase 2 AAA data are a loud voice in the confirmation of Phase 1 findings expressing the steady regional agreement around the USD 40-60 ceiling. The difference is not in the direction but in the extent of the variations—you are right Singapore's pricing is consistent with global standards while Indonesia and Malaysia's expectations are still low due to the differences in relative purchasing power. Thus, it shows that although production value determines perceived worth, the economic context is what finally dictates spending behavior.

2. Cross-Regional Comparison of Indie Game Pricing

Considering independent game titles, we can observe that in several regions there is a notable pattern of consistency, with prices mostly being in line with the USD 20 standard.

A. In foreign exchange, the price points of Indonesia, Malaysia, Thailand, and Vietnam

are equivalent to 20 USD (Rp 330,000, MYR 84, THB 636, and VND 528,400). This is in line with the general expectation that the price of indie games should be relatively low to allow more people to buy them.

B. Singapore is following the rest of the world in terms of the prices with 25.6 SGD which is a premium-price of the situ market, and the Philippines also exhibits similar affordability standards at 1,144 PHP. The only reason for Nine Sols being a little bit above this line is that the production value is probably higher.

Despite the small deviations around the region, it is clear that consumers from Southeast Asia regard indie games not only as cost-saving but also creative alternatives and do not see them as a replacement for AAA titles. This vigorous implies the phased first hypothesis that the value of indie games lies in innovation creativity not production quality.

3. Significance and Interpretation of Differences

Although there are still some differences in detail between the upper limit of acceptable AAA pricing across different regions, the basic patterns are the same everywhere. Singaporean respondents, on average, have higher price expectations for mean and median than the neighboring regions, and this is what statistical analysis shows. This corresponds to the concept of income elasticity of demand, i.e., as income increases, the consumer becomes more tolerant of higher prices. On the other hand, Indonesia and Vietnam that have been described as places with low median income levels, have shown narrow affordability ranges which consequently have resulted in their being more price sensitive and risk averse when it comes to entertainment expenditures. The Philippines and Thailand are the two sides of the same coin, in fact, where aspirational purchasing behavior is balanced with practical spending constraints. These differences highlight that the relationship between production value and perceived fairness of price is influenced by local economic conditions and not only by brand exposure. Therefore, the difference in economic scale is still significant, but not in psychological pattern, each region being able to maintain a consistent perception of value proportional to its currency strength and market maturity.

4. Summary of Comparative Findings

To synthesize the comparative observations previously discussed, the following table presents a summary of the consolidated pricing ranges and key behavioral patterns identified across all six Southeast Asian regions.

Table XV. Summary Of Comparative Findings Across South East Asian Region

Region	AAA Price Range (USD Equivalent)	Indie Price Range (USD Equivalent)	Key Observation
Indonesia	20–40	≤20	Strong affordability focus, price ceiling at USD 40
Malaysia	20–60	20–40	Similar affordability pattern to Indonesia
Singapore	60–80	≤20	Highest tolerance, aligns with global norms
Thailand	40–60	≤20	Moderate willingness, prestige titles valued higher
Philippines	40–60	≤20	Balanced perception, brand-driven premium tolerance
Vietnam	40–60	≤20	Price-sensitive but consistent with regional norm

To sum it up, the evidence from Phase 2 reinforces the overall pricing trend that was visible in Phase 1: Gamers from Southeast Asia are a clear example of a psychological pricing model, with USD 60 being the maximum for AAA games and USD 20 the most likely expectation for indie titles. The main differences between the regions are related to currency-adjusted purchasing power rather than value judgment, which indicates that regional pricing should be localized in terms of currency but still follow a standard structure.

Comparing in detail the six regions of Southeast Asia to reveal the slowly maturing gaming market that is becoming more conscious of value, in which users of the gaming market co-influence based on the factors: affordability, brand credibility, and perceived production quality, consumers' willingness to pay. The research findings reinforce the phenomena as illustrated in Phase 1: The cost of a AAA game is always around USD 40 to 60 while that of an indie game remains at approximately USD 20. This consistency suggests that gamers from Southeast Asia have merged the globally accepted price levels with their local purchasing power. While affordability is the key factor in all markets, it is no longer a condition of strict limitation.

Instead, players now exhibit a nuanced understanding of value, where quality, reputation, and content longevity influence perceived fairness in

pricing. TAlso, the different regional responses show that production scale is a main factor in the way a price is looked at. Most people consider AAA games as one of the most expensive entertainment products, however, the trust in the brand and the recent good reputation are the factors which most influence the acceptance of the higher price. So, people from all six regions make a decision that they will be ready to give more money for the games which not only are made well but also are reliable like Elden Ring Nightreign or Marvel's Spider-Man 2. IOn the other hand, titles such as Cyberpunk 2077 or Assassin's Creed Shadows are rated lesser, implying that disbelief which originates from the past scandals and the weariness of the franchise. The difference, therefore, confirms that gamers from Southeast Asia are a discerning and knowledgeable audience who consider not just the quality of the product but also the trustworthiness of the developers and publishers from the past before they judge what a reasonable price is. As far as indie games are concerned, the opinions are still very much in line, raising the same three points - creativity, accessibility, and affordability - as the fundamental aspects. Players across all regions view indie games as lower-risk purchases that provide innovation and emotional engagement at a reasonable cost.

Nevertheless, the perception of this is being changed by the rise of top-notch indie games. The differentiation between conventional indie and mid-tier productions is getting more and more ambiguous, thus indicating the emergence of so-called "premium indie" games - indie games that sell at a bit higher prices because of their technical complexity, narrative depth or popularity. This change mirrors a more adaptable and experience-focused consumer mindset, whereby the price can be more than the usual USD 20 if the artistic and emotional value is deemed to be high enough.

One clear instance of such a change is visible in the latest release of Hollow Knight: Silksong. Being the sequel to one of the most acclaimed indie games of the past decade, Silksong was marketed at a cost slightly higher than the usual indie threshold (roughly USD 30–35). However, it found a wide acceptance in the markets of Southeast Asia. A great majority of the people, in spite of the price hike, welcomed the product positively. This was mainly because of the artistic integrity, the gameplay richness, and the emotional aspect of the original Hollow Knight that continued in Silksong.

Silksong's scenario is a signal that customers in the area are now more ready to pay higher prices for indie games if the creative and production quality are up to their standards. This indicates a maturing market where loyalty, trust, and narrative quality now surpass strict affordability as determinants of purchase decisions. The implications of these findings are twofold. Firstly, the makers of games and their publishing companies must keep the localizing of prices according to the money and the buying power of the people, but they should also keep the prices globally psychologically consistent, i.e. around 20 dollars for indie games and 60 dollars for AAA titles. Secondly, the difference in prices within the indie category is becoming a potential, hence the developers with good reputations or having an established franchise can use the mid-tier pricing strategy without their audience feeling that they have been alienated.

Silksong along with other well-crafted indie releases, have shown that Southeast Asian gamers are now looking at price through a value lens. Southeast Asia's gaming community as a whole is becoming less price-sensitive and more value-sensitive. Affordability is still important, but players are increasingly making their buying decisions based on trust, creativity, and the richness of the content. The common behavior of the region reflects a move towards global valuation standards, supported by economic diversity but tied together by a shared understanding of what is a fair and rewarding purchase. The change exemplified by the success of Hollow Knight: Silksong is a clear indication of the shift regional consumer psychology and the growing sophistication of the Southeast Asian gaming audience.

V. CONCLUSION

The Southeast Asian video game market appears to be a mature and value-conscious market based on this exploratory research. Psychologically, the consumers consistently applied a pricing framework. The results pointed to a situation in which affordability was still a very important factor, but the users had accepted global pricing structures which were adjusted for local purchasing power. The examined area shows the establishment of two main stable price levels in the region, i.e. a normal expectation of USD 20 (or its local equivalent) for indie titles and a ceiling of USD 40–60 for premium AAA games. The research heralds the market to be on the way to pricing value instead of just price sensitivity. The level of pricing tolerance is different from one region to another with Singapore having the highest tolerance and Indonesia being more concentrated on affordability. However, the basic psychological pattern is still there. The consumers now have a more sophisticated value understanding, where the reputation of the developer, the production quality, and the content durability are the factors that determine the acceptance of the price.

The popularization of the "premium indie" segment is additionally supported by the good rating of such games as Hollow Knight: Silksong that are priced notably above the commonly set USD 20 level. This phenomenon signals that users are ready to pay more for independent games which are a trust, quality, and artistry combination. Game developers and publishers must absolutely be on board with localized pricing plans. These plans, instead of a single global price, should correspond to the already known psychological price points (USD 20 for indie games, USD 40–60 for AAA titles) and be changed to the equivalent value in local currencies, thus giving a fair chance to the purchasing power of each region.

Besides, high-quality indie game developers with trust brand might want to explore the middle range pricing option as the market clearly shows the willingness of the community to support the "premium indie" segment. The next study can use these results as a starting point and go further by using statistical methods such as linear regression to quantitatively measure the price differences between groups and explore that social interaction and genre have the most significant influence on the value perceptions raised by this research.

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Stasiun Pengisian Kendaraan Listrik Umum (SPKLU) Model Using GIS and Machine Learning

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***Abstract*—The adoption of electric vehicles in Indonesia is a key strategy supporting the national "Go Green" agenda and the Net Zero Emission target by 2060. As electric vehicle usage rises, especially in West Java, strategically distributed Stasiun Pengisian Kendaraan Listrik Umum (SPKLU) locations are needed to ensure service accessibility and operational efficiency. Previous studies on SPKLU planning generally relied on buffer analysis focused on demographic variables, resulting in uneven infrastructure distribution. However, socio-economic factors also influence purchasing power and charging demand, indicating the need for a more comprehensive analytical approach. This study aims to develop a reliable prediction model for identifying potential SPKLU locations by integrating spatial and socio-economic variables. Geographic Information System (GIS) techniques are combined with machine learning algorithms, namely Multi-Layer Perceptron (MLP) and Support Vector Machine (SVM). Spatial datasets from OSM, Geofabric, and Open Data West Java are collected and processed through proximity analysis to classify locations into Shared-Residential, Enroute, and Destination categories. These outputs are merged with socio-economic variables such as population density, income level, vehicle ownership, household characteristics, education level, and age distribution. The results show that the MLP model performs best, achieving an accuracy of 92.8%. The most influential variable is the number of productive-age residents, minority population, unemployment, and total population. The study concludes that demographic and socio-economic factors significantly influence SPKLU suitability.**

Keywords: SPKLU, GIS, Multi-Layer Perceptron, Support Vector Machine, Socio-Economic

I. INTRODUCTION

The use of electric vehicles in Indonesia is one of the Government's efforts to realize the "Go Green and Net Zero Emission" program in 2060. To realize this challenge, proactive steps and strict management implementation are needed to control and minimize emissions produced by vehicles[1].

The Head of the Energy and Mineral Resources Agency revealed that the number of electric vehicle users in West Java as the research, reached 29,465 in 2024[2]. This shows that interest in using electric vehicles is increasing every year. This growth indicates an urgent need for supporting infrastructure to ensure the convenience and sustainability of electric vehicle use, particularly Stasiun Pengisian Kendaraan Listrik Umum (SPKLU) as the primary charging facilities.

Previous studies on SPKLU planning have predominantly relied on spatial buffer analysis and demographic indicators to identify suitable charging locations, which often led to infrastructure recommendations that were uneven and spatially biased [3]. Although demographic variables such as population density and vehicle ownership provide useful baseline insights, they do not fully capture the complex behavioral and economic dimensions that influence EV adoption [4]. Recent literature highlights that socioeconomic attributes including income level, household expenditure, employment status, and poverty distribution play a critical role in determining purchasing power, charging affordability, and long-term EV market demand [5] . However, these variables were frequently simplified or excluded in earlier suitability models, resulting in limited predictive accuracy and reduced planning relevance at local scales [6]. For instance, several location-allocation studies prioritized proximity and mobility factors without incorporating income inequality or economic segmentation, which led to planning outcomes that favored high-density urban areas while neglecting suburban and lower-income communities [7].

Addressing this gap, the present study introduces a more comprehensive predictive framework by integrating both spatial and socioeconomic variables to access SPKLU feasibility. By incorporating indicators such as income distribution, employment ratios, household composition, and socio-demographic structure, the proposed model improves the contextual relevance of suitability results and enhances sensitivity to real-world EV adoption potential. This expanded

variable set supports a more accurate, equitable, and demand-responsive understanding of charging needs, representing a significant methodological advancement beyond previous approaches. Addressing this gap, the present research introduces a more comprehensive predictive by integrating both spatial and socioeconomic variables to assess SPKLU feasibility.

Spatial analysis in this research is conducted using Geographic Information System (GIS), to integrate diverse geospatial layers such as proximity to infrastructure, land use, and accessibility criteria into a unified suitability model that captures spatial patterns which cannot be captured by simple buffer or demographic techniques alone, as demonstrated in recent EV charging station studies that combine GIS with advanced analytical methods [8]. The spatial outputs generated through GIS are then combined with socio-economic variables and processed using machine learning algorithms such as Multi-Layer Perceptron (MLP) and Support Vector Machine (SVM) to capture complex nonlinear relationships and classification boundaries within the data, resulting in a robust predictive model for optimal SPKLU location identification [9].

A similar approach was also found in the multistage model [10], which incorporated MLP within a spatio-temporal demand prediction framework to produce more precise infrastructure needs estimates. MLP, as a multilayer neural network, is capable of learning intricate and nonlinear variable interactions, which strengthens its ability to identify spatial and socio-economic patterns associated with charging demand. Prior studies have reported that MLP achieved high prediction accuracy often exceeding 90% in EV charging usage modelling and demand forecasting scenarios, outperforming basic neural structures and decision-tree-based approaches [11]. On the other hand, the SVM algorithm is widely used for classification tasks related to the feasibility of charging station locations, [12] which utilized SVM to assess potential locations based on demographic criteria, accessibility, and traffic density. Furthermore, the [13] showed that SVM excels in predicting the availability and success of charging slot reservations at stations, thereby helping operators identify points at risk of over and under-utilization. Recent comparative evaluations have shown that SVM models achieved accuracy levels between 85% and 92% in EV infrastructure feasibility classification tasks, surpassing several baseline models such as logistic regression and random forest in smaller sample settings [11]. Overall, MLP provides strong demand prediction capabilities, while SVM plays an important role in classification and determining location feasibility, making it a relevant combination in SPKLU analysis and planning.

Building upon these previous findings, the present research expands the application of MLP and SVM by focusing the analysis on the integration of spatial data and geolocation parameters such as road networks, housing, apartment, parking and amenities (university, school and hospital) by GIS technology to form indicators of the feasibility of SPKLU locations in West Java Province. The purpose of this research is to assess the feasibility of locations based on the type of charging usage and compare the effectiveness of MLP and SVM algorithms in classifying SPKLU feasibility using features obtained from spatial data extraction. In addition, this research also visualizes the distribution of feasible SPKLU locations based on the best-performing model into a thematic map, thereby providing spatial information support for future infrastructure planning.

II. METHODOLOGY

The research methodology was carried out using two phases, namely data preparation for the analysis process with GIS and the analysis stage using the MLP and SVM algorithms.

A. Studi Area

The study area in this research is the administrative area of West Java province, as presented in Fig. 1. West Java is located in the western part of Java Island, bordering the DKI Jakarta province to the north, Banten Province to the west, and Central Java Province to the east. To the south, West Java borders the Indian Ocean. The total area of West Java is approximately ± 35,378 km², making it one of the largest provinces in Indonesia[14]. West Java Province has high geological complexity, consisting of various rock formations that are divided into three main zones, namely, the geology of the North zone (Bekasi, Karawang, Subang) which has the characteristics of young alluvial lowlands, dominated by clay and sand deposits, fertile and relatively stable soil suitable for housing and industry, then the central zone (Bandung, Sumedang, Cianjur) which has the characteristics of volcanic plateaus, dominated by andesite rocks, breccias, tuffs, traces of ancient volcanic activity, has the risk of earthquakes and landslides. This region is very densely populated, especially Greater Bandung and the southern zone (Garut, Tasikmalaya, and Sukabumi). It features folded mountains and igneous/plutonic rocks, numerous active faults, relatively unstable, steep, and landslide-prone soils, but is fertile for agriculture, and the population is more sparsely distributed. West Java Province has a total of 27 administrative regions, divided into nine cities: Bandung, Banjar, Bekasi, Bogor, Cimahi, Cirebon, Depok, Sukabumi, and Tasikmalaya. It also comprises 18 administrative districts: Bandung, West Bandung, Bekasi, Bogor, Ciamis, Cianjur, Cirebon, Garut, Indramayu, Karawang, Kuningan, Majalengka, Pangandaran, Purwakarta, Subang, Sukabumi, Sumedang, and Tasikmalaya.

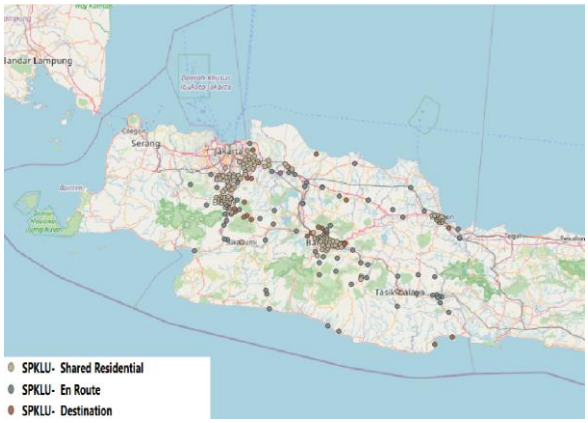

Fig. 1. Study area of research West Java with SPKLU point

B. Methodology

Research methodology process begins by determining the location parameters for SPKLU based on spatial analysis using QGIS software, then modeling classifying SPKLU location types using a comparison of the MLP and SVM algorithms

1. Preparation Data
   - Gather spatial datasets from the three sources shown: OpenStreetMap (OSM) for road networks, housing, apartments, parking, and public amenities (schools, hospitals, universities); Geofabrik for administrative boundary shapefiles (West Java); and OpenData Jabar for existing SPKLU point locations.
   - Data sample preparation to inspect the SPKLU point dataset for duplicates, missing coordinates, incorrect attributes, or outliers.
   - Boundary clipping using Administrative Boundaries
   - Use the West Java administrative polygon to clip all OSM-derived layers and other datasets so the analysis extent is constrained to the study area. This ensures consistency and reduces processing load.
   - Convert each thematic vector layer to raster at a defined spatial resolution (cell size).
   - For each raster layer, compute proximity (distance-to-feature) raster's using GIS proximity/distance tools.
   - Optionally compute Kernel Density Raster's (KDE) for point datasets to capture concentration.
   - Convert raw distance raster's to suitability indicators with reclassify distances into suitability scores or continuous normalized values.
   - Normalization of data values
   - Overlay Data
   - From the composite suitability map, segment areas into the three target categories:
     - Shared Residential SPKLU: locations of housing
     - Road Route SPKLU: Enroute locations
     - Destination Type SPKLU: Malls, University, Office.
2. Kernel Density Estimation (KDE), compute KDE for relevant point data (e.g., existing SPKLU, population centers, amenities) to produce continuous density surfaces. Extract KDE values at sample locations and add them as features to the dataset.
3. Input parameter of socio-economic as variable predictor such as population, median household income, total household, vehicles mode, minority population, population below poverty level, population density, population with college education, household size, vehicle ownership, and median age
4. Data Analysis, the extracted data was analyzed and divided into two parts such as testing and training data
5. Architecture Model, two types of machine learning algorithms were used as the model architecture such as Multi-Layer Perceptron (MLP) and Support Vector Machine (SVM)
6. Evaluation Model, the two models were compared using the following evaluation metrics such as Precision, Accuracy, Recall, and F1 Score
7. Best Model, the model with the best performance based on the evaluation was selected as the final model for classifying SPKLU locations.
8. Map Layout, the classification results were visualized as a map of SPKLU locations classified according to their types.

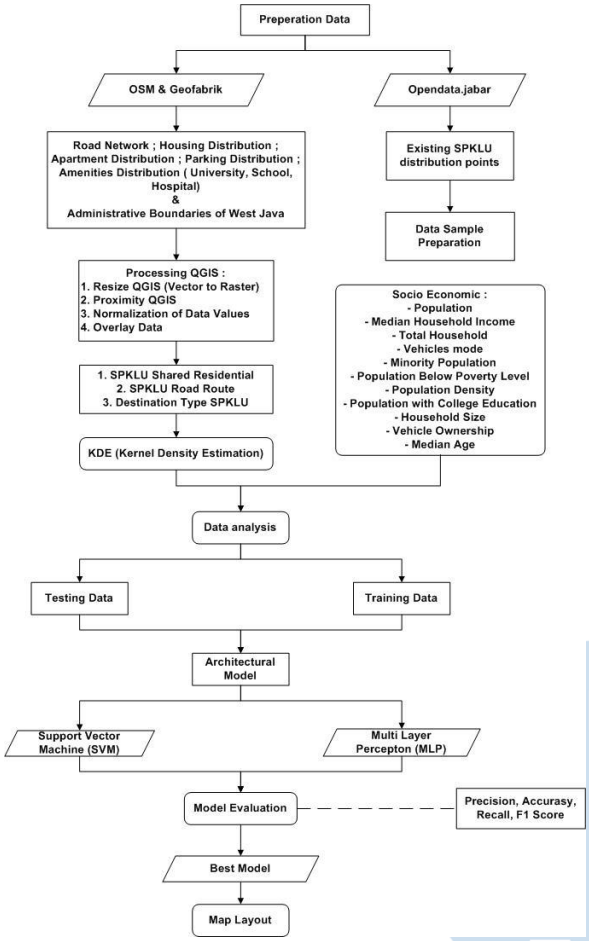

Fig. 2. Methodology

C. *Multi-Layer Perceptron (MLP)*

The Multi-Layer Perceptron (MLP) is a type of artificial neural network designed to learn complex, non-linear relationships between input variables and an output target. In the context of predicting potential SPKLU locations, MLP is used to determine whether a given location (represented as feature data) has high suitability for SPKLU placement[15]. The MLP architecture is as follows (Fig. 3.):

1. Input Layer: Feeding the SPKLU Predictors
   In this research, each sampled location is represented using many features derived from spatial and socio-economic data. These include:
   - Spatial suitability scores (Shared-Residential, Enroute, Destination)
   - KDE-based density scores
   - Population characteristics (productive-age population, minority population, total population)
   - Socio-economic indicators (income, poverty, unemployment)
   - Infrastructure-related variables (vehicle ownership, household distribution)
   - Educational and demographic variables (education index, median age)
2. Hidden Layers: Learning Non-Linear Relationships
   MLP contains one or more hidden layers with neurons that apply activation functions such as ReLU or sigmoid [16]. These layers learn:
   - Patterns between demographic variables and demand for charging stations
   - Spatial relationships (e.g., distance to roads or public facilities)
   - Interactions between socio-economic conditions and EV adoption potential
   - Non-linear combinations of variables that a simple statistical model cannot capture
3. Output Layer: Predicting SPKLU Suitability
   The output layer produces a binary prediction or probability score indicating whether the location is suitable for SPKLU development:
   - 1 or high probability → Suitable
   - 0 or low probability → Not suitable
4. Learning Process: Training With Existing SPKLU Locations
   The MLP learns by comparing its predictions with known existing SPKLU points:
   - Training samples with "SPKLU" (positive class)
   - Background or non-SPKLU samples (negative class)

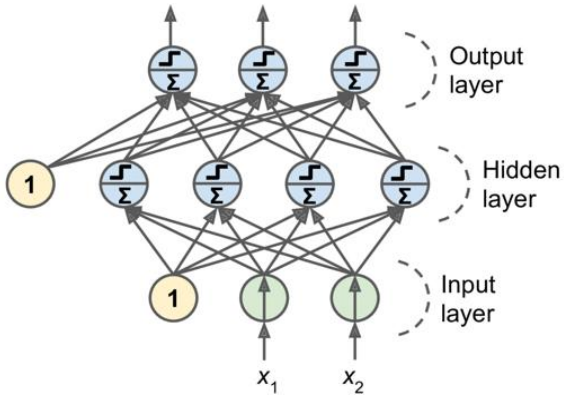

Fig. 3. Architecture of MLP

D. *Support Vector Machine (SVM)*

A Support Vector Machine (SVM) is a supervised classifier that learns to separate "suitable" vs. "unsuitable" locations for SPKLU by finding an optimal decision boundary (hyperplane) in a multi-dimensional feature space. Concretely, an SVM computes a function of the form

$$f(x) = sign(w \cdot x + b) \quad (1)$$

where x is the input feature vector (e.g. spatial coordinates and socio-demographic attributes of a candidate site), w is a learned weight vector, and b is a bias term. The algorithm chooses w and b to maximize the margin, the distance between the boundary and the nearest training points of each class[17].

The SVM takes as input a vector of spatial and socio-economic features describing each candidate site. Spatial features might include the site's geographic coordinates or derived measures such as distance to the nearest road, proximity to city centres or public transit, or local land-use indicators. Socio-demographic features can include population density, average income, vehicle ownership levels, existing SPKLU adoption rates, or usage patterns in the area. SVM handles nonlinearity via kernel functions that implicitly map the input features into a higher-dimensional space. Instead of computing $\varphi(x)$ explicitly, the SVM uses a kernel function

$$K(x, x') = \varphi(x) \cdot \varphi(x') \quad (2)$$

that returns inner products in feature space. Common kernels include linear, polynomial, sigmoid, and the Radial Basis Function (RBF)[18]. The SVM architecture is as follows (Fig. 4.):

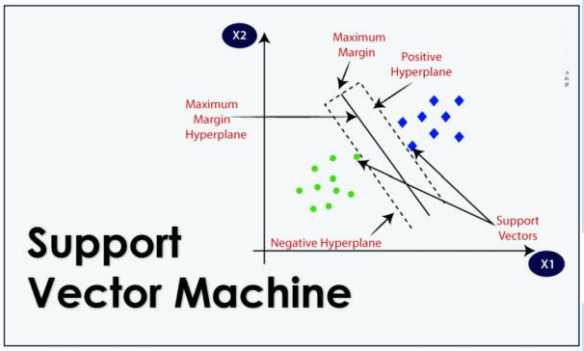

Fig. 4. Architecture of SVM

E. Evaluation Model

After developing the prediction models, we performed a validation test to assess their accuracy by comparing the predicted values with the actual values from the previously partitioned testing dataset. To evaluate model performance, a confusion matrix was employed, where accuracy is calculated as the percentage ratio between the sum of true negatives (TN) and true positives (TP) and the total number of testing samples, as shown in Table 1.

TABLE I. CONFUSION MATRIX OF MODEL VALIDATION

	Predicted: No SPKLU (0)	**Predicted: SPKLU exist (1)**
Actual: No SPKLU (0)	True Negative (RN)	False Positive (FP)
Actual: SPKLU exist (1)	False Negative (FN)	True Positive (TP)

III. PREVIOUS RESEARCH

Several previous researches have explored the spatial aspects of SPKLU. One such research, "Examining Spatial Disparities in Electric Vehicle Charging Station Placements Using Machine Learning," examined the spatial disparities in the distribution of Electric Vehicle Charging Stations (EVCS) in Orange County, California. Random Forest algorithm successfully identified areas with low access to charging facilities 11.04% of the county that required prioritizing investment. The model achieved 94.9% accuracy at a spatial resolution of 3 km, demonstrating that social, economic, and demographic factors have a significant influence on more equitable and equitable EVCS planning[19].

Another research in Indonesia highlighted the optimization of SPKLU locations through a geospatial approach. The research, titled "Optimizing SPKLU Development Locations Using Geographic Information Systems in Medan City with the Buffer Analysis Method," utilized buffer analysis to determine the most potential areas for providing SPKLU[20]. Through spatial data processing, the research produced a digital map depicting the adequacy of SPKLU coverage in Medan City. These findings underscore the importance of utilizing GIS to support equitable access and electric vehicle infrastructure planning in urban areas.

Furthermore, "Research of Electric Vehicle Charging Facility Development in the Greater Bandung Area," broadens the scope of the analysis by incorporating the perspectives of various stakeholders[21]. Conducted over three years through literature review, field surveys, and focus group discussions. The research emphasized the role of collaboration between the government, academics, and the electric vehicle user community. The research resulted in recommendations for infrastructure development aimed at reducing greenhouse gas emissions, minimizing dependence on fossil fuels, and strengthening the electric vehicle ecosystem in the Bandung metropolitan area.

A machine learning-based approach to determining SPKLU locations is also seen in the research "Decision Support System for Determining the Location of Stasiun Pengisian Kendaraan Listrik Umum (SPKLU) with Machine Learning." with combining the Analytic Hierarchy Process (AHP) method and geospatial data processing. This research assesses the feasibility of SPKLU locations in Ambon City based on criteria of accessibility, population density, and electricity infrastructure conditions. The model results recommend several strategic points, including Jalan Yos Sudarso, which is considered the most effective for SPKLU development and has a positive impact on economic growth and carbon footprint reduction.

In addition to location and spatial feasibility approaches, several studies have highlighted the

technical aspects of electric vehicle charging. The research of, "Application of Deep Learning and Reinforcement Learning with Convolutional Neural Network Methods for Electric Vehicle Charging in Smart Grids," focuses on predicting charging load profiles in smart grids[22]. The study utilized various deep learning architectures such as ANN, LSTM, GRU, and ANFIS. The results showed that ANFIS provided the highest accuracy in predicting charging patterns influenced by seasonal factors. These findings provide an important basis for electric vehicle energy management to be more efficient and responsive to demand fluctuations[23].

IV. Result and Discussion

A. *Data Preparation*

Several predictor and respon variables used in the analysis process are converted into raster map. The response variables used in this research are proximity of Kernel Density Estimation (KDE) that obtained from phase 1 divided into three categories such as SPKLU Shared-Residential, SPKLU Enroute and SPKLU Destination [24] (Fig. 5.).

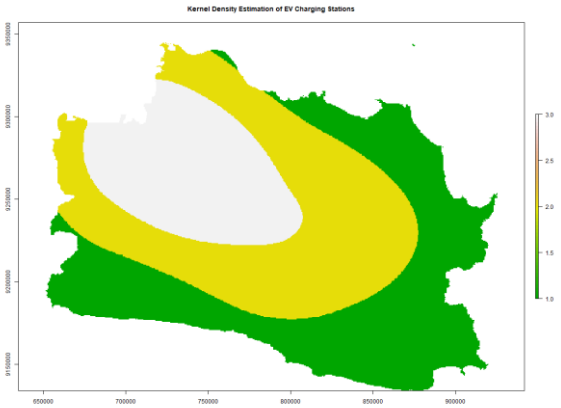

Fig. 5. Kernel Density Estimation (KDE)

Next, the predictor variables used in the analysis process are socio-economic. (Fig. 6.).

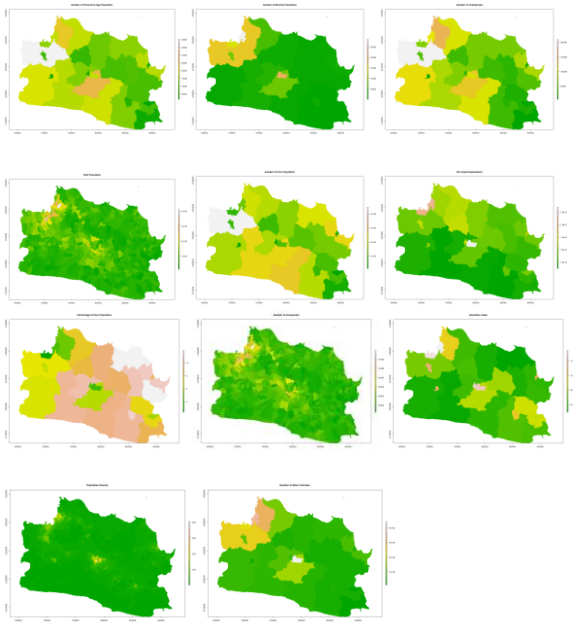

Fig. 6. Variabel predictor such as number of productive-age population, number of minority population, number of unemployed, total population, number of poor popuation, per capita expenditure, percentage of poor population, number of household, education index, population density, and number of motor vehicles

The data used in this research amounted to 147,911 with a total of 12 variables. As for the predictor variables encompass key socio-economic indicators, including the number of productive-age individuals, minority populations, unemployed persons, total population, poor populations, per capita expenditure, percentage of poverty, number of households, education index, population density, and the number of motor vehicles. These variables collectively represent demographic pressure, economic capacity, and mobility demand, making them essential determinants for spatial modeling and strategic planning of SPKLU infrastucture [25](Table II).

TABLE II. Predictor and Respon Variable

No	KDE	number of poor popuation	number of motor vehicles	population density	number of household	number of minority population	education index	total population	number of unemployed	per capita expenditure	percentage of poor population	number of productive-age population
1	2	204500	307404	3.196	14296	164728	69.14	40845	142818	12500000	4.80	2354038
2	2	204500	307404	3.196	14296	164728	69.14	40845	142818	12500000	4.80	2354038
3	2	204500	307404	3.196	14296	164728	69.14	40845	142818	12500000	4.80	2354038
4	2	204500	307404	3.196	14296	164728	69.14	40845	142818	12500000	4.80	2354038
5	2	204500	307404	3.196	14296	164728	69.14	40845	142818	12500000	4.80	2354038
…	…	…	…	…	…	…	…	…	…	…	…	…

114	1	187800	135737	4.637	20516	51786	60.75	52050	100404	12942000	7.86	1810263
115	1	187800	135737	4.637	20516	51786	60.75	52050	100404	12942000	7.86	1810263
116	1	187800	135737	4.637	20516	51786	60.75	52050	100404	12942000	7.86	1810263
117	1	187800	135737	4.637	20516	51786	60.75	52050	100404	12942000	7.86	1810263
118	1	187800	135737	4.637	20516	51786	60.75	52050	100404	12942000	7.86	1810263
…	…	…	…	…	…	…	…	…	…	…	…	…
67187	3	175900	67146	12.656	32349	8980	58.88	87354	107550	9815000	6.87	1934988
67188	3	175900	67146	14.830	17838	8980	58.88	54697	107550	9815000	6.87	1934988
67189	3	175900	67146	14.830	17838	8980	58.88	54697	107550	9815000	6.87	1934988
67190	3	175900	67146	14.830	17838	8980	58.88	54697	107550	9815000	6.87	1934988
67191	3	175900	67146	14.830	17838	8980	58.88	54697	107550	9815000	6.87	1934988

B. Model of Multi-Layer Perceptron

The train:test dataset ratio in this research is 80:20. The variable importance results from the MLP analysis can be seen in Fig. 7.

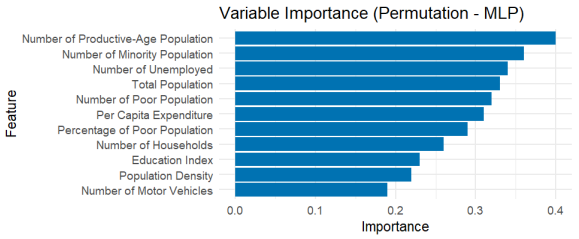

Fig. 7. Variable importance of MLP

Based on Fig. 8, the three variables that most influence the SPKLU prediction are the productive-age population (40%), the minority population (35%-40%), and the unemployed (30%-35%). The analysis results are then mapped to the West Java region. The map layout for the predicted SPKLU placement generated using the Multi-Layer Perceptron (MLP) method for the West Java region is shown in Fig. 8.

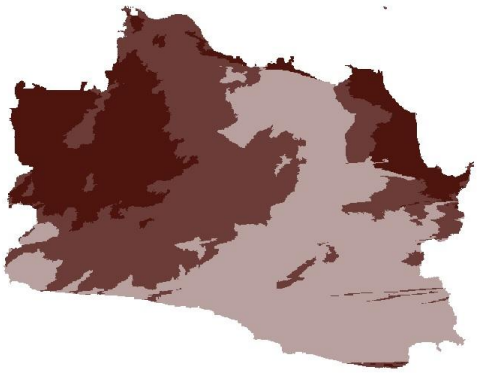

Fig. 8. Model MLP SPKLU

C. Model of Support Vector Machine

The variable importance results from the SVM analysis can be seen in Fig. 9.

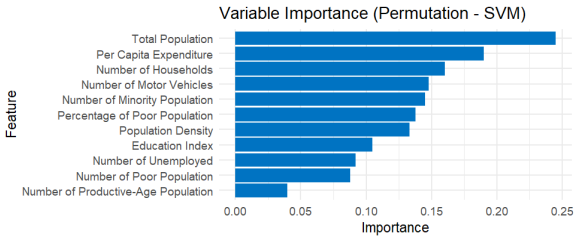

Fig. 9. Variable importance of MLP

The analysis in Fig. 10 indicates that the most influential predictors for SPKLU placement are total population (20%-25%), followed by per capita expenditure (17.5%–20%) and the number of household (15%–17.5%). These findings were subsequently visualized across the West Java area. The resulting spatial distribution of predicted SPKLU locations produced by the SVM model for West Java is presented in Fig. 10.

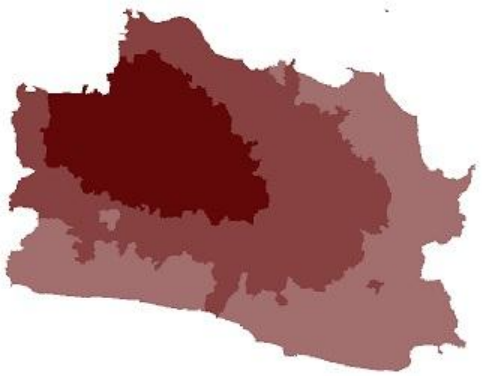

Fig. 10. Model MLP SPKLU

D. Model Evalution

The performance comparison between MLP and SVM shows (Table III) that both models achieve strong classification results across all three classes, with MLP demonstrating a slightly more balanced performance overall. For Class 1, MLP attains marginally higher precision, recall, and F1-score than SVM, indicating better consistency in identifying Shared-Residential

locations. In Class 2, MLP again performs slightly better in all metrics, suggesting stronger reliability for Enroute category predictions. Although SVM achieves the highest precision for Class 3, MLP maintains superior recall, resulting in an equal or slightly higher F1-score, reflecting more stable performance for Destination class classification. Overall, MLP exhibits slightly stronger and more consistent predictive capability across all classes, reinforcing its suitability as the preferred model for SPKLU location prediction.

TABLE III. CLASS-WISE METRICS

Class	Precision		Recall		F1	
	MLP	SVM	MLP	SVM	MLP	SVM
1	0.938	0.934	0.931	0.919	0.935	0.926
2	0.903	0.891	0.910	0.912	0.906	0.901
3	0.955	0.963	0.955	0.954	0.955	0.958

Meanwhile, the accuracy results of the two models can be seen in the following table IV:

TABLE IV. ACCURACY MODEL

Model	Accuracy (%)	AUC
MLP	92.8	0.93
SVM	92.4	0.90

At Table IV, the accuracy comparison shows that both models between MLP and SVM perform very well in predicting SPKLU location classifications, with only a slight difference between the two. MLP achieves the highest accuracy at 92.8% and AUC 0.93, indicating its slightly superior ability to learn complex spatial–socio-economic patterns in the dataset. Meanwhile, SVM also demonstrates strong performance with an accuracy of 92.4% and AUC 0.90, suggesting that it remains a reliable alternative despite its marginally lower score. Overall, these results confirm that both machine learning models are highly effective, but MLP provides the best predictive capability for this study.

V. CONCLUSION

This study demonstrates that integrating GIS-based spatial analysis with machine learning provides an effective framework for predicting optimal SPKLU locations in West Java. By combining proximity features with socio-economic variables processed through KDE, the model particularly the MLP classifier with 92.8% accuracy successfully identifies areas with high potential demand. The dominance of demographic predictors, especially the productive-age population, underscores the importance of human-activity patterns in determining strategic SPKLU charging infrastructure placement. These findings highlight that data-driven spatial modeling can significantly support evidence-based decision-making for SPKLU infrastructure planning, ultimately enhancing the efficiency, accessibility, and sustainability of Indonesia's transition toward low-carbon mobility.

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Needle Stick Injury Report Application Design at XYZ Hospital in Tangerang

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Abstract — **Needlestick injuries are common among healthcare workers. There is a potential risk of transmitting HBV, HCV, and HIV infections to healthcare workers due to needlestick accidents. At XYZ Hospital, reporting is done manually using paper-based forms that must be completed and submitted to other departments. To expedite the process, the forms are photographed and sent via WhatsApp. Manual reporting is still considered inefficient, so a web-based reporting application was created that can be accessed quickly and easily via mobile phones, tablets, and laptops. To ensure the project meets user needs, this application is created using a prototyping methodology, so that it can be completed on time according to user needs. By implementing a web-based reporting application, reporting, tracking, and documentation can be simplified and streamlined by reducing physical/paper documents and shifting to digital documents. This could simplify the reporting process and organize archives efficiently using digital technology.**

Keywords — **Application, Hospital, Needle Stick Injury, Prototype, Web Responsive, Website.**

I. PRELIMINARY

Safety, security, and health are important things that need to be achieved in various types of work. To achieve safety, security, and health in the workplace, it is necessary to pay attention to several factors that can endanger workers. Based on research conducted by Wayan et al [1], workload, work stress, and sleep quality have a significant impact on work fatigue so that it can have a fatal impact on worker safety. At the end of 2019, the world of health was overwhelmed by the Corona Virus Disease 2019 or also known as COVID-19. COVID-19 has caused a global health crisis, Indonesia is also not immune to the transmission of COVID-19. In March 2020, the COVID-19 pandemic hit Indonesia, resulting in an increase in infection cases. The increase in patients also had an impact on health workers. Based on research conducted by Hendrastutik et al [2] regarding the Prevention of Covid-19 Transmission in Health Workers at Sebelas Maret University Hospital, one of the problems experienced by health workers is fatigue due to the increase in patients and busy schedules.

According to Dadan et al [3], the impact of fatigue on healthcare workers is negligent actions (unsafe actions) that can lead to needle stick injuries. According to Chiarello et al [4], needle stick injuries are a term used to describe injuries caused by needles or other sharp medical instruments contaminated with patient blood. Needle stick injuries themselves have a significant impact on healthcare workers' health, such as the risk of contracting diseases present in the patient's blood.

At XYZ Hospital in Tangerang, needle stick injuries are also common among healthcare workers. One contributing factor is the busy schedules of healthcare workers, which leads to fatigue and negligence, which can have fatal consequences, such as needle stick injuries.

According to Brela et al [5], there are several potential risks of transmission through needle stick injuries accident to healthcare workers include infection with Human Hepatitis B Virus (HBV), Human Hepatitis C Virus (HCV), and Human Immunodeficiency Virus (HIV). According to Amilah, incidents with acute impacts resulting from needle stick injuries are more common among hospital workers than in other occupations [6]. With the probabilities of HIV of 4:1000, HBV of 27-37:100 and HCV of 3-10:100 [6].

Based on the needle stick injury reporting guidelines published by the Faculty of Medicine at sebelas maret university, contaminated needle stick injuries must be immediately disinfected with isopropyl 70% alcohol antiseptic, then washed with flowing water and soap or antiseptic [7]. Reports should then be made to superiors, the Patient and Public Involvement (PPI) Committee, and the Hospital Workers Health and Safety Care or well known as “Kesehatan dan Keselamatan Kerja Rumah Sakit” (K3RS). In the next steps, the HIV/HBV and HCV status will then be determined based on the source of exposure/infection. The K3RS procedures is needed to be implemented properly to minimize various cases of work accidents [8].

According to an article published on the Sardjito Hospital website, exposed personnel are required to report to the person in charge of the room or the person in charge of supervising care [9]. Needle stick injuries reporting is generally still done by manual process, it’s all done by delivered the consultation letter from the doctor in charge. Healthcare workers who experience needle stick injuries accident must done the reporting

activities to the internal medicine clinic during working hours, if the accident happened in off-hour, they needed to do the reporting to the Emergency Department (ED) for further treatment [6]. At XYZ hospital, reporting is done manually using paper-base form that must be completed and submitted to other departments that handle the needle stick injury reporting. To expedite the process, the form is photographed and sent via WhatsApp.

In the reporting and documentation process, there are several things need to be included such as the time, day, and date accident happened, location, chronology of the incident, the exposed area, the cause, the source of exposure (blood, feces, or urine), and the volume of exposure/contaminations. The status of the exposed healthcare worker (patient with a history of certain medical conditions) will then be determined. After determining the healthcare worker's status as a patient, the exposed healthcare worker's status will be determined whether they infected by hepatitis B or not. If the source of exposure is unknown, HCV, HIV, and HBV status will be examined. If the exposed healthcare worker is free of HCV, HBV, or HIV and is not in the incubation period, no special action is required, but counseling is still permitted if there is any doubt [6].

At XYZ Hospital, the reporting process is carried out by standard procedures, but the reporting system is done manually, which can be time-consuming. Given the need for immediate treatment, a computerized system is needed to make the reporting easier and digitize reporting to make it more efficiently. According to Cusumano et al [10], digitalize documentations are essential for improving data quality and standardization for automation.

According to Scott et al [11], digitizing hospital records reporting will be more consistent and clear, and it can optimize the reliability and usability of digital medical records, even for internal employee medical records, such as needlestick injuries.

Based on case at XYZ Hospital, reporting needs to be done quickly, so website-based reporting was chosen. Using a web-based application is considered easier because it can be accessed from a hospital desktop, a personal laptop, a tablet, or a mobile device like a cell phone/mobile phone. By using a web-based application, it allows faster reporting without the need to install any software.

II. *METHODOLOGY*

The project will be carried out using the prototype methodology, which is a methodology that focuses on the main functions and initial testing. This methodology has proven effective in creating applications within a limited time and is able to meet user needs as shown in the creation of the Syllabus Management System and Coordinator Recommendation System application at Multimedia Nusantara University [12]. In the “Syllabus Management System and Coordinator Recommendation System application at Multimedia Nusantara University” project development, the prototype methodology has proven to be able to be used to build web-based applications that focus in detail on user needs.

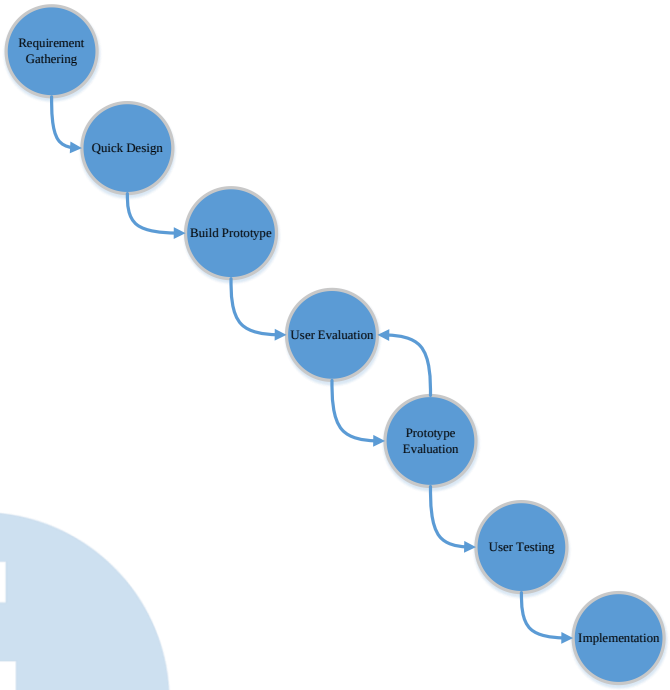

Fig. 1 7 steps prototype methodology

The prototype methodology consists of 7 steps as shown in fig 1, here are the 7 steps.

1. In the initial stage, Requirement Gathering will be carried out to obtain user needs, after which analysis and design will be carried out related to the requirements obtained.
2. In the second stage, a Quick Design will be conducted so that users can view and check the input and output in the draft/sketch as a form of confirmation to the user. At this stage, users will check and confirm the completeness of the application in draft/sketch form.
3. In the third stage, a prototype will be created based on a draft/sketch in the form of a usable application (demo app).
4. In the fourth stage, the prototype will be evaluated by the user. At this stage, the user will determine whether the prototype meets their needs or not. If the prototype does not meet these requirements, revisions will be made to the previous stage.
5. In the fifth stage, the prototype will be evaluated and improvements made to better meet the project's needs. Iterations will occur at this stage, repeating the process until the prototype meets user expectations.
6. In the sixth stage, user testing is conducted. If there are still deficiencies, further improvements will be made.
7. In the seventh stage, implementation and maintenance are carried out to ensure the application can be used by all users in real time. Regular

maintenance is performed to ensure the project runs smoothly in the future.

Prototypes, also known as "Proof of Concept," emphasize the successful achievement of the main idea or concept, rather than a perfect final product. This is because the website-based application being developed needs to focus more on its functionality as a reporting application. By using the prototype methodology, the project can be completed by a relatively small development team, thus reducing costs.

III. RESULTS

1. In the initial stage, user requirements were gathered through documentation samples and user needs analysis. Users explained that the current needlestick injury reporting system was paper-based and manual, and the system was difficult to monitor due to the loss of paper documentation.

Furthermore, in the reporting standards based on the documentation sample provided there is information/data that must be filled in and meet standards. In addition, there is some additional information related to the needs of XYZ Hospital. Some of the standard information required includes:

a. The date of incident happened, uses the time of reporting as the default for user convenience but can be changed according to the time of the incident.
b. The date of reporting, by using the time of the report submitted based on system date and cannot be changed manually.
c. Victim identification data including the victim's name, telephone number, occupation, location of the incident, immediate supervisor, and the supervisor's telephone number.
d. Route of exposure, users can choose several option due to route of exposure, bite, mouth (exposure via oral splashes), skin injury, eye (exposure via splashes to the eye), and other options that can be filled in by the user.
e. Source of exposure that can be filled with text. In the process, all forms of date and time will use the current default date and time so that it can make input easier for users.

Users also need an article features to post any information about prevention and treatment methods for workers who experience needle stick injuries. The article also required multiple images inside the content to improve the reader experience with rich text format by adding picture or graphic, tables, videos and other rich formats just like an article.

This web apps has 2 types of users : as a User and an Admin.

1. Users can use the apps as a reporting system for needle stick injuries. Additionally, users can read articles on the website about initial treatment steps and steps to prevent needle stick injuries.
2. Admin uses the application to receive reports submitted by the users. These reports will then be followed up on or added to a list of monitored users. Additionally, admin can input articles to help users better understand how to handle and anticipate needle stick injuries.

When a needle stick injury incident happened, users can report it by filling out a digital form on the website, either personally or with the assistance of another healthcare professional.

After reporting, the needle stick injury wound will be treated by professional while the report will be received by an administrator. The administrator will then review the report and action taken to ensure the users receives an appropriate safety precautions.

Admin can print/download the report form format according to the hospital's standard format and mark the report status as has been handled/complete/done.

2. Based on the user requirements, the process continues to the second stage. The quick design conducted by using HTML & CSS to build the reporting input form and output based on the required data in previous stage as showed in figure 2. This step focuses on the NSI reporting input form and output design to ensure the design meets user needs.

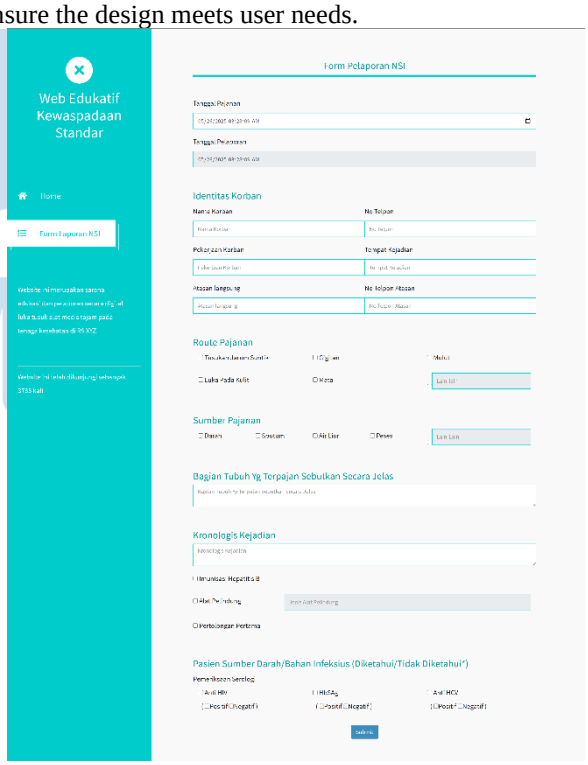

Fig. 2 Needle stick injury reporting form in desktop view mode

The application made using a web-based application to make it accessible from any device such as hospital desktop/PC, a personal laptop, a tablet, or a mobile device like a cell phone. Further more the website needed responsive features to fit the desktop or mobile phone view mode as showed in figure 3. To achieve responsive technology, bootstraps are used. Bootstraps

are used to create websites using a 12 column grid system produces a website layout that automatically adjusts to the width of the user's browser [13].

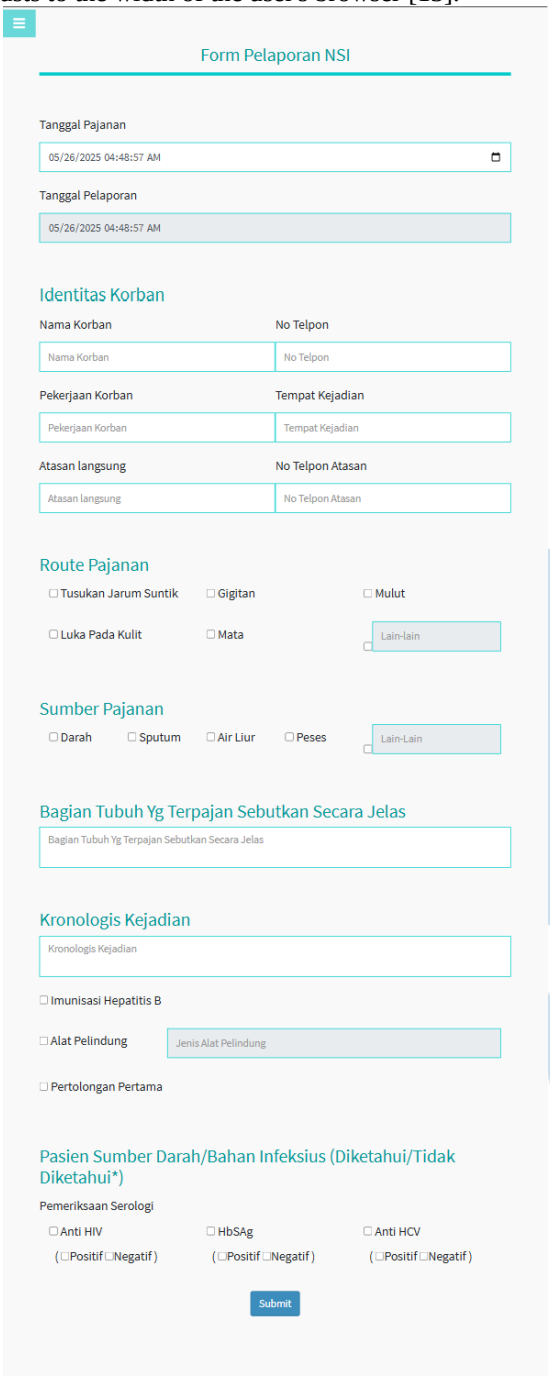

Fig. 3 Needle stick injury reporting form in mobile view mode

To ensure that the output has exactly the same design as the official form, layout adjustments are made to ensure the design is appropriate as showed in figure 4. The output format stored in the database and can be accessed via website, and can also be printed or saved in PDF format.

FORMULIR LAPORAN INSIDEN TERTUSUK JARUM/TERPANJAN CAIRAN TUBUH

Tanggal Pelaporan : 2025-05-26 Jam : 05:05:04
Tanggal Pajanan : 2025-05-26 Jam : 05:03:04

Identitas Korban :
Nama : Yuni
Pekerjaan : Dokter
Atasan Langsung : dr. Amirudin
No Telp : 081234567890
Tempat Kejadian : IGD Bed 1
No. Telp. Atasan : 08098765432 1

Route Pajanan :
☑ Tusukan Jarum Suntik ☐ Gigitan ☐ Mulut
☑ Luka Pada Kulit ☐ Mata ☐ Lain-lain

Sumber Pajanan :
☑ Darah ☐ Sputum ☐ Air Liur ☐ Peses ☐ Lain-lain

Bagian Tubuh Yang Terpajan Sebut Secara Jelas :
Lengan tangan kanan

Kronologi Kejadian :
Jarum suntik bekas pasien terlepas dan tertusuk secara tidak sengaja

- Imunisasi Hepatitis B Sudah ~~Belum~~
- Alat Pelindung Dipakai ~~Tidak~~ Jenis APD standard
- Pertolongan Pertama Ada ~~Tidak~~

Pasien Sumber Darah/Bahan Infeksius (Diketahui/Tidak Diketahui*)
Pemeriksaan Serologi
☑ Anti HIV (~~Positif/Negatif~~) ☐ HbSAg (Positif/Negatif) ☐ Anti HCV (Positif/Negatif)

Mengetahui
Atasan Langsung

Tanggal : 2025-05-26
Pegawai Terpajan

(_____) (_____)

Fig. 4 NSI report output format

3. The process then continues to the third stage. Build prototype conducted by using HTML & CSS continues the previous process by combining with Javascript to make the webpage more interactive and PHP & MySql as the server side combined to make the website complete.

In this step the website build using a PHP custom framework. This framework could generate backend UI, database query connectivity, security, encryption etc easily. The custom framework is also lighter to run on servers with low specs.

Apart from the primary features, there are also article feature requirements. Based on those requirements, the article features need rich text format. To meet these requirements, What You See Is What You Get (WYSIWYG) technology is used to make things easier for the users to add images within text, list items/bullets for steps, highlight text with colour, colorize text, bold text, underline text, resize text, etc as showed in figure 5. Thus WYSIWYG features also make the audience easier to understand the articles [14]. NicEdit was chosen as the WYSIWYG plugin used in this project, because NicEdit is a WYSIWYG integrated with the custom framework. Also NicEdit is a Lightweight, Cross Platform, Inline Content Editor for web.

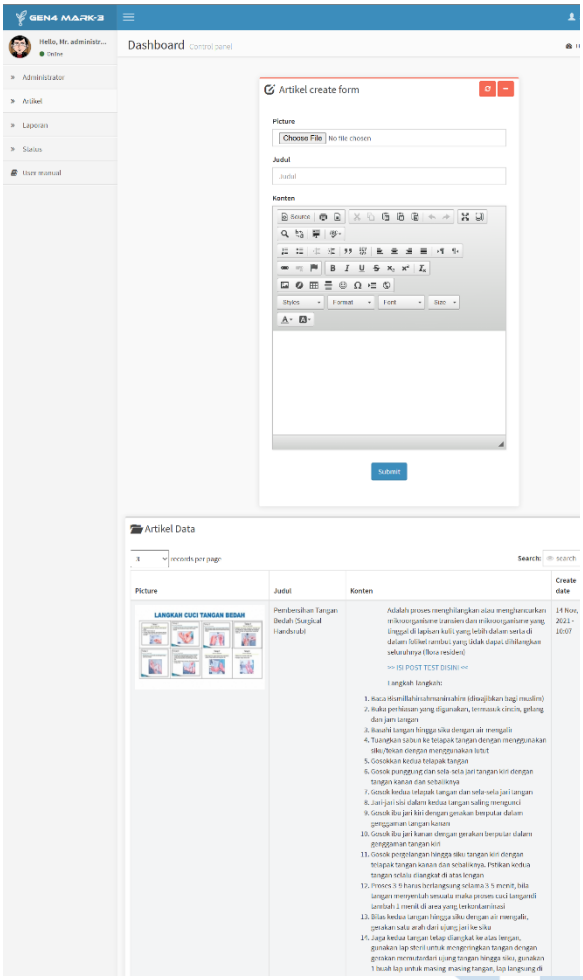

Fig. 5 The admin article input page with WYSIWYG feature

The submitted articles are showed in tiles form with a limit of 6 content per page as shown in figure 6.

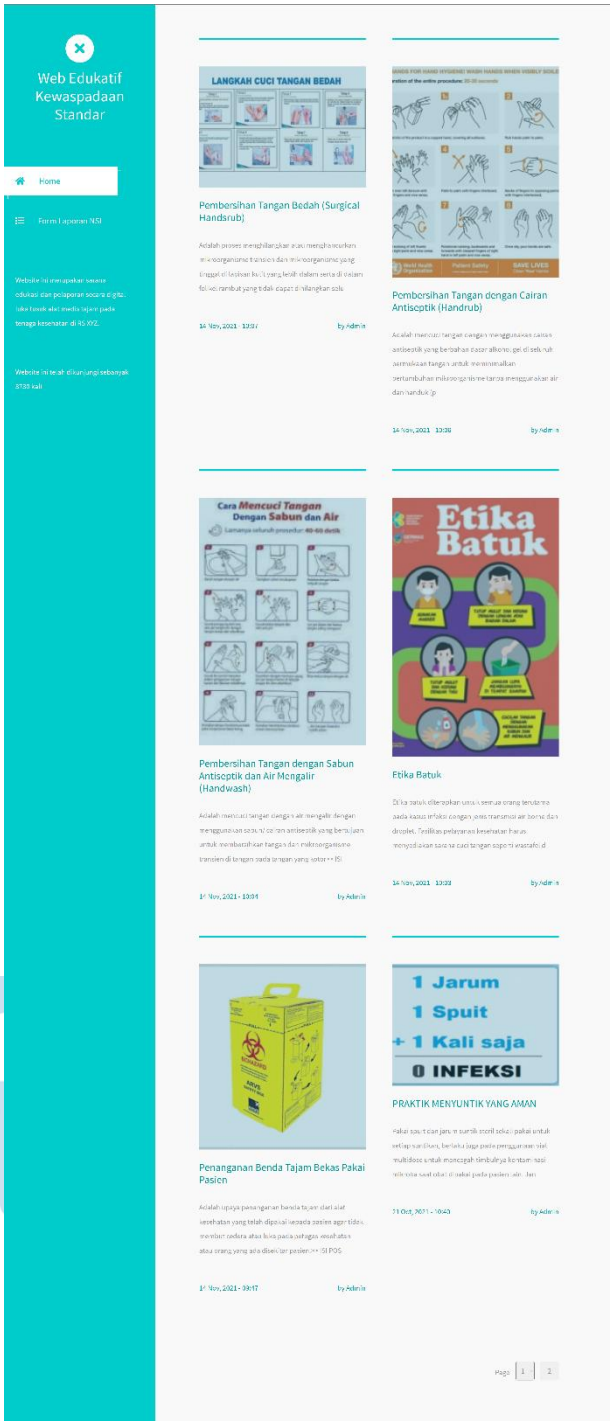

Fig. 6 Articles page in the front page showed in tiles format with a limit of 6 content per page

The posted articles also need to be displayed exactly as the admin inputs, so the WYSIWYG feature also needs to be adjusted on the front page as showed in figure 7.

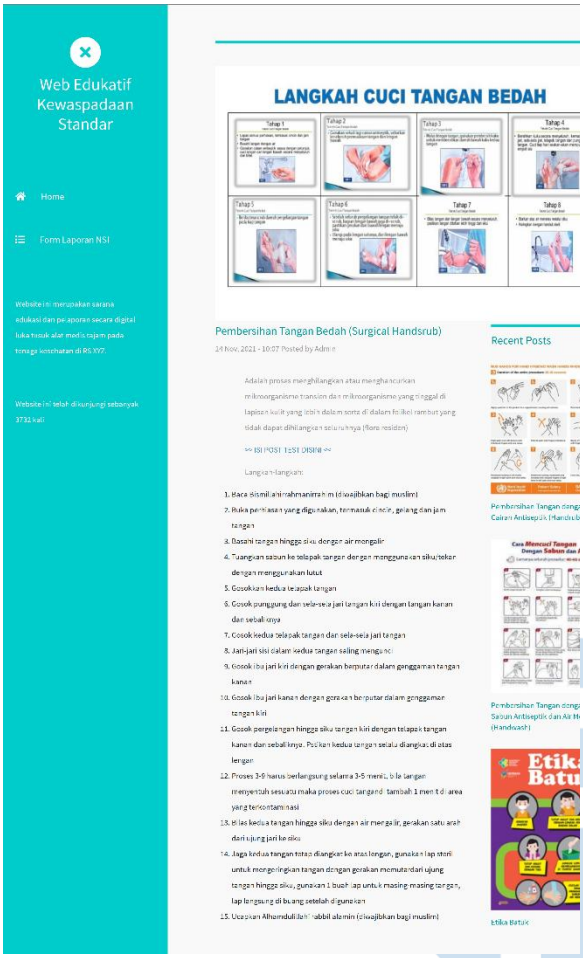

Fig. 7 Article details page showed in the front page

In the admin reporting page which shown in figure 8, there's main feature for receiving and monitoring the needle stick injury report. On this page, the admin can download the reports in PDF format or print them as shown in figure 4. Admin can also mark the NSI victim report as handled (Sudah ditangani).

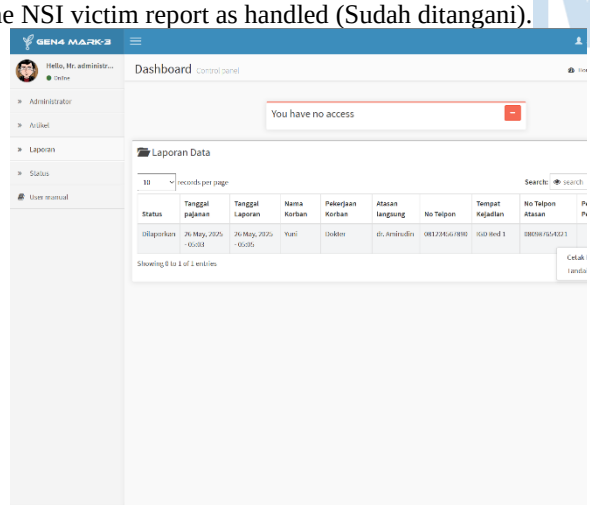

Fig. 8 Admin report page

4. The process then continues to the fourth stage. The user evaluates pages that do not meet expectations and then makes changes until they meet the user expectations. During the evaluation process, the front page of the article is adjusted to meet user needs, such as the font format which is required to follow the website font standard to standardize the format by disabling the feature to change the font face on the WYSIWYG admin page.

5. The process then continues to the fifth stage. The prototype is evaluated by collecting direct feedback based on a demo given to 1 user to identify incompatibility in both design and features. In this step, the user requests to simplify the data displayed on the admin report page and only provide a mark as handled (Sudah ditangani) button as shown in figure 8.

6. In the sixth stage, users perform testing to ensure the website is functioning properly. This stage runs smoothly on both mobile devices and laptops.

Because this website has quite simple features, the users have no difficulty in using it. The WYSIWYG feature is also similar to the typical Word application, making it easier to use.

7. The process then continues to the seventh stage. Implementation conducted to make sure the user understand how to use and access the entire system.

This web app is implemented online so it can be used anywhere using any kind of networks (The hospital Wifi or the users personal mobile networks) to make it easier to be accessed. However, the web app link will not be published as global website as it is intended for use only at XYZ Hospital.

To make it accessible for all the users smartphone and tablets there is will be a Quick Response (QR) code in every serving desk, all the users needed to do just scan through their smartphone or tablets. By using QR codes requires no specific or additional hardware for scanning and visualization (just a mobile device) to implement the desired functionality [15], since QR codes can be applied in a variety of scenarios, such as access website applications by scanning the QR codes. For the PC users, there will be a shortcut link and bookmark. All the PC users have to do is click the shortcut and the web apps will be appeared.

After the implementation, users found that reporting needle stick injury become easier and the documents stored more effective because they were digitalized, and they able to searches it quickly. The observed healthcare workers can easily be tracked through the application by viewing users who have not set as "Done" yet by filtering the data.

Compared to the previous manual reporting system, the previous manual reporting is considered quite difficult because the user needed to take a reporting form in paper form and write it down manually, then the tracing process also become easier because the observed healthcare workers are listed and can be sorted by name, status, exposure date, report date, and status. Admins can also search using the search bar, as shown in Figure 6. Furthermore, archives can be printed or downloaded as PDFs in hospital-standard formats and stored in a computer folder, so they don't get mixed up with other files and become difficult to find later.

IV. CONCLUSION

Most healthcare institution choose not to create apps for small systems like needle stick injury reporting. They prefer to use existing facilities like paper reporting and sending it via WhatsApp. By doing so, documentation can become messy and difficult to track, which can become a big problem later on. In this paper, a web application for reporting needle stick injuries was created to simplify reporting and simplify documentation and tracing.

By using a web-based reporting system, the reporting process is able to access anytime through any device anywhere. This could simplify the reporting process and organizes archives efficiently using digital technology.

The needle stick injury reporting application is a highly efficient tool for reporting needle stick injuries. This has been proven by the fact that tracing needle stick injuries is more organized and coordinated by both the admin and the user, eliminating the clutter of documents by turn it into digital files and allowing for efficiency and orderly monitored through the applications.

Besides the application itself, user awareness also needs to be increased through educational articles that can be added to the website.

As a suggestion for future development, a web application with a small system like Needle stick injury report can also be created and implemented in hospitals or other healthcare institutions, making it easier for other hospitals to handle all kinds of reporting, tracking, observation, and maintenance of documentation properly by reducing physical/paper documents and switching to digital documents.

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