POLITEKNIK UNGKU OMAR

THE E-BUZZER INNOVATION FOR CHRONOMETER ON LIGHT MACHINES AT CONSTRUCTION INDUSTRY (TEBIC)

MUHAMMAD RAZIS BIN RASHIDIN

(01BCT21F3018)

CIVIL ENGINEERING DEPARTMENT

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A project report/thesis submitted in partial fulfillment of the requirement for the award of the Bachelor of Civil Engineering Technology with Honours

CIVIL ENGINEERING DEPARTMENT

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DECLARATION OF ORIGINAL AND OWNERSHIP

TITLE: THE E-BUZZER INNOVATION FOR CHRONOMETER ON LIGHT MACHINES AT CONSTRUCTION INDUSTRY (TEBIC)

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…………………….
(MUHAMMAD RAZIS BIN RASHIDIN)

B. In front of me, HJH AZIZAH BINTI HARON @ HASSAN)
as project supervisor on date: ……….)

……………………...

(HJH AZIZAH BINTI HARON @ HASSAN)

APPRECIATION

Apart from my effort, I’d want to offer my heartfelt appreciation to everyone who helped bring this project. First and foremost, I want to thank my supervisor, Hjh Azizah binti Haron @ Hassan, for her unwavering enthusiasm, important advice, and insightful comments. Her steadfastness and unwavering support were essential in shaping the results of this study. I am also grateful to Sunway Construction for allowing me to get practical knowledge and experience at the RTS-JB Project career exposure and mentorship from Sunway Construction professionals have been invaluable in my career development.

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ABSTRACT

This research addresses critical challenges in the construction industry, focusing on the role of civil engineering technology in advancing Malaysia's infrastructure. The sector is highly dependent on diverse equipment, such as heavy machinery and generators, which face challenges such as breakdowns, downtime, maintenance expenses and possible project delays, which require effective solutions. The E-Buzzer Chronometer Project, adapted for light engines and generators, addresses this issue by implementing strategic operational time limits. The financial constraints that lead to equipment sharing and frequent breakdowns highlight the importance of vigilant monitoring, particularly targeting the prolonged operation of 20,000-volt generator sets, emphasizing adherence to operational guidelines to increase efficiency, minimize delays, foster user awareness, and contribute to overall project success. In addition to light machinery, the study explores wider implications for heavy machinery, aiming to reduce disruptions by identifying causes of delays, designing timers, innovating E-Buzzers and evaluating effectiveness. This research highlights the importance of proper lighting to avoid delays and Non-Conformance Reports, with potential significant impact on projects such as RTS-JB, promise increased productivity, streamlined time management and improved safety. Questionnaires gathered input from construction workers on the effectiveness of genset timers, with tests ensuring user-centered design and prototypes for systematic evaluation, revealing dissatisfaction with current machine conditions, and emphasizing the need for technology to improve worker satisfaction. Expected results include the reduction of maintenance delays and costs, the contribution of energy savings, and the promotion of sustainable practices. Finally, the project of chronometer efficiently addresses machine breakdowns, project delays, and workplace safety, smoothly aligning with the objectives of RTS-JB.safety in the construction sector, aligning seamlessly with the objectives of RTS-JB.

ABSTRAK

Penyelidikan ini menangani cabaran kritikal dalam industri pembinaan, memfokuskan kepada peranan teknologi kejuruteraan awam dalam memajukan infrastruktur Malaysia. Sektor ini sangat bergantung kepada peralatan yang pelbagai, seperti jentera berat dan penjana, yang menghadapi cabaran seperti kerosakan, masa henti, perbelanjaan penyelenggaraan dan kemungkinan kelewatan projek, yang memerlukan penyelesaian yang berkesan. Projek Kronometer E-Buzzer, disesuaikan untuk enjin ringan dan penjana, menangani isu ini dengan melaksanakan had masa operasi strategik. Kekangan kewangan yang membawa kepada perkongsian peralatan dan kerosakan yang kerap menyerlahkan kepentingan pemantauan yang berhati-hati, terutamanya menyasarkan operasi berpanjangan set penjana 20,000 volt, menekankan pematuhan kepada garis panduan operasi untuk meningkatkan kecekapan, meminimumkan kelewatan, memupuk kesedaran pengguna, dan menyumbang kepada kejayaan keseluruhan daripada projek itu. Selain jentera ringan, kajian itu meneroka implikasi yang lebih luas untuk jentera berat, bertujuan untuk mengurangkan gangguan dengan mengenal pasti punca kelewatan, mereka bentuk pemasa, menginovasi E-Buzzers dan menilai keberkesanan. Penyelidikan ini menyerlahkan kepentingan pencahayaan yang betul untuk mengelakkan kelewatan dan Laporan Ketidakpatuhan, dengan potensi kesan ketara ke atas projek seperti RTS-JB, menjanjikan peningkatan produktiviti, pengurusan masa yang diperkemas dan keselamatan yang lebih baik. Soal selidik mengumpul input daripada pekerja binaan tentang keberkesanan pemasa genset, dengan ujian memastikan reka bentuk dan prototaip berpusatkan pengguna untuk penilaian sistematik, mendedahkan ketidakpuasan hati dengan keadaan mesin semasa, dan menekankan keperluan teknologi untuk meningkatkan kepuasan pekerja. Hasil yang dijangkakan termasuk pengurangan kelewatan dan kos penyelenggaraan, sumbangan penjimatan tenaga, dan penggalakan amalan mampan. Akhir sekali, projek kronometer dengan cekap menangani kerosakan mesin, kelewatan projek dan keselamatan tempat kerja, menjajarkan dengan lancar dengan objektif RTS-JB.keselamatan dalam sektor pembinaan, menjajarkan dengan lancar dengan objektif RTS-JB.

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LIST OF ABBREVIATION

CIDB	Construction Industry Development Board
SUNCON	Sunway Construction Sdn Bhd
MRTS	Mass Rapid Transit System
RTS	Rapid Transit System
IR 4.0	Innovation Revolution 4.0
RFI	Request for Information (form)
IoT	Internet of Thing
KKR	Kementerian Kerja Raya
GENSET	Generator Set
TAM	Technology Acceptance Model

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

Civil engineering technology plays a pivotal role in practically applying engineering principles to advance and sustain the country's infrastructure. Malaysian civil engineering technologists collaborate closely with civil engineers to ensure the successful execution of a variety of projects, involving essential tasks such as surveying, drafting, project management, and quality assurance, all of which are fundamental to the effective implementation of civil engineering initiatives (Board of Engineers Malaysia, "Guidelines for the Registration and Accreditation of Engineering Technologists"). This field is further bolstered by educational programs provided by Malaysian institutions, equipping students with the knowledge and skills required to bridge the divide between design and construction, thus making a substantial contribution to the growth and durability of Malaysia's infrastructure (Lee, 2018).

Housing design, planning, construction, operation, and upkeep is the responsibility of construction companies. Structures such as buildings, roads, airports, docks, harbours, irrigation systems, vital city utilities, bridges, tunnels, dams, reservoirs, power plants, etc. Typically, these building projects required different types of equipment's and machine have their own level of equipment usage (Knutson et al., 2007). Residential projects, for instance, need very little equipment. Pneumatic tools and basic, conventional machinery such as forklifts, backhoes, hauling and lifting apparatus, and material handling are needed and some light machines such as genset, tower light and water pump. A moderate amount of machinery and equipment is used in commercial projects. For the building of pipelines, railroads, stabilizing, compacting, asphalt paving, and finishing, among many other specialized tasks, industrial and heavy construction projects required a high and intensive use of machines (Gransberg et al., 2006). Heavy and light machinery plays an essential part in the building business these days. Multiple types of construction equipment are being used to carry out a range of difficult construction projects (Waris et al., 2013). The increasing need for industrialization in the construction sector has also made the use of machinery necessary to achieve effectiveness and efficiency.

Machine breakdown refers to the unexpected failure or malfunction of a mechanical system or equipment, leading to a temporary cessation of its intended functions. This phenomenon is a critical concern in various industries, as it can result in downtime, production losses, and increased maintenance costs. The occurrence of machine breakdowns can be attributed to a variety of factors, including wear and tear, inadequate maintenance practices, material fatigue, and unforeseen events. Managing and minimizing machine breakdowns is crucial for maintaining operational efficiency and productivity in industrial settings (Smith, 2019).

The utilization of machines on construction sites not only improves labourers' productivity but also reduces the time needed to finish tasks (Waris et al., 2013). However, a substantial amount of funding and resources are needed to purchase and operate a fleet of heavy construction equipment. For the building of pipelines, railroads, stabilizing, compacting, asphalt paving, and finishing, among many other specialized tasks, industrial and heavy construction projects required a high and intensive use of machines (Gransberg, 2006). Heavy construction equipment is frequently used for, among other things such as earthwork & structural steel works, concreting, building, assembly and lifting and positioning of components (Mahbub, 2012).

In conclusion, this study's objectives are closely aligned with the urgent requirements and complexities encountered in civil engineering, specifically concerning the utilization of machines in construction endeavours. The primary aim is to conceive and fabricate a specialized chronometer expressly tailored for machines deployed at construction sites, catering to the essential necessity for meticulous time synchronization in the operations of machines. The envisaged chronometer seeks to elevate operational efficiency, diminish delays, and significantly contribute to the overall triumph of construction projects.

As underscored, the construction sector heavily depends on the deployment of heavy machinery and some light machines to augment productivity and streamline operational tasks. Nevertheless, the extensive and intensive usage of machinery, coupled with the potential occurrence of machine breakdowns, presents challenges that necessitate a methodical approach. The study acknowledges the critical importance of minimizing machine breakdowns, which can result in operational standstills, production setbacks, and escalated maintenance expenditures. Through the development of a chronometer specifically crafted to alleviate delays and optimize project flow, this research aspires to enrich the adept management of light machinery in construction environments.

Moreover, the study recognizes the considerable investment essential for procuring and maintaining heavy construction equipment, emphasizing the need for judicious utilization. The proposed specialized chronometer endeavours to play a pivotal role in the cost-effective administration of light machines, aligning with the growing imperative for industrialization in the construction domain.

Fundamentally, this research is poised to make significant contributions to the engineering domain by presenting a technological remedy for the challenges intrinsic to light machines operations. The envisaged chronometer is anticipated to not only enhance the technical prowess of light machinery but also address critical safety considerations and curtail delays, ultimately fostering a construction environment that is more efficient and resilient. As the construction industry undergoes continual evolution, innovative solutions such as the specialized chronometer hold the potential to play a decisive role in advancing the overall efficiency and efficacy of construction projects.

1.2 RESEARCH BACKGROUND

The background of the study for the Johor Bahru Rapid Transit System (RTS – JB) construction site project is very important to understand the context and needs of the study. This construction site project, linked to the RTS-JB is considered a major initiative in infrastructure development in Malaysia. The construction and management of the RTS - JB construction site involves complex aspects such as planning, implementation, and resource management. Realizing this, this study aims to investigate some issues that may arise during the construction and operation of this construction site.

One aspect that may be the focus of the study is the use of light machinery at the RTS - JB construction site. The use of machines such as genset, tower light, air compressor is essential to ensure the construction and progress of the project. However, the risk of machine failure or unexpected damage can cause serious disruption to the work schedule, causing delays in this project. Therefore, this study will focus on researching the possible causes of heavy and light machine breakdowns, as well as ways to improve the management and maintenance of machines to reduce this risk.

In addition, careful time planning is also a critical aspect of the RTS - JB construction site. Punctuality of construction implementation is key to ensure the project runs smoothly and according to the set schedule. By understanding this complex background, this research aims to unravel the challenges related to the use of light machines at the RTS - JB construction site. Overall, this research background serves as a basis for outlining related issues and deeper research needs in the context of the RTS - JB construction site project.

1.3 PROBLEM STATEMENT

Most of the construction activities need machines to keep progress in construction. Machines are important equipment to use but it so cost. So, in this construction site the company only buys a little machine, and we need to share it with others. Machines equipment such as genset, bulldozers, excavators, and cranes are designed to perform progress quickly. Without them, construction may take longer or be delayed completing, leading to delays and increased labour costs. Frequent breakdowns of equipment pose widespread challenges in the construction industry, adversely affecting project timelines, productivity, and overall project success. Despite the important role of construction machinery in the implementation of projects, repeated incidents of equipment failure contribute to significant delays, thus requiring a critical examination of the underlying issues and potential solutions. The prolonged duration required for machine repairs following breakdowns is anticipated. This extended repair period is poised to result in a substantial delay before the resumption of normal operations (Ku et al., 2019).

The persistent issue of machine breakdowns at construction sites stands as a critical challenge with profound implications for project efficiency and timely completion within the engineering context. Disruptions caused by equipment failures interrupt the smooth progression of construction activities, resulting in substantial periods of downtime, challenges in resource allocation, and the potential for cost overruns. Addressing this recurring concern necessitates a comprehensive examination to unravel its multifaceted origins, evaluate its broader impact on project management, and devise strategic interventions to bolster project resilience. (Smith and Johnson's, 2019) investigation, as documented in the "International Journal of Construction Management," underscores the urgency of a thorough exploration into the causes and repercussions of machinery breakdowns in construction projects. Their work emphasizes the pivotal role of preventive measures and timely interventions in effectively grappling with this pervasive challenge. Employees operate the machine negligently, under the assumption that the machine is immune to breakdowns (Queen University Belfast, 2023).

The absence of adequate lighting, security personnel will issue a Non-Conformance Report (NCR) to mandate the cessation of work. The reason behind this directive is the lack of proper illumination for safe working conditions. This occurrence has the potential to introduce delays in the construction site operations, as the absence of suitable work lights not only compromises the safety of the workers but also triggers a necessary pause in activities until the safety concern is addressed (Theotokas, 2018). The implementation of robust lighting systems is crucial not only for the overall efficiency of construction projects but also for maintaining a secure working environment, thereby mitigating the risk of accidents, and ensuring compliance with safety protocols.

Machine breakdowns pose multifaceted challenges in the construction industry, impacting not only project timelines but also introducing significant risks to workplace safety. The correlation between machine breakdowns and project delays has been underscored in previous research (Johnson et al., 2018; Smith, 2020). Beyond temporal setbacks, such breakdowns may lead to an increased incidence of rework due to the exigency of rapid repairs, as highlighted by studies in construction project management (Brown et al., 2017). This intricate relationship emphasizes the need for a comprehensive examination of the interdependencies among machinery reliability, project schedules, and overall project success.

A holistic exploration of these factors is essential for understanding the root causes of machine breakdowns and implementing proactive measures to address them. Previous studies in engineering and reliability management have demonstrated the effectiveness of preventive maintenance strategies in reducing the occurrence of machine failures (Williams & Davis, 2016; Chen et al., 2019). By adopting such measures, stakeholders in the construction industry can enhance the resilience of their machinery, minimizing the impact of breakdowns on project timelines and fostering a more efficient and secure construction environment. This approach aligns with the broader goal of cultivating a construction industry that is better equipped to navigate the challenges posed by machinery reliability issues.

1.4 OBJECTIVE OF STUDY

The purpose of this project is to minimize disruption at the construction site for all personnel, including those in the site office and those directly involved in construction operations, by introducing a product that can be used on the machine. This study outlines several key objectives to achieve the project goals:

i. To identify the cause of project delays.

ii. To innovate a chronometer and buzzer that works to set the time on genset at a construction site.

iii. To test the effectiveness of chronometer

1.5 SCOPE OF STUDY

The investigation will scrutinize the utilization, upkeep, and performance of machines deployed at the RTS-JB construction site. This project focuses on light machines like genset, tower light and water pump that almost runs for 16 hours per day. This machine has proven to be the most used machine in construction sites rather than the heavy machine. This comprehensive analysis encompasses a diverse array of construction apparatus, including machines vital to the construction processes. Emphasis will be placed on identifying potential challenges related to machines breakdowns, safety protocols, and operational efficiency.

As for Chronometer, the study will centre on the conceptualization, creation, and implementation of a specialized chronometer finely tuned to meet the distinct requirements of the RTS-JB construction site. The primary function of this chronometer is to guarantee precise time synchronization for the operation of machinery, facilitating streamlined coordination and sequencing of construction activities. This phase involves a thorough examination of existing timekeeping systems, the design of a chronometer tailored to the intricacies of construction machines, and the seamless integration of this technological solution into the construction workflow. A pivotal component of the study entails evaluating the impact of the chronometer on project timelines, work schedules, and the overall flow of the project. The goal is to provide insights into how this technological innovation can significantly contribute to mitigating delays and refining construction processes at the RTS-JB site.

By addressing both the machines and chronometer dimensions, this study strives to furnish a holistic comprehension of the complexities inherent in the management of heavy construction equipment and the adept assimilation of cutting-edge timekeeping technology. The derived findings are poised to yield practical recommendations for stakeholders actively engaged in the RTS-JB project, thereby playing a pivotal role in advancing the successful and efficient realization of this momentous infrastructure initiative.

Figure 1.1: Site Location (RTS JB-SG)

1.6 SIGNIFICANT OF STUDY

This research holds significant implications for Mass Rapid Transit system (MRTS), with Sunway Construction serving as the primary contractor for the project. The study revolves around the development of a specialized chronometer tailored for accurately setting the time on light machines utilized at construction sites. The successful implementation of this research stands to yield widespread advantages within the engineering and construction sector. Firstly, the custom-designed chronometer ensures precise time accuracy for the operation of light machine, facilitating exact and efficient synchronization in construction activities.

Moreover, the positive outcomes of this study can foster increased productivity and efficiency at construction sites. The deployment of a chronometer explicitly designed for light machinery might enhance the regularity and systematic management of operating hours. This, in turn, simplifies the task of decision-makers and site managers in planning more effective work schedules, thereby contributing to the overall seamless execution of construction operations.

Beyond its impact on time management, this specialized chronometer also plays a crucial role in enhancing the safety of construction sites. The time accuracy guaranteed by this unique chronometer helps mitigate potential schedule conflicts and reduces the risk of accidents arising from inconsistencies in the operation of light machinery. Consequently, this study not only elevates the technical performance of light machinery but also places a significant emphasis on critical safety considerations in the construction environment.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

In the ever-evolving realm of construction and engineering endeavors, a multitude of factors can contribute to intricacies and setbacks. One prevalent concern within this domain is the prolongation of project timelines, commonly known as the delay of work, signifying instances where the completion of project tasks exceeds the initially established timeframe. These delays can be ascribed to a diverse array of factors, encompassing unforeseen circumstances, alterations in project scope, or challenges related to the availability of essential resources. The repercussions of these delays are profound, exerting an impact on project schedules, financial allocations, and the overall operational efficiency of the undertaking (Koushki et al., 2005). A nuanced understanding of the root causes and the deployment of effective management strategies to alleviate delays are imperative for the triumphant execution of engineering projects.

Another significant challenge in construction and industrial contexts is the excessive utilization of machinery, commonly referred to as overworking machinery. Continuous and unwarranted operation of machinery beyond its designated capacity or prescribed operational limits can result in accelerated wear and tear, heightened maintenance demands, and, in extreme cases, mechanical failures. Beyond posing safety risks, this practice contributes to operational downtime and impedes the progression of projects. Rigorous adherence to maintenance schedules, operational guidelines, and periodic assessments of machinery conditions are crucial to prevent overworking, ensuring the durability and reliability of equipment (Li et al., 2018).

Within the domain of power generation, strict adherence to specified time limits for generators (gensets) stands as a critical factor for maintaining operational efficiency. Generators play a pivotal role in furnishing a dependable power supply during construction projects, events, or in regions characterized by inconsistent grid power.

Failure to adhere to established time limits for genset operation may result in amplified fuel consumption, heightened maintenance costs, and potential disruptions to the power supply. The establishment and enforcement of stringent time limits for genset usage are indispensable for optimizing fuel efficiency, curtailing operational costs, and guaranteeing the steadfast availability of power at construction sites or remote locations (Vakiloroaya et al., 2019).

Cost overrun represents an overarching challenge prevalent in construction projects, often stemming from a misalignment between estimated and actual project costs. This phenomenon can be attributed to diverse factors, including alterations in project scope, unforeseen site conditions, fluctuations in material prices, or inaccuracies in initial cost assessments. The consequences of cost overruns extend across project budgets, profitability, and stakeholder satisfaction. Prudent project management, precise cost estimation techniques, and the implementation of proactive risk mitigation strategies stand as indispensable components in the effective control and prevention of overruns (Flyvbjerg et al., 2003).

2.2 DELAY OF WORK

A delay in the construction industry is defined as beyond the set completion date in a contract or exceeding the mutually agreed-upon delivery deadline for a project. It appears as a variation from the anticipated schedule and is a common problem in construction projects. Delays lead into revenue loss for project owners due to a lack of

production facilities or rentable space, or a dependency on existing facilities. Contractors, on the other hand, face high overhead costs because of extended work periods, increased material costs due to inflation, and rising labour costs.

While project completion on time is a measure of efficiency, the building process is intrinsically vulnerable to numerous variables and unforeseen influences originating from various sources. These sources include the performance of the parties engaged, the availability of resources, the environment, the engagement of other entities, and contractual agreements. However, projects that are completed within the stated timeframe are uncommon (Sadi and Sadiq, 2006)

The significance of the delay of work caused by machines, particularly generators, in construction projects cannot be overstated, as it exerts profound effects on project timelines, costs, and overall operational efficiency. Delays in the operation of critical machinery, such as generators, have a cascading impact on the entire construction project schedule. Time is a critical factor in the construction industry, and any deviation from the meticulously planned timeline can result in financial repercussions. Extended project timelines often translate into increased labour costs, elevated overhead expenses, and potential contractual penalties, all of which contribute to financial strain on the project.

The repercussions of delayed machine operations extend beyond mere financial considerations. Construction projects are intricate endeavours with interdependent tasks and activities. The timely availability of resources, including power from generators for tools and equipment, is essential for the seamless progression of construction activities. A delay in the operation of machines can create bottlenecks in the workflow, disrupting the carefully orchestrated sequence of tasks and hindering overall project progress. This not only affects the construction timeline but also necessitates a reassessment of project budgets and resource allocations to accommodate unforeseen challenges.

Scholarly literature in construction project management underscores the critical role of efficient equipment utilization and the timely operation of machinery in preventing project delays (Abdul-Rahman et al., 2014). Delays resulting from machine breakdowns or inefficiencies are identified as factors that demand proactive management strategies to maintain project timelines and optimize resource utilization. These strategies include preventive maintenance schedules, contingency planning, and the incorporation of technology for real-time monitoring and diagnostics to identify potential issues before they escalate.

2.3 OVERWORKING MACHINERY

Overworking construction machinery puts project timetables at risk, potentially generating delays and disturbances in the construction industry. Continuous operation at or above recommended capacities causes rapid wear and tear on crucial components, increasing the likelihood of failure and necessitating more frequent maintenance (Smith, 2020). This extra maintenance, in turn, causes unscheduled downtime, lowering the overall efficiency of the construction process (Brown, 2001).

Overworked machines become less dependable, with diminished performance and efficiency, resulting in slower progress and poorer output (Johnson, 2013). Furthermore, safety concerns arise because weary equipment operators are more prone to errors, and worn-out machinery increases the likelihood of an accident. The effect on project timelines is severe, with delays cascading across the construction schedule, potentially leading to financial penalties and contractual issues (Turner, 2005).

Construction management must adhere to recommended operating capabilities, execute regular maintenance schedules, and provide extensive training for machine operators to mitigate these hazards. Furthermore, techniques such as rotating equipment to disperse workloads and monitoring performance to detect signs of wear early are critical for averting significant breakdowns and limiting delays (Zhang et al., 2018).

2.4 MACHINE MAINTENANCE

Machine maintenance, a fundamental practice in engineering and industrial sectors, revolves around the meticulous care and upkeep of machinery to ensure optimal performance. This includes routine tasks such as cleaning surfaces, lubricating gears, and inspecting components for wear and tear, aiming to prevent malfunctions or damage. Beyond these, maintenance extends to monitoring key indicators of potential problems, such as variations in vibration patterns, temperature fluctuations, or increases in energy usage. The aftermath of a machine breakdown involves critical procedures, such as damage evaluation and component replacement, which are integral aspects of comprehensive machine maintenance (Bill, 2021).

Diverse strategies exist within the realm of machine maintenance, each serving distinct purposes. Reactive maintenance involves fixing machinery when a breakdown occurs, while preventive maintenance entails planning for replacements at regular intervals to forestall part failures. Condition-based maintenance involves replacing parts when they exhibit signs of excessive wear, and predictive maintenance utilizes past data to forecast part failures, often leveraging artificial intelligence and machine learning. Prescriptive maintenance employs advanced data analysis to present hypothetical outcomes, guiding optimal actions before failure, addressing safety hazards, and managing quality concerns (Bill, 2021).

For manufacturers, a strategic focus on data gathering and analysis emerges as a highly effective approach to optimize equipment maintenance. Embracing data-driven maintenance offers multiple advantages, such as the judicious replacement of still-usable parts, reducing downtime resulting from unexpected failures, minimizing the time maintenance personnel spend, lowering the risk of machine and safety issues arising from poorly maintained machinery, and reducing the storage space needed for extra replacement parts stocks. Moreover, data-driven maintenance enhances predictability, influencing budgets, timetables, and production expectations (Bill, 2021).

Condition-based maintenance serves as a viable alternative to reactive maintenance, as it leverages machine control and sensor information to communicate equipment health and trigger notifications before a breakdown occurs. This proactive approach allows manufacturers to keep machines operational without squandering resources on a calendar-based strategy that might lead to over-maintenance. The continuous improvement of maintenance programs involves leveraging more data to drive progressively advanced plans, with each stage contributing to increased equipment uptime while simultaneously decreasing expenses (Bill, 2021).

The cost of maintenance stands as a significant aspect of equipment management for contractors and equipment owners, particularly those dealing with an extensive fleet of machinery. Geraerds (1983) aptly defines maintenance as "all activities aimed at keeping an item in, or restoring it to, the physical state deemed necessary for the fulfilment of its production function." Heavy and light equipment maintenance encompasses a spectrum of duties, including preventative maintenance, operating repairs, fuel management, tire care, and more. According to Peurifoy (2006), repair costs constitute the most substantial component of machine cost, accounting for approximately 40% of the machine cost over its operational life. Repair costs, encompassing labour and parts, pose challenges for estimation, constituting 15% to 20% of the equipment budget (Vorster, 2009). Maintenance expenses exhibit variability based on work conditions, operator skills, and corporate maintenance policies, making the estimation of owning and operating equipment costs a complex endeavour (Geraerds, 1983; Peurifoy, 2006; Vorster, 2009).

Sustainable maintenance solutions necessitate acknowledging technology as an integral component of progress. The evolution of new technologies and end-user needs has profoundly impacted maintenance operations and planning. The term "smart machine" denotes a machine that is highly connected, flexible, efficient, and safe, capable of responding swiftly to evolving demands (Małgorzata 2019). As asserted by

Porter and Heppelmann (2014), intelligent and connected machines bring forth an entirely new array of functions and capabilities, including monitoring, control, optimization, and autonomy.

Monitoring involves machines autonomously tracking their state, operation, and external environment through s ensors and external data sources, with the capability to alert users or stakeholders to changes in circumstances or performance. Control empowers machines to be remotely controlled via commands or algorithms stored in the machine cloud. Optimization sees smart, linked machines enhancing output, utilization, and efficiency through the application of algorithms and analytics to real-time or historical data. Autonomy represents the culmination of monitoring, control, and optimization capabilities, endowing smart, networked devices with unprecedented levels of autonomy (Małgorzata 2019; Porter & Heppelmann, 2014).

At its most basic, an autonomous machine operates in real time, utilizing sensors and software for immediate responsiveness. More advanced iterations may learn about their surroundings, self-diagnose service needs, and adapt to human preferences. Autonomy not only reduces the need for human operators but also enhances safety in hazardous conditions and facilitates operation in remote areas. This integration of technology underscores the transformative potential of advancements in machine maintenance, contributing to sustainability and efficiency across diverse industries (Małgorzata 2019; Porter & Heppelmann, 2014).

2.5 COST OVERRUN

Overruns in time and money have been a recurrent problem for a long time. Researchers from all around the world have extensively discussed the elements that contribute to time and expense overruns, emphasizing the problem's persistence and worldwide significance. Arditi et al. (1985) reported 23 aspects of delays in the construction sector, including material shortages, payment delays, contractor problems obtaining credit, and organizational features.

The issue of schedule and expense overruns in building projects is a common and crucial issue that has existed for a long time. This phenomenon occurs when the actual time and financial resources required for a construction project surpass the values that were initially predicted or intended. These overruns have numerous repercussions for project stakeholders. Several factors contribute to construction time and expense overruns (Frimpong, 2003). These include, but aren't limited to, poor project planning, unanticipated changes in project scope, unanticipated site conditions, material delivery delays, lack of machinery, labour shortages, and the difficulty of construction processes. These contributing factors have been extensively examined by researchers and industry professionals to find patterns and develop solutions to limit the impact of overruns.

Time overruns can derail project timelines, resulting in completion delays and possibly contractual fines. Furthermore, extended construction times may result in increasing overhead costs, hurting the project's overall profitability. Cost overruns, on the other hand, can impose a strain on project budgets, affecting financial feasibility and potentially leading to disagreements among project stakeholders (Mansifield et. al. 1994).

Addressing the issue of time and expense overruns in construction requires a comprehensive approach. A method to reduce these overruns must include effective project management, accurate initial estimating, rigorous risk assessment, and proactive risk management. Best practices in the industry, technology breakthroughs, and lessons learned from previous projects all play important roles in refining procedures and improving the sector's ability to control and mitigate schedule and cost overruns in construction. Recognizing the dynamic and diverse character of this challenge is critical for developing a resilient and efficient construction industry.

2.6 GENERATOR

A generator set, also known to as a "genset," is a portable type of technology that generates power by combining an engine with an alternator or electric generator. Generators, which are typically used in places without access to the power grid or in areas prone to frequent power outages, serve an important role in guaranteeing a consistent energy supply. They are used in a variety of contexts, including distant areas such as mines, where a dependable and independent power source is critical for operational continuity. During times of heavy electricity demand, generators can serve as both the primary energy source and a backup power supply. Their versatility makes them useful for meeting the changing energy requirements of various situations.

A genset, also known as a generator, set, is a composite system that combines a prime mover, usually an engine, with an alternator. The engine is critical in transforming the chemical energy in fuel into mechanical energy. This mechanical energy is subsequently converted into electrical energy and used to power the alternator. The alternator, which consists of a rotor and a stator, serves as the electrical generation component. Electromagnetic induction occurs while the alternator rotor spins within the magnetic field generated between the rotor and stator, resulting in voltage generation on the alternator stator. When this voltage is applied to a load, it causes an electrical current to flow, allowing the generator to produce power. In essence, a genset efficiently converts the chemical energy of fuel into electrical energy.

The generator, sometimes referred to as the alternator, and the engine are the two main parts of every genset. Fuel is used by the engine to power the generator, which generates energy to power a variety of devices. For larger generator sets that are frequently used in transportation, diesel fuel is usually the preferred option. It is noteworthy, nonetheless, that these generators frequently demonstrate their versatility by being able to operate on alternate fuels such as diesel. Their capacity to run on two fuels increases their adaptability in many operational scenarios.

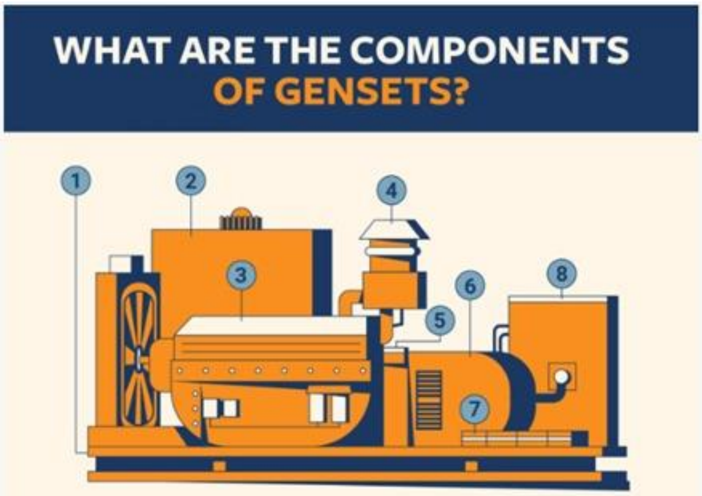
Generator sets must be built strongly to endure changing weather and environmental factors because they are often used in distant and difficult settings. Low emissions are a bonus that certain gensets provide, which helps with environmental concerns. But, regardless of where they are used, gensets require adequate ventilation, just like other kinds of engines. Sufficient ventilation guarantees appropriate cooling and effective performance, while also aiding in the mitigation of possible problems related to the functioning of these power generators. To improve the dependability and durability of gensets under a variety of operating conditions, it emphasizes the need of keeping an environment that is balanced and well-ventilated.

An engine, usually powered by diesel, starts a genset in motion. Rotational energy is produced by the engine when it burns the diesel fuel. The generator is then powered by this rotating energy, allowing it to generate electricity. When a coil rotates inside a magnetic field, rotational energy is converted into electrical energy. The voltage created is then passed to the electrical load when the generator is connected to it, enabling the load to function. This procedure demonstrates the basic method via which a generator sets transforms fuel energy into electrical power for a range of uses (Dustin, 2023).

Diesel generators function constantly if fuel is supplied. Because of this feature, these totally portable generators are reliant on a consistent fuel supply. Despite this reliance, the advantage of diesel gensets is their versatility they can operate in a variety of settings, particularly in areas without a power grid connection. Because of their portability, they can offer electricity in remote or off-grid places, making them significant assets in situations when a consistent power source is required despite a lack of access to standard electrical infrastructure (Dustin, 2023).

The Importance of Generators in Construction Projects lies in ensuring a dependable power supply, a critical consideration for construction endeavours, especially in areas with limited or no access to the electrical grid. Even within urban settings, construction sites frequently exceed the power capacity accommodated by existing infrastructure. Generators assume a crucial role in such contexts, providing a reliable power source to facilitate the smooth operation of various components at the construction site. This involves energizing essential tools and machinery, illuminating the site, and supporting worker facilities. In this capacity, generators become indispensable assets, fulfilling the energy requirements of construction projects, and facilitating their seamless progression despite limitations in the local power supply infrastructure.

In addition to their primary function as energy providers, generators also serve as essential backups during power interruptions. Power disruptions are common, and even brief outages can lead to significant delays and increased costs in the construction sector. Generators serve as dependable contingency plans, ensuring uninterrupted construction activities during unforeseen circumstances. By acting as emergency backups, generators play a pivotal role in maintaining operational continuity, assisting in adhering to construction schedules, and effectively managing budgets, even in the face of challenges posed by power fluctuations or outages.



COMPONENT	USED TO:
1. Frame	Support and stabilize the generator
2. Fuel Systems	Supply the engine with fuel
3. Engine	Supply mechanical energy
4. Exhaust System	Dispose of gases or any toxic chemicals
5. Voltage Regulator	Regulate the generator's voltage output
6. Alternator	Produce the electrical output
7. Battery Charger	Provide continuous power for the generator
8. Control Panel	Control the functions of the generator

Figure 2.1: The Component of Genset (Tolbert 2003).

Generators are essential assets in the construction business, providing a dependable power source that assures the smooth running of tools, machinery, site lighting, and workers' facilities. The dynamic and demanding nature of construction sites frequently necessitates a reliable and regular energy supply, and generators play an important role in satisfying these requirements. Their adaptability extends to both urban environments, where construction sites may exceed the capacity of the local power system, and isolated places where grid connections are non-existent. Because of this capability, generators are essential in meeting the broad and intensive power requirements inherent in building projects (Barnes, 2023).

Despite their critical role, generators might have problems when overloaded. Overworking can lead to greater fuel consumption, higher temperatures, overheating, and, in extreme situations, engine failure. Several causes contribute to generator overwork, including inadequate sizing for the job at hand, continuous running without breaks, and powering multiple devices at the same time. To alleviate these issues, adequate sizing must be carefully considered, ensuring that the generator matches the precise demands of the construction work (Barnes, 2023). Furthermore, sensible management measures such as restricted run hours and controlled device connections are required to avoid overworking and maintain generator efficiency.

Overworking them may result in increased thirst for gasoline, a dangerous rise in temperature, overheating, and, in the worst-case situation, engine failure (Barnes, 2023). It's equivalent to expecting someone to work nonstop around the clock - burnout is unavoidable. Factors such as maintaining the proper generator size for the job, allowing for adequate rest periods, and not overloading it with too many duties at once become critical. We not only assure the longevity and effectiveness of generators by treating them with care, but we also contribute to the smooth flow of building projects, keeping them on track and within budget.

Figure 2.2: Denyo 20KVA Genset (Tolbert 2003).

2.7 CHRONOMETER

In this era of timekeeping and instrumentation, a chronometer stands out as an extraordinary timekeeping device meticulously crafted to meet exacting standards of precision and dependability. Unlike conventional watches, which primarily serve as timekeepers, chronometers undergo a rigorous examination and certification process conducted by authoritative bodies such as the Control Official Suisse des Chronometer (COSC) in Switzerland. This meticulous evaluation ensures that these timepieces adhere to stringent mechanical standards, thereby guaranteeing an unparalleled level of accuracy in timekeeping.

The term "chronometer" carries historical weight, particularly in the domains of marine and aviation navigation, where precise timekeeping is of paramount importance for determining longitude and ensuring accurate navigation. During the 18th and 19th centuries, marine chronometers played a pivotal role in maritime exploration and trade, exemplified by the revolutionary H4 marine chronometer created by John Harrison. This groundbreaking invention transformed navigation by providing a reliable means of determining longitude at sea, significantly advancing maritime endeavours.

In contemporary contexts, the concept of a chronometer has evolved beyond traditional timepieces, expanding to encompass electronic devices or systems designed for measuring and displaying time with exceptional precision. In scientific research or industrial applications, chronometers find utility in synchronizing experiments or operations that demand meticulous timing, reflecting their adaptability in modern technological landscapes.

A crucial reference point in understanding the term "chronometer" concerning watches is the COSC, an independent Swiss organization tasked with certifying the accuracy and precision of Swiss watches. Timepieces that successfully navigate the rigorous tests conducted by the COSC earn the prestigious designation of "chronometer," serving as a testament to their extraordinary accuracy and reinforcing their standing as top-tier timekeeping instruments in the world of horology.

2.8 TIMER

Efficient time management is critical in reducing delays in the construction industry, according to data from 13 publications. Project planning and scheduling are critical components of good time management. As a result, a practical and well-structured schedule enables site managers to expertly organize workers, allowing for the smooth execution of building projects (S. Durdyev, M. Omarov, and S. Ismail 2017). a timer is a versatile tool essential for quantifying and managing the passage of time in a variety of applications. Functioning as a temporal supervisor, this device ensures accuracy and efficiency in diverse activities. Whether manifesting as traditional mechanical hourglasses from historical contexts or contemporary digital counterparts, timers consistently serve the fundamental purpose of providing a dependable mechanism for tracking time intervals. Timers are instrumental in everyday engineering tasks, assisting in activities such as precise cooking durations, timing fitness routines, and coordinating time-sensitive engineering processes. Particularly within industrial settings, timers function as integral components for orchestrating intricate processes, contributing to the synchronization of machinery, and optimizing production workflows.

In the domain of electronic timers, technological advancements have yielded sophisticated systems renowned for their programmability and precision. Hicks (2017) delves into these digital timers, elucidating their capacity to enable users to set specific time durations, execute sequences of timed events, and seamlessly integrate into automated processes. The programmable nature of these timers enhances their adaptability across a broad spectrum of engineering applications, spanning from industrial automation to the meticulous timing requirements of scientific experiments. Timers, in the engineering context, play a dual role by not only enhancing efficiency but also upholding accuracy, ensuring that engineering tasks are executed with meticulous adherence to predefined timeframes.

Timers, often known as counters in the field of electrical engineering, play an important part in embedded systems. Timers are frequently used in embedded systems to record and manage time-related events. Timers, which function essentially as binary counters, are used to tally pulses within circuits or systems. When the timer reaches its maximum value, it automatically resets to zero, resulting in an interrupt and an overflow flag. This function is very handy for calculating elapsed time or monitoring external occurrences within a given time interval. Timers help to synchronize the operation of embedded systems with the system clock, which might be an external clock or the system's internal clock (Ngan, 2019).

Repeatability, or the timer's ability to reliably recreate the same time setting, is an important consideration in timer functionality. Notably, progress in solid-state timer accuracy has witnessed tremendous increases since the days of resistor/capacitor networks. (M D. 2002). One reliable technique uses the alternating current line frequency as its timing foundation. This method assures that repetition accuracy is consistent and is exactly proportional to line frequency. Another cutting-edge technology uses an inbuilt quartz oscillator as its timing foundation, improving precision and dependability in timekeeping (M D. 2002).

Timers' adaptability extends to a wide range of applications in circuits and embedded systems. They are used, among other things, to create baud rates, measure time intervals, and add delays. Timers are extremely useful for iterating loops in a methodical and effective manner. Timers manage the difficult work of loop iteration, which entails cycling through precise ranges of cycles. Programming timers is a simple alternative to using various programming techniques for loop repetitions. Timers are essential components in guaranteeing the exact and synchronized operation of embedded systems, whether they are counting peripheral clock cycles or tracking externally provided clock cycles.

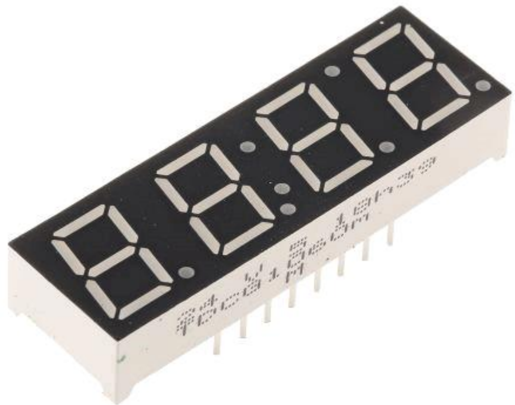


Figure 2.3: Digital Timer (Ajawo et al; 2016)

2.9 BUZZER

A buzzer represents an electroacoustic transducer, functioning as a device that converts electrical energy into sound waves, thus generating an audible tone or signal. This electronic component typically incorporates a vibrating diaphragm, or a similar sound-producing mechanism activated by an electrical current. The ubiquity of buzzers spans a broad spectrum of applications, ranging from commonplace household devices to sophisticated industrial machinery and intricate electronic systems. In its fundamental role, a buzzer serves as a signalling device, emitting distinctive sounds to alert individuals to specific events, conditions, or changes in a system. The audible output of a buzzer can exhibit variations in pitch, volume, and duration, contingent upon its design specifications and intended purpose. For instance, in household appliances, buzzers may be employed to signal the completion of a cooking cycle, indicate low battery levels, or highlight malfunctions.

Beyond their basic function as alerting mechanisms, buzzers have evolved to find applications across diverse fields. In the realm of electronic games, buzzers are seamlessly integrated into quiz show-style setups, offering a dynamic and engaging method for participants to signal responses. In industrial environments, buzzers play a critical role in safety systems, acting as auditory warnings to alert personnel to potential hazards or signalling emergency situations. The adaptability and versatility of buzzers emanate from their ability to communicate information through sound, rendering them indispensable components in a myriad of electronic, communication, and interactive systems.

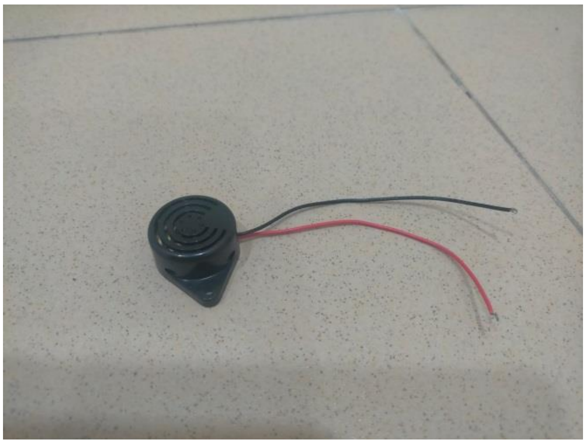


Figure 2.4: Buzzer

2.10 CONCLUSION

In conclusion, the difficulties encountered in the construction and engineering domains, such as job delays, overworking machinery, and machine maintenance, highlight the complexities of project management and operational efficiency. Work delays, which is frequently caused by unforeseen situations, changes in project scope, or resource constraints, has serious repercussions for project timetables, financial allocations, and overall operational efficiency. Overworking machinery, particularly generators, endangers project delays, costs, and safety, necessitating adherence to recommended operating capabilities, frequent maintenance, and rigorous machine operator training.

Machine maintenance is critical to guaranteeing optimal performance, avoiding malfunctions, and improving resource use. Various maintenance systems, such as reactive, preventive, condition-based, and predictive maintenance, provide different approaches to addressing machinery concerns. The strategic integration of data-driven maintenance emerges as a powerful instrument, giving benefits such as prudent part replacements, reduced downtime, and improved budget and timeline predictability. Recognizing technology as an inherent component of progress is required for sustainable maintenance solutions, with smart equipment providing monitoring, control, optimization, and autonomy.

The diverse nature of construction and engineering undertakings necessitates a comprehensive approach to project management. Stakeholders can proactively negotiate these difficulties by recognizing the interdependence of delays, machinery use, and maintenance. They not only protect against financial and operational setbacks, but they also establish the framework for more sustainable and simplified construction project execution. This entire strategy, which includes excellent planning, thorough execution, and a dedication to continuous maintenance, is critical for project success and longevity in the fast-paced world of construction and engineering.

CHAPTER 3
METHODOLOGY

3.1 INTRODUCTION

Design thinking is a problem-solving approach that prioritizes a human-centred perspective, emphasizing empathy, collaboration, and experimentation. At its core, design thinking is not just a set of methods or processes but rather a mindset that seeks to understand and address the needs and experiences of end-users. The process typically involves several iterative stages, with a strong focus on gaining insights into the user's context, defining the problem, ideating potential solutions, prototyping, and testing. These stages often don't follow a linear path but involve back-and-forth movement as designers continuously learn and refine their understanding.

In the empathize stage, designers immerse themselves in the user's environment, aiming to understand their perspectives, needs, and challenges. This often involves interviews, observations, and other research methods to gather qualitative data. The defining stage involves synthesizing the gathered information to pinpoint the core problems and challenges faced by the users. This step is crucial in framing the design challenge and ensuring that the subsequent solutions directly address real user needs.

The ideation phase is where creativity takes centre stage. Designers generate a multitude of ideas without judgment, encouraging a diverse range of perspectives. These ideas are then refined and consolidated to form potential solutions. Prototyping is the next step, where designers create tangible representations of their ideas, allowing for quick and cost-effective testing. This phase embraces the concept of "fail fast, fail cheap" the idea that early failure in the prototyping stage is valuable for learning and refining ideas before investing significant resources.

Finally, the testing phase involves obtaining feedback on the prototypes from actual users, refining the solutions based on this feedback, and iterating the entire process as needed. This user-centric, iterative approach distinguishes design thinking from traditional problem-solving methods, making it highly adaptable to complex challenges. The goal is not just to create aesthetically pleasing products but to generate solutions that genuinely meet the needs of the end-users in a meaningful and effective way. Design thinking has found applications across various industries, from product design to service innovation, and is recognized for fostering a culture of innovation and user-centric problem-solving.

3.2 DESIGN RESEARCH

Design research represents a systematic and investigative methodology employed to comprehend, inform, and enhance the engineering design process. Its significance spans across diverse engineering fields, including product design, graphic design, architecture, and user experience (UX) design. The central goal of design research in engineering is to amass valuable insights that can steer and elevate decision-making within the design process. This involves delving into user requirements, preferences, behaviours, and the cultural context relevant to the engineering design.

A critical facet of design research within an engineering context is user-centred design, placing emphasis on comprehending end-users and involving them in the design procedure. This approach facilitates the development of solutions aligned with the targeted audience, resulting in designs that are not only successful but also user-friendly. Research techniques in engineering design may encompass surveys, interviews, observations, and usability testing, enabling the collection of both qualitative and quantitative data. Through the application of these methods, engineers can gain a profound understanding of the problem space, pinpoint opportunities, and validate design choices.

Moreover, design research in engineering underscores the importance of iteration and prototyping. Engaging in continuous feedback loops allows engineers to refine and enhance their creations, ensuring that the final product aligns with user needs and expectations. This iterative strategy promotes a more adaptable and responsive design process, where modifications are based on empirical evidence rather than assumptions.

Beyond the user-centric focus, design research in engineering extends its purview to investigate broader trends, market dynamics, and technological advancements. By staying abreast of external factors influencing design, engineers can anticipate future challenges and opportunities, contributing to the formulation of more innovative and forward-thinking engineering designs. In summary, design research in engineering is a versatile discipline that amalgamates empirical investigation, user understanding, iterative development, and a comprehensive contextual awareness, enriching the design process and yielding more effective and impactful engineering solutions.

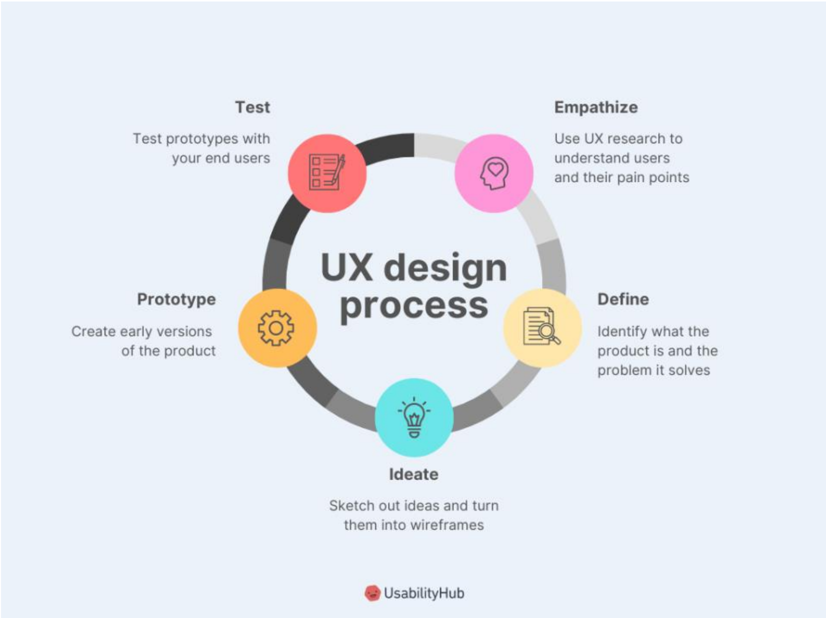


Figure 3.1: UX Design Process illustrates to make TEBIC

3.3 DEVELOPMENT OF RESEARCH

This study uses a research development framework to demonstrate the scientific development of a project. Figure 3.1 illustrates the sequence of research development, beginning with a literature review and culminating in evaluating the effectiveness of the developed product. The research methodology is divided into three phases, each of which involves specific tasks and approaches to ensure comprehensive analysis and successful implementation of the project.

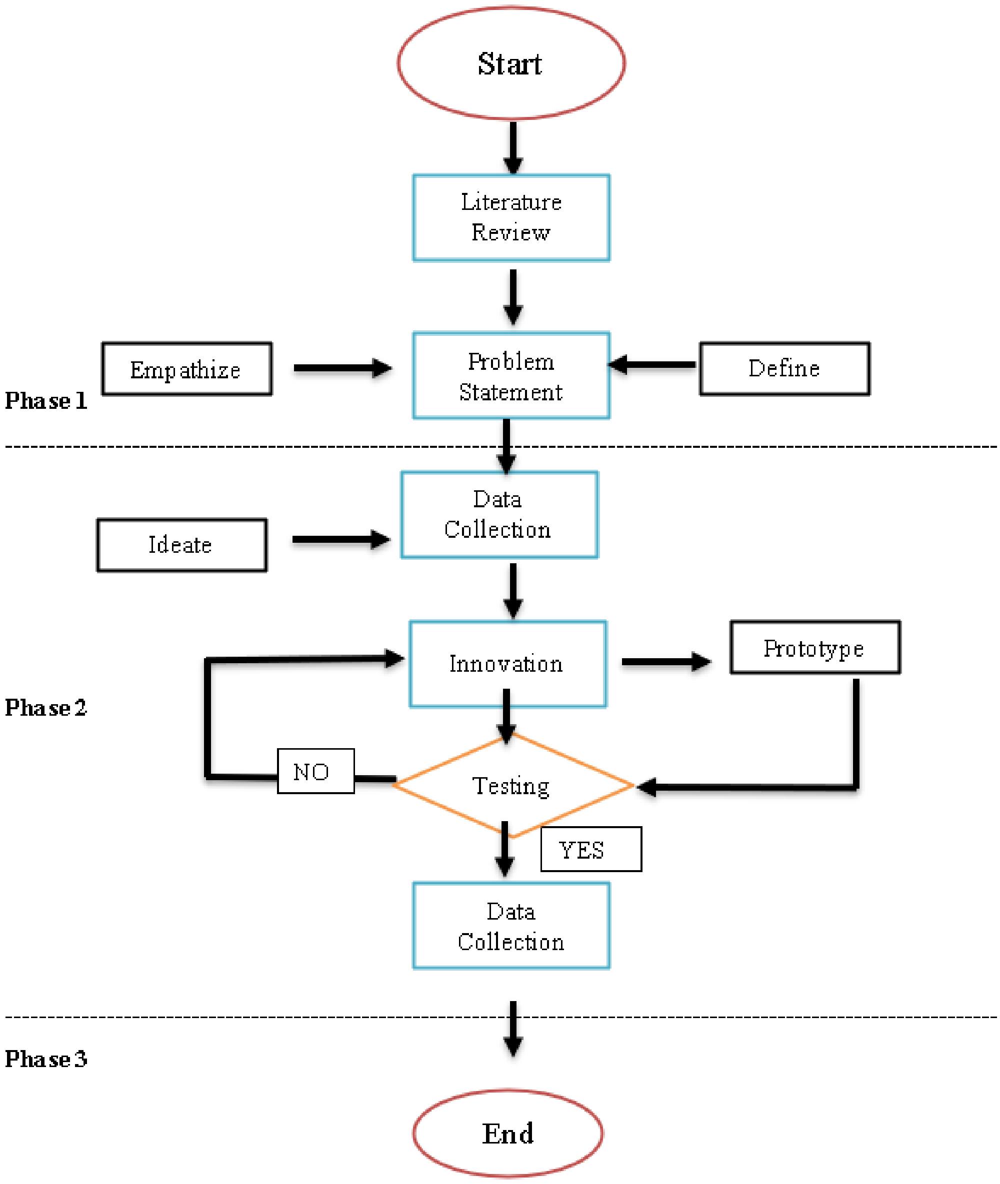


Figure 3.2: Research Development Flowchart

Phase 1 – Problem Discovery and Literature Review

In the initial phase from Figure 3.2, the focus is on design planning and project analysis. This phase is critical because it sets the foundation for the entire study. It involves a thorough review of the existing literature to identify gaps and define the problem statement. This stage also includes meetings with project supervisors and mentors to refine research objectives and approaches. The goal is to gather relevant information that will guide the development of the project. This phase is designed to take at least two weeks, providing enough time to ensure a solid foundation.

Phase 2 – Product Development and Data Collection

The second phase from Figure 3.2 aims to compare existing market applications to inform the development of new models or prototypes. This phase uses various fact-finding techniques, including questionnaires and interviews, to collect primary data directly from individuals involved in the construction project, such as contractors and professionals. The data collected through these interactions is essential to understand the practical aspects and needs of the project.

In addition, secondary data was collected from journals, the Internet and company records, providing a wider context and supporting information for the study. During this phase, mobile application design sketches and prototypes are created. The prototype serves as a visual reference and is continuously refined based on feedback from mentors and supervisors. The development process involves the use of software tools such as Microsoft Studio to build a functional system capable of implementing the planned features.

Phase 3 – Testing, Analysis, and Interpretation of Data

In the final phase, the developed mobile application undergoes rigorous testing to identify and resolve any errors or issues. This ensures that the application operates smoothly without compilation or runtime errors. The effectiveness of the workforce integration tracking system is then evaluated by comparing its performance with previously used methods. This evaluation helps to determine the improvements and advantages that the new system brings.

During this phase, detailed analysis and interpretation of the collected data is conducted to draw meaningful conclusions about the success and impact of the project. Flowcharts are created to document the system and ensure the project runs smoothly and according to plan. This structured approach helps in maintaining clarity and organization throughout the project lifecycle.

Overall, this study demonstrates a methodical approach to research development, emphasizing careful planning, data collection, product development, and rigorous testing to achieve successful results.

3.4 SYSTEM DESIGN AND DEVELOPMENT

The process of system design and development in engineering represents a multifaceted and methodical approach with the primary goal of creating effective and operational systems that are specifically tailored to meet the unique objectives of an organization or project. According to Sommerville (2011), this intricate process unfolds through a sequence of well-defined stages, encompassing planning, analysis, design, construction, testing, deployment, and maintenance. In the initial stages, feasibility studies are conducted to evaluate the technical, operational, and economic viability of the proposed system. Following this, a comprehensive requirement analysis is undertaken, focusing on a detailed understanding of end-users' needs and system goals. The subsequent design phase involves system architects conceptualizing the system's structure, components, modules, and data structures to lay the groundwork for the entire system, ensuring alignment with specified requirements.

The development phase comprises coding, programming, and database development, accompanied by rigorous testing to identify and rectify errors or bugs. Once the system is deemed stable, it progresses to the deployment phase, where it is implemented for regular use. Post-deployment, ongoing maintenance and support activities become critical for the system's sustained operation, adaptation to evolving needs, and resolution of unforeseen issues (Sommerville, 2011). Throughout this lifecycle, iterative methodologies like the waterfall model or agile development guide the systematic progression of tasks. Successful system design and development hinge on effective communication and collaboration among stakeholders, including developers, analysts, and end-users. The overarching objective is to craft a robust and scalable system that enhances organizational efficiency, meets user requirements, and remains adaptable to evolving technological landscapes, as underscored by the insights of Sommerville (2011) and Pressman (2014). This systematic approach ensures that the final product aligns seamlessly with intended objectives, fostering successful and sustainable solutions in the dynamic field of system design and development.

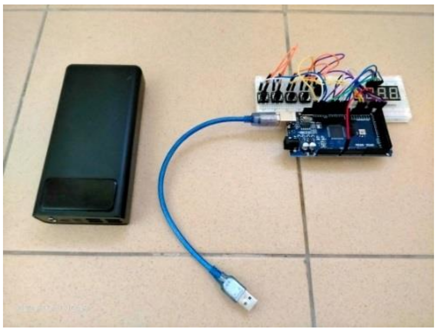
The structure served as a guide to ensure that the project was carried out in accordance with the intended goals. This investigation's procedural procedures are divided into discrete phases, as the figure that goes with it illustrates.

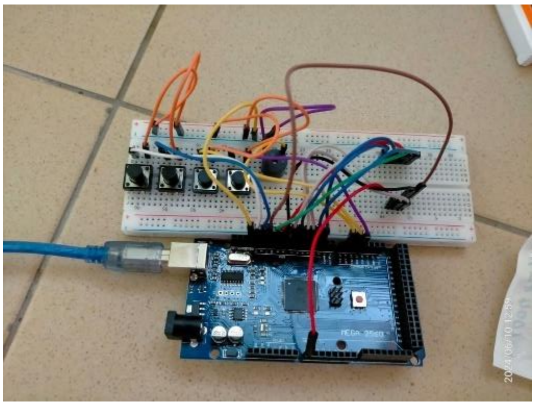
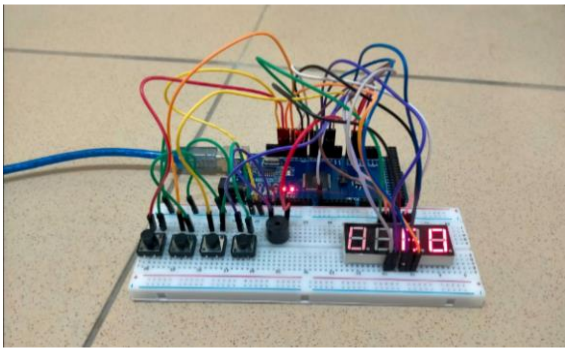
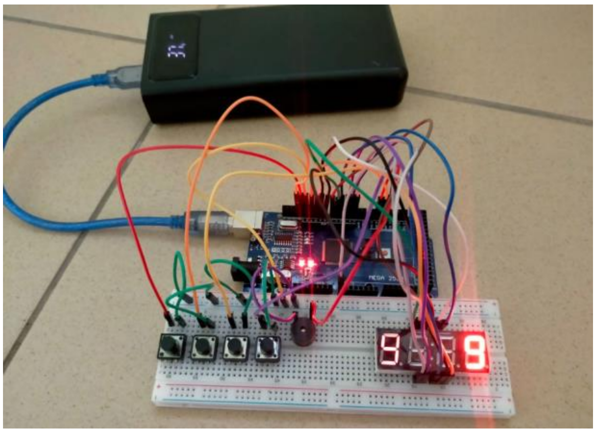
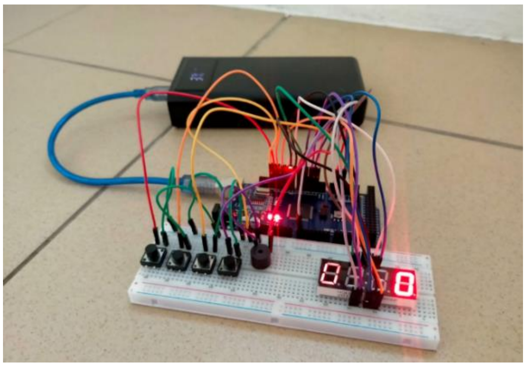
3.4.1 System Design

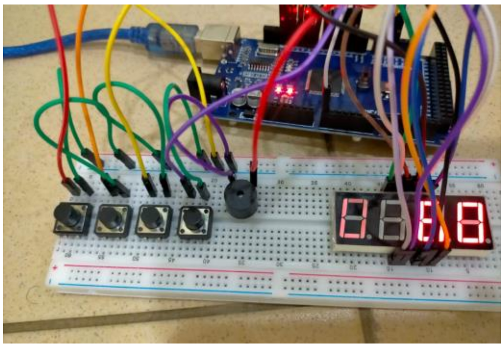
System design describes the prototype and its overall functionality, important for users and researchers to understand the innovation. It details the function of each button and the operation timer. This prototype is environmentally friendly. System design involves the determination of system elements such as modules, architecture, components, interfaces, and data based on established requirements, aiming to meet the specific needs of a business or organization (Bennett, 2021).

Here is the method to create and use the prototype of Innovative E-Buzzer for Chronometer on the generator and its function. Construction users need to know how to handle the project before use.

Table 3.1: Step to use the Prototype.

<table>
<tr><th>Image</th><th>Procedure</th></tr>
<tr><td>
</td><td>Step 1: To use the prototype, coding for the Arduino Mega 2560 is required.</td></tr>
<tr><td></td><td>Step 2: Gather and assemble all the prototype components.</td></tr>
</table>

	Step 3: To understand the function of each button (Start, Reset, + Timer, and - Timer buttons).
	Step 4: Connect the Arduino to the power bank to supply electricity
	Step 5: Press start (The timer will begin counting down when the start button is press)
	Step 6: The buzzer will start ringing when reach 0 second.

	Step 7: Press reset (The timer will back at starting time)

3.5 MATERIAL USED

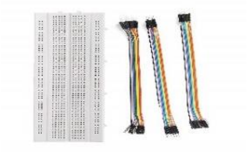
The essential elements employed in a generator set (genset) equipped with a timer machine, including the generator set itself, a digital timer, and a buzzer, embody a sophisticated amalgamation of technologies engineered to optimize the processes of power generation. The genset, serving as a cornerstone in this configuration, amalgamates an engine and a generator, establishing the fundamental infrastructure for power generation. The generator plays a pivotal role by converting mechanical energy sourced from the engine into electrical power, rendering it an indispensable component applicable in a range of scenarios, such as emergency power backup systems and remote power supply setups (Smith et al., 2020).

The digital timer, as a complementary element to the genset, assumes a pivotal function in coordinating time-related operations within the system. Through adept measurement and management of time, the digital timer governs the duration of specific operations, thereby augmenting overall efficiency. This temporal synchronization holds particular significance in applications where precise timing is paramount, including scheduled maintenance cycles or the timed activation of auxiliary systems (Jones & Brown, 2018).

The incorporation of the buzzer, operating as a timer-based alarm sound generator, underscores the sophistication of this engineered system. Its selection, driven by considerations of simplicity, efficiency, and seamless integration, positions the buzzer as an audible indicator capable of emitting warning signals or alarms when the digital timer reaches its predetermined limit. This feature heightens user awareness concerning the operational time of the genset, fostering safety practices and expediting attention to maintenance requirements (Johnson, 2019). The meticulous curation of these components results in a cohesive and efficient system that significantly contributes to the seamless and synchronized operation of the genset with a timer machine across diverse engineering applications.

Table 3.2: Material Used for Project

Material	Function
Arduino Mega 2560 	A microcontroller board designed for complex projects that require more input/output (I/O) pins and processing power.
Digital Timer 	A digital timer is an electronic device that manages time intervals.
Buzzer 	A buzzer is an electronic device that produces sound, often used as an alert or notification mechanism in various applications.
Push Button 	A push button is a simple switch mechanism for controlling some aspect of a machine or a process.
Power Bank 	A power bank functions like a generator by supplying electricity.

Breadboard and wire 	Breadboards facilitate circuit prototyping without soldering; wires connect components and Arduino Mega 2560 for power, ground, and signal transmission.

3.6 INNOVATION

The primary goal of prototyping is to efficiently validate and refine design concepts, whether in the form of a physical model, software mock-up, or a combination of both. Prototyping aids in early identification of potential weaknesses, user experience issues, and design challenges, fostering an iterative and hands-on approach that accelerates innovation. This process enhances communication among team members and contributes to the development of a final product more attuned to user needs.

The aim is to create a prototype centred around 'The Timer of Machine' to enhance users' understanding of the machine's time limit for operation. This timer concept visually informs users about the remaining operational time before reaching the predefined limit. The objective is to enable users to easily monitor and manage their machines' operational time.

This initiative is grounded in the recognition that prolonged machine use can lead to breakdowns. By implementing this timer, users will receive a visual warning as the machine approaches or reaches the set time limit, mitigating the risk of potential damage due to excessive use. 'The Chronometer of Machine' prototype intends to raise user awareness regarding operational time, optimizing machine performance, and ensuring reliability and extended service life.

3.7 DATA COLLECTION AND ANALYSIS

The final product is evaluated using an online questionnaire. Developed with an Arduino Mega 2560, it was tested by 35 employees from Sunway Construction (RTS JB-SG), including engineers, site supervisors, project managers and workers. The questionnaire was based on the Technology Acceptance Model by Davis (1988). The Technology Acceptance Model (TAM; Davis, 1989) is a highly influential framework for understanding technology acceptance, focusing on two main factors: perceived ease of use and perceived usefulness (Neil, 2016). The sample size was determined using Google Forms and SPSS to generate data. For a population of 35 respondents, 15 samples were deemed sufficient. Table 3.3 presents the questionnaire sample.

Table 3.3: Example of questionnaire

No	Effectiveness Categories	Issues Related to Existing Method and TEBIC system	Level of Agreement					
			Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
			1	2	3	4	5	6
1.	Work Progress	Existing method can increase the effectiveness of performing task/work.						
		Existing method can increase the effectiveness of performing task/work using TEBIC.						

To evaluate the effectiveness of the product, a paired t-test was used for data analysis using the Social Science Statistics website. This statistical method determines whether the mean difference between paired measurements is statistically significant. It is particularly useful when comparing before and after measurements in the same group of subjects. The paired t-test assumes that the distribution of differences between paired measures is normally distributed. Also referred to as the dependent samples t-test, paired difference t-test, matched-pairs t-test, or repeated-samples t-test, it is appropriate for the analysis of paired data where each pair consists of related measures.

Before running a paired t-test, it is important to ensure that the data meet certain criteria, such as the normality of the difference between paired measures. In cases where the sample size is small, the assumption of normality may not hold, requiring alternative nonparametric tests or careful interpretation of the data. This section discusses the prerequisites for conducting paired t-tests, including data inspection, test execution procedures, and detailed statistical considerations.

To perform a paired t-test, the researcher needs two variables: one defines the pair of observations and the other represents the measurement variable. Sometimes, the data already include pairwise differences for the measurement variable. In other instances, researchers may need to calculate these differences using separate variables for the "before" and "after" measurements in each pair. This approach allows for a thorough analysis of how the effectiveness of the product varies before and after its implementation (Sall, 1989).

3.8 GANTT CHART

The Gantt charts illustrate the project schedule spanning from September 2023 to June 2024, detailing the activities involved in a work-based learning (WBL) and research initiative. Table 3.4 outlines the initial phase, which emphasizes registration and the introduction to research. This phase includes defining research, examining various perspectives, and gathering insights from the workplace. Subsequent stages involve identifying and discussing the research topic with a supervisor, followed by the development of a comprehensive research framework. This framework encompasses problem statement identification, setting objectives, conducting literature reviews, and designing the research methodology. The timeline demonstrates steady progress through these activities, targeting the completion of initial drafts and proposal submissions by late January 2024.

In Table 3.5, the project moves into the implementation phase starting in February 2024, concentrating on resource preparation and data collection. The following months are dedicated to product development and testing, with overlapping tasks indicating simultaneous progress. By April, the focus shifts to interpreting results, summarizing findings, and continuing the report writing process. The final phase from May to June is allocated for final preparations, presentations, and report submissions. The charts reflect a well-organized approach, showing that planned activities and actual progress are closely aligned, ensuring the project remains on schedule for successful completion.

Table 3.4: The duration allocated for each task or activity undertaken for the purposes of this study.

NO	WORK DESCRIPTION	SEPTEMBER			OCTOBER					NOVEMBER				DECEMBER				JANUARY			
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20
		11/09/2023 - 16/09/2023	18/09/2023 – 23/09/2023	25/09/2023 – 30/09/2023	02/10/2023 – 07/10/2023	09/10/2023 – 14/10/2023	16/10/2023 – 21/10/2023	23/10/2023 – 28/10/2023	30/10/2023 – 04/11/2023	06/11/2023 – 11/11/2023	13/11/2023 – 18/11/2023	20/11/2022 – 25/11/2023	27/11/2023 – 02/12/2023	04/12/2023 – 09/12/2023	11/12/2023 – 16/12/202	18/12/2023 – 23/12/2023	25/12/2023 – 30/12/2023	01/01/2024 – 06/01/2024	08/01/2024 – 13/01/2024	15/01/2024 – 20/01/2024	22/01/2024 – 27/01/2024
1	**WBL REGISTRATION AND RESEARCH AT WORKPLACE (INDUSTRY)**																				
2	**RESEARCH INTRODUCTION**																				
2.1	Definition of Research																				
2.2	Epistemology from various perspective.																				
2.2	Get an idea from the Department Workplace																				
3	**RESEARCH TOPIC**																				
3.1	Investigate and observe the issues																				
3.2	Identify the Topic and discuss with Supervisor																				
4	**RESEARCH FRAMEWORK**																				
4.1	Identify the problem statement arise in existing method																				
4.2	Set the objectives and the aim																				
4.3	Literature Review																				
4.4	Research Methodology																				
4.5	Research Design																				
5	**OBSERVATION 1**																				
6	**RESEARCH PROPOSAL**																				
6.1	Draft of Chapter 1: Introduction																				
6.2	Draft Chapter 2: Literature Review																				
6.3	Draft of Chapter 3: Methodology																				
6.4	Submission of Chapter 1,2 & 3 Draft																				
6.5	Editing of Proposal																				
7	**PROPOSAL PRESENTATION (Slide preparation for proposal Presentation)**																				
8	**PROPOSAL PRESENTATION**																				
9	**PROPOSAL FINAL EDITING (Final editing of Proposal)**																				
10	**OBSERVATION 2**																				
11	**SUBMISSION OF FINAL PROPOSAL**																				
12	**FINAL EVALUATION & KEY IN PROCESS OF MARKS**																				

Legend:	
	Progress of Work
	Actual Progress

Table 3.5: The duration allocated for each task or activity undertaken for the purposes of this study.

NO	WORK DESCRIPTION	FEBRUARY			MARCH					APRIL				MAY				JUNE			
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20
		29/01/2024 - 03/02/2024	05/02/2024 - 10/02/2024	12/02/2024 - 17/02/2024	19/02/2024 - 24/02/2024	26/02/2024 - 02/03/2024	04/03/2024 - 09/03/2024	11/03/2024 - 16/03/2024	18/03/2024 - 23/03/2024	25/03/2024 - 30/03/2024	01/04/2024 - 06/04/2024	08/04/2024 - 13/04/2024	15/04/2024 - 20/04/2024	22/04/2024 - 27/04/2024	29/04/2024 - 04/05/2024	06/05/2024 - 11/05/2024	13/05/2024 - 18/05/2024	20/05/2024 - 25/05/2024	27/05/2024 - 01/06/2024	03/06/2024 - 08/06/2024	10/06/2024 - 15/06/2024
1	**WBL REGISTRATION AND RESEARCH AT WORKPLACE (INDUSTRY)**																				
1.1	Submission Appendix B1 and B2 to PUO																				
1.2	Preparation of Data Collection.																				
2	**PREPARATION FOR DATA COLLECTION**																				
2.1	Resources identification and selection.																				
3	**PROJECT IMPLEMENTATION AND DEVELOPMENT**																				
3.1	Data Collection																				
3.2	Product Development																				
3.3	Test run the project																				
4	**RESULTS AND ANALYSIS**																				
4.1	Interpret the results																				
4.2	State and summarize all the results																				
5	**REPORT WRITING**																				
5.1	Continuation on the writing of final report.																				
5.2	Preparation For Final Year Project Dissertation																				
5.3	Presentation at industry																				
6	**PREPARATION FOR FINAL YEAR PROJECT DISSERTATION AND PRESENTATION**																				
8	**FYP PRESENTATION**																				
9	**PRESENTATION WITH INSUDTRIAL PANELS**																				
10	**FINAL REPORT SUBMISSION**																				

3.9 CONCLUSION

Based on the comprehensive analysis and development framework outlined in this study, several important conclusions emerge to summarize the findings and implications. Initially, using design thinking as a problem-solving strategy played an important role in guiding the creation of the innovative "Machine Chronometer" prototype. By emphasizing a human-centered approach, design thinking facilitates a deep understanding of user needs and preferences among employees of Sunway Construction (RTS JB-SG). This methodology ensures that the final product not only addresses the practical challenges associated with uptime monitoring but also improves user experience and satisfaction.

Furthermore, integrating design research in an engineering context underscores the importance of empirical investigation and iterative refinement. Through phases such as problem discovery, literature review, and product development, valuable insights are gathered and synthesized to inform the decision-making process. This systematic approach not only verifies the prototype's effectiveness but also identifies opportunities for further improvement based on user feedback and market analysis.

The structured research development framework illustrated in Figure 3.2 offers a methodical path from initial planning to evaluating the developed product. Each phase—problem discovery, product development, and testing contribute uniquely to project success by ensuring comprehensive coverage of the design process. This methodical approach not only reduces risk but also optimizes resource allocation and project management throughout the study.

Finally, the systematic approach to system design and development, detailed in Section 3.4, underlines the importance of a clear life cycle from planning and analysis to deployment and maintenance. By adhering to methodologies such as agile development and iterative prototyping, the project demonstrates flexibility and responsiveness to changing user needs and technological advances. This approach not only fosters innovation but also ensures the creation of robust and adaptable systems capable of meeting long-term operational requirements.

In conclusion, this study illustrates the successful integration of design thinking, design research, systematic research development, and systems design methodology in an engineering context. By prioritizing user-centered principles and iterative improvements, the "Chronometer of Machine" prototype not only achieved its intended objective but also laid the foundation for future advancements in construction technology. These insights contribute valuable knowledge to both academic research and practical applications, highlighting the importance of empirical validation, user involvement, and systematic development in engineering design efforts.

CHAPTER 4
DATA AND ANALYSIS

4.1 INTRODUCTION

Efficiently managing the operation of a generator involves implementing a strategic time limit, which can significantly reduce work delays and enhance overall productivity. By restricting the running time of the genset to specific windows, resources are utilized more judiciously, leading to minimized downtime and a streamlined workflow. Workers can plan their tasks with greater precision, confident that the generator will be available during designated time frames. This proactive approach aids in scheduling work activities without the disruptions caused by unexpected power fluctuations, thereby optimizing the efficiency of the entire operational process.

Furthermore, implementing a time limit on generator operation serves as a preventive measure against breakdowns, addressing the issue of wear and tear on its components. Continuous or extended usage without breaks can accelerate the deterioration of the generator, necessitating frequent repairs. By setting operational boundaries, the likelihood of unexpected breakdowns is diminished, allowing for more manageable and scheduled maintenance during downtimes. This systematic approach ensures that the generator remains in optimal working condition, thereby reducing the frequency and cost associated with repairs.

In addition to operational and maintenance benefits, implementing time limits on genset usage translates into tangible cost savings. Extending the lifespan of the generator and minimizing breakdowns directly results in reduced maintenance and repair expenses. The ability to schedule preventive maintenance more efficiently within specified time limits mitigates the need for costly emergency repairs. Moreover, embracing alternative power sources during periods when the genset is not required only contributes to overall energy conservation but also leads to substantial cost savings. In essence, the strategic management of generator operation through time limits presents a multifaceted approach to enhancing efficiency, reducing costs, and promoting sustainable energy practices.

4.2 PRE-DEVELOPMENT AND POST-DEVELOPMENT DATA ANALYSIS

In this study, we have utilized two distinct types of surveys: the pre-development questionnaire and the post-development questionnaire. These surveys play a crucial role in facilitating a comparative analysis between the conditions observed before and after the development phase.

The pre-development questionnaire functions as a foundational tool designed to capture initial conditions, perceptions, and feedback from stakeholders or participants before any changes or interventions are introduced. It serves to establish a baseline snapshot of the existing status quo, providing valuable insights into the prevailing challenges, needs, and expectations among the target population.

Conversely, the post-development questionnaire is administered after the implementation of new systems, interventions, or solutions. Its primary objective is to assess the outcomes, impacts, and effectiveness of the changes made during the development phase. By soliciting feedback and perceptions after the implementation, this questionnaire aids in evaluating how effectively the new systems or interventions have addressed the identified challenges and met the stakeholders' needs.

The comprehensive analysis of responses from both questionnaires enables a thorough assessment of the project's impact over time. It allows researchers and stakeholders to compare data points, identify trends, improvements, or areas that may still require attention. This structured approach not only validates the effectiveness of the development efforts but also furnishes empirical evidence to inform decision-making processes for future developments or iterations.

Furthermore, the comparative analysis facilitated by these questionnaires contributes to a deeper understanding of how interventions influence the target population or system under study. It sheds light on the dynamics of change and adaptation, highlighting tangible benefits or areas where further adjustments may be warranted.

In conclusion, the use of pre-development and post-development questionnaires in this study serves as a methodological framework for evaluating the impact of development initiatives. It underscores the significance of empirical data collection and user feedback in guiding effective decision-making and fostering continuous improvement in engineering design projects. This approach not only enhances transparency and accountability but also fosters a user-cantered approach to problem-solving and innovation.

Table 4.1: Data collection from Questionnaire of Demographic Profile for Pre and Post Development

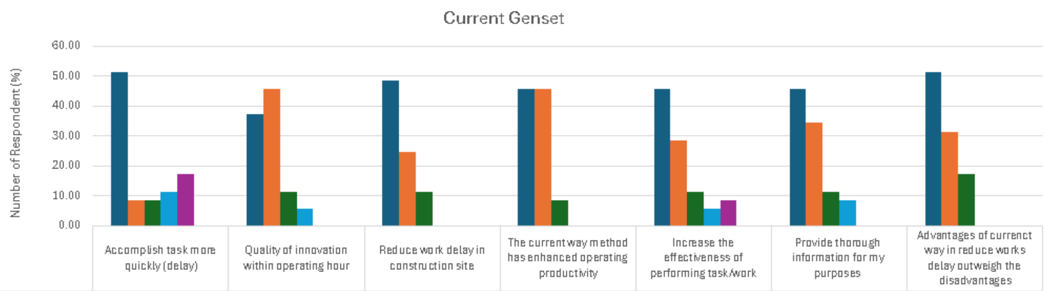
	Gender	**No. of Respondent**	**Percentage (%)**
1	Male	35	100%
2	Female	0	0%
	Age	**No. of Respondent**	**Percentage (%)**
1	21- 30 Years	11	31.43
2	31- 40 Years	8	22.86
3	41 - 50 Years	9	25.71
4	51 – 60 Years	7	20
5	60 Years and above	0	0
	SunCon Department	**No. of Respondent**	**Percentage (%)**
1	Sunway Construction	24	68.57
2	Waitatt Sdn Bhd	6	17.14
3	BinaChuan Sdn Bhd	5	14.29
	Work Experience	**No. of Respondent**	**Percentage (%)**
1	< 2 Years	2	5.71
2	3 Years – 5 Years	11	31.43
3	6 Years – 10 Years	13	37.14
4	> 10 Years	9	25.71

The demographic data collected in this study provides a detailed picture of the participants, revealing important insights into the composition of the respondent group. All 35 respondents were men, accounting for 100% of the sample, which highlights the absence of gender diversity in the studied population. The age distribution showed a varied range of participants, with the majority being in the age categories of 21-30 years (31.43%) and 41-50 years (25.71%). Notably, no participants were over 60 years of age, perhaps suggesting a younger workforce in the organizations studied.

In terms of department affiliation, most respondents (68.57%) were from Sunway Construction, followed by Waitatt Sdn Bhd (17.14%) and BinaChuan (14.29%). This distribution underlines the significant underrepresentation of Sunway Construction, possibly reflecting the company's larger workforce or greater involvement in the study.

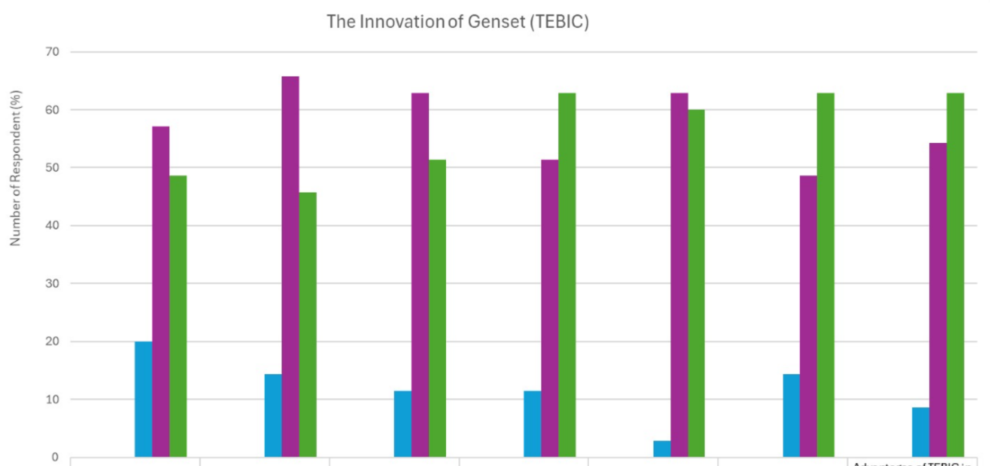
The respondents' work experience varied significantly, with a significant concentration in the range of 6-10 years (37.14%), indicating that most participants had sufficient experience in their respective fields. In addition, 31.43% of respondents have 3-5 years of experience, and 25.71% have more than 10 years of experience, indicating an experienced sample. Only a small percentage (5.71%) has less than 2 years of work experience, further emphasizing the experienced nature of most respondents.

Overall, the data depicts a group of highly experienced all-male respondents with a diverse age range, most of whom are affiliated with Sunway Construction. This demographic analysis is important to understand the background of the participants, which can significantly influence their perceptions and responses in the study, especially in evaluating new systems or interventions introduced during the development phase.



	Accomplish task more quickly (delay)	Quality of innovation within operating hour	Reduce work delay in construction site	The current way method has enhanced operating productivity	Increase the effectiveness of performing task/work	Provide thorough information for my purposes	Advantages of current way in reduce works delay outweigh the disadvantages
Strongly Disagree	51.43	37.14	48.57	45.71	45.71	45.71	51.42
Disagree	8.57	45.71	24.56	45.71	28.57	34.29	31.43
Somewhat Disagree	8.57	11.43	11.42	8.57	11.43	11.43	17.14
Somewhat Agree	11.43	5.71	0	0	5.71	8.57	0
Agree	17.14	0	0	0	8.57	0	0
Strongly Agree	0	0	0	0	0	0	0

Figure 4.1: Data collection from Questionnaire of Perceived Usefulness (PU) for Pre-Development



	Accomplish task more quickly (delay)	Quality of innovation within operating hour	Reduce work delay in construction site	TEBIC has enhanced operating productivity	Increase the effectiveness of performing task/work	Provide thorough information for my purposes	Advantages of TEBIC in reduce works delay outweigh the disadvantages
Strongly Disagree	0	0	0	0	0	0	0
Disagree	0	0	0	0	0	0	0
Somewhat Disagree	0	0	0	0	0	0	0
Somewhat Agree	20	14.29	11.43	11.43	2.86	14.29	8.57
Agree	57.14	65.71	62.86	51.43	62.86	48.57	54.29
Strongly Agree	48.57	45.71	51.43	62.86	60	62.86	62.86

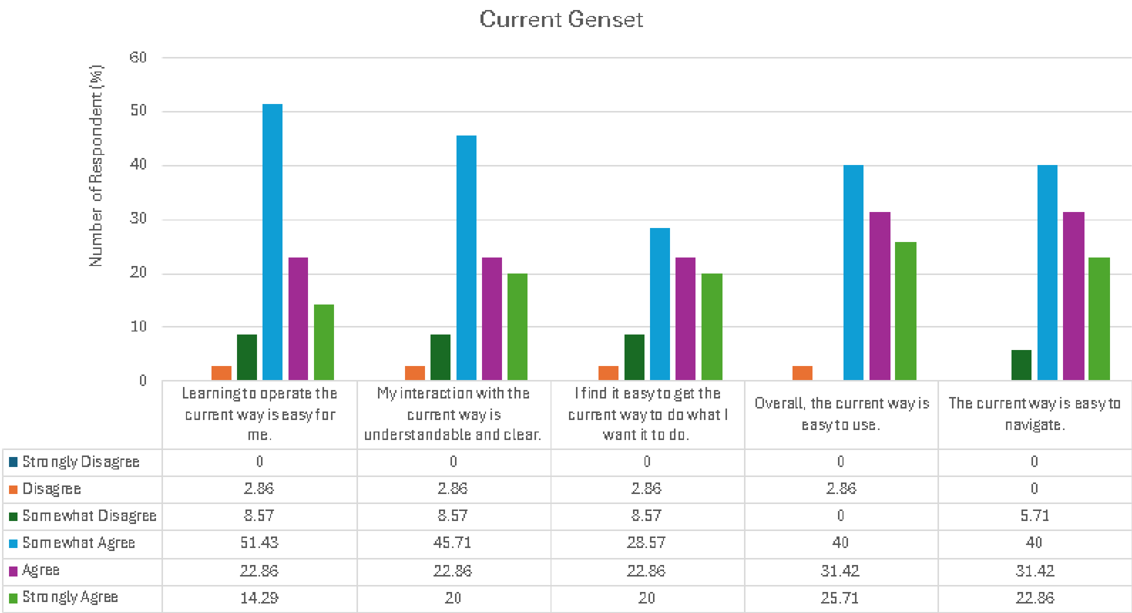
Figure 4.2: Data collection from Questionnaire of Perceived Usefulness (PU) for Post-Development

In Figure 4.1, most respondents rated the performance of the current genset quite negatively across various aspects. For instance, 51.43% strongly disagree that it accomplishes tasks quickly, and 45.71% disagree with its innovation quality during operating hours. Additionally, 48.57% strongly disagree that it reduces work delays on construction sites. These high percentages of disagreement and strong disagreement indicate significant dissatisfaction with the genset's performance. The data suggests that the genset does not meet the respondents' expectations in enhancing productivity or providing effective task performance.

In contrast, Figure 4.2 depicts the respondents' perceptions after the genset was innovated (TEBIC). There is a noticeable shift towards positive responses. For instance, 57.14% agree and 48.57% strongly agree that the innovated genset accomplishes tasks more quickly. The quality of innovation within operating hours also saw a significant improvement, with 65.71% agreeing and 45.71% strongly agreeing. The perception of reducing work delay improved remarkably, with 62.86% agreeing and 51.43% strongly agreeing. These positive shifts indicate that the innovation has substantially enhanced the genset's effectiveness and efficiency.

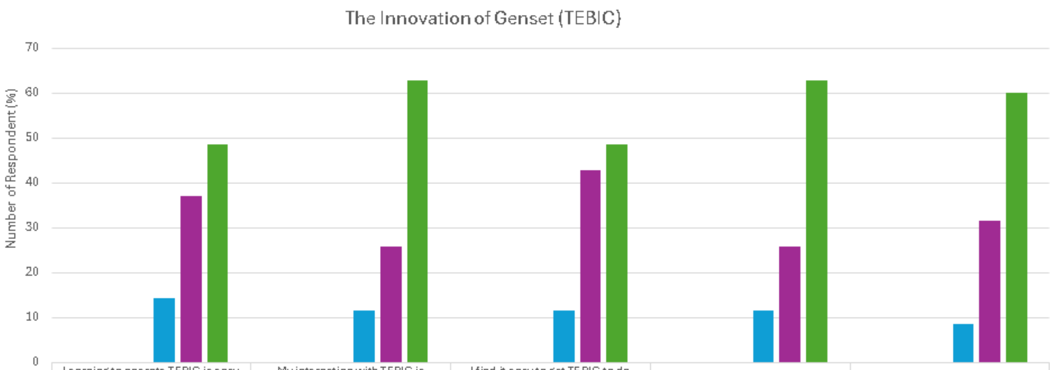
Comparing Figures 3 and 4, the innovation has led to substantial improvements in the genset's performance. Prior to innovation, the genset was viewed negatively, with high levels of dissatisfaction in all categories measured. Post-innovation, there is a significant positive turnaround. The strong disagreements in Figure 3 have transformed into strong agreements in Figure 4. The respondents' satisfaction with the genset's ability to enhance productivity, reduce delays, and perform tasks effectively has increased markedly. This demonstrates that the innovation (TEBIC) addressed the critical shortcomings of the previous genset.

The analysis demonstrates the vital role that innovation plays in enhancing the performance and efficiency of technology in construction environments. The significant improvements from pre- to post-innovation data emphasize the necessity of ongoing improvement and adaptation to meet operational demands. Innovation not only resolves existing issues but also increases overall satisfaction and productivity. This observation is consistent with existing research on technological adoption in industrial contexts, which shows that innovations significantly improve operational efficiency and stakeholder satisfaction (Jin et al, 2019).



	Learning to operate the current way is easy for me.	My interaction with the current way is understandable and clear.	I find it easy to get the current way to do what I want it to do.	Overall, the current way is easy to use.	The current way is easy to navigate.
Strongly Disagree	0	0	0	0	0
Disagree	2.86	2.86	2.86	2.86	0
Somewhat Disagree	8.57	8.57	8.57	0	5.71
Somewhat Agree	51.43	45.71	28.57	40	40
Agree	22.86	22.86	22.86	31.42	31.42
Strongly Agree	14.29	20	20	25.71	22.86

Figure 4.3: Data collection from Questionnaire of Perceived Ease of Use (PEU) for Pre-Development



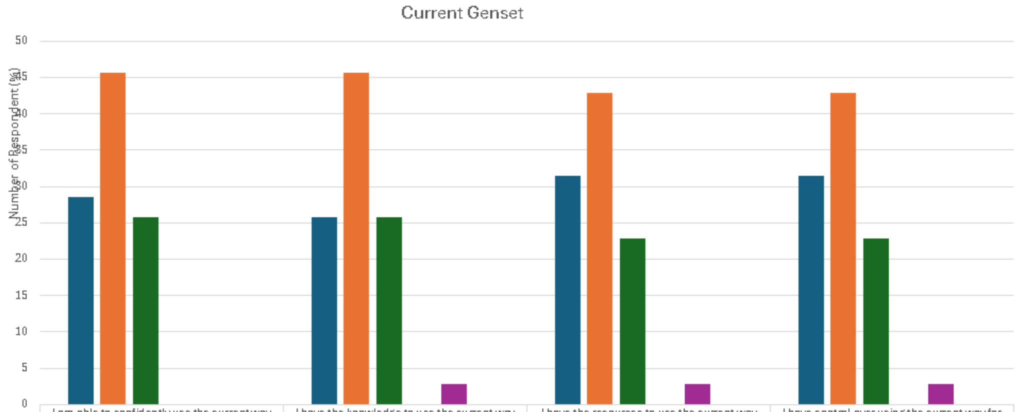
	Learning to operate TEBIC is easy for me.	My interaction with TEBIC is understandable and clear.	I find it easy to get TEBIC to do what I want it to do.	Overall, TEBIC is easy to use.	TEBIC is easy to navigate.
Strongly Disagree	0	0	0	0	0
Disagree	0	0	0	0	0
Somewhat Disagree	0	0	0	0	0
Somewhat Agree	14.29	11.43	11.43	11.43	8.57
Agree	37.14	25.71	42.86	25.71	31.43
Strongly Agree	48.57	62.86	48.57	62.86	60

Figure 4.4: Data collection from Questionnaire of Perceived Ease of Use (PEU) for Post-Development

Data collected from the Perceived Ease of Use (PEU) questionnaire revealed a comprehensive comparison between the current Genset system and the innovative Genset system (TEBIC) in the pre- and post-development phases. For the current Genset, most respondents found the system relatively easy to learn (51.43%), with a smaller percentage expressing strong agreement (14.29%). Clarity of interaction and ease of achieving tasks followed the same trend, with the majority somewhat agreeing or agreeing to ease of use. However, some respondents experienced difficulties, as shown by the presence of disagreements in the data. Overall, the current Genset received mixed reviews, with a significant portion of the sample agreeing on the ease of navigation and overall usability.

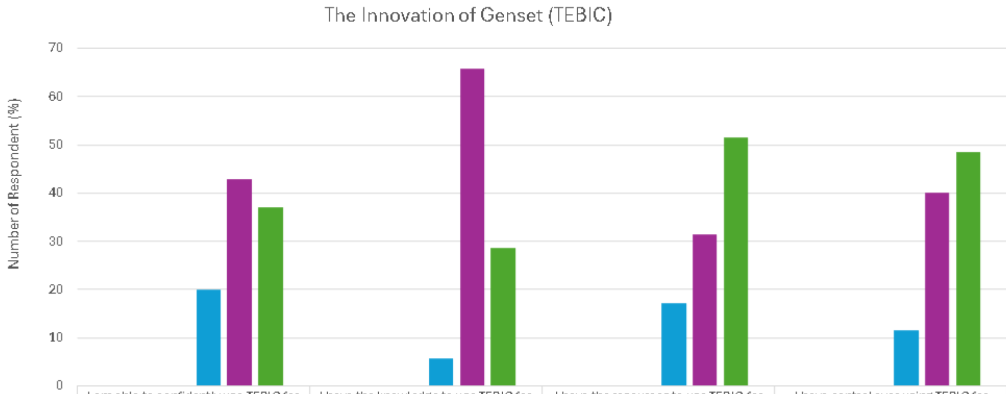
On the other hand, the innovative Genset system (TEBIC) shows significant improvement in all categories. Most respondents strongly agreed that TEBIC is easy to learn (48.57%) and interact with (62.86%), with no respondents expressing disagreement. Ease of accomplishing tasks, overall ease of use and ease of navigation saw similarly high levels of strong agreement, indicating a clear improvement in user experience. The complete absence of negative responses in this category underlines the effectiveness of development efforts in addressing previous challenges and increasing user satisfaction.

The comparative analysis underlines the significant progress achieved with TEBIC. Post-development data highlights improved user-friendliness, with significant improvements in ease of learning, clarity of interaction and navigation. The transition from the current Genset to TEBIC reflects the successful application of development interventions, resulting in a more intuitive and efficient system. This improvement not only validates the development process but also emphasizes the importance of iterative design and user feedback in engineering projects.



	I am able to confidently use the current way for reduce works delay in construction sites.	I have the knowledge to use the current way for reduce works delay in construction sites.	I have the resources to use the current way for reduce works delay in construction sites.	I have control over using the current way for reduce works delay in construction sites.
Strongly Disagree	28.57	25.71	31.42	31.42
Disagree	45.71	45.71	42.86	42.86
Somewhat Disagree	25.71	25.71	22.86	22.86
Somewhat Agree	0	0	0	0
Agree	0	2.86	2.86	2.86
Strongly Agree	0	0	0	0

Figure 4.5: Data collection from Questionnaire of Perceived Behavior Control (PBC) for Pre-Development



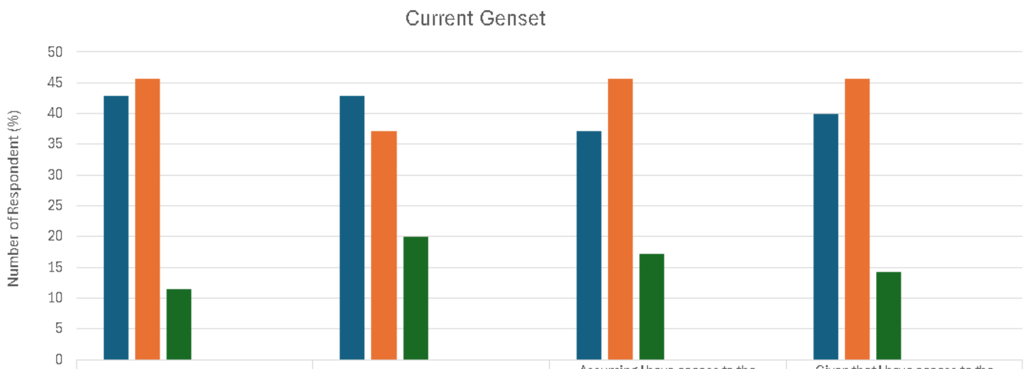
	I am able to confidently use TEBIC for reduce works delay in construction sites.	I have the knowledge to use TEBIC for reduce works delay in construction sites.	I have the resources to use TEBIC for reduce works delay in construction sites.	I have control over using TEBIC for reduce works delay in construction sites.
Strongly Disagree	0	0	0	0
Disagree	0	0	0	0
Somewhat Disagree	0	0	0	0
Somewhat Agree	20	5.71	17.14	11.43
Agree	42.86	65.71	31.43	40
Strongly Agree	37.14	28.57	51.43	48.57

Figure 4.6: Data collection from Questionnaire of Perceived Behavior Control (PBC) for Post-Development

Figures 4.5 and 4.6 present the findings from a survey evaluating Perceived Behaviour Control (PBC) in relation to using current genset techniques and the innovative genset (TEBIC) to mitigate construction site delays. Figure 4.5 details respondents' confidence and perceived control regarding the current genset methods, whereas Figure 4.6 displays these metrics for the TEBIC innovation.

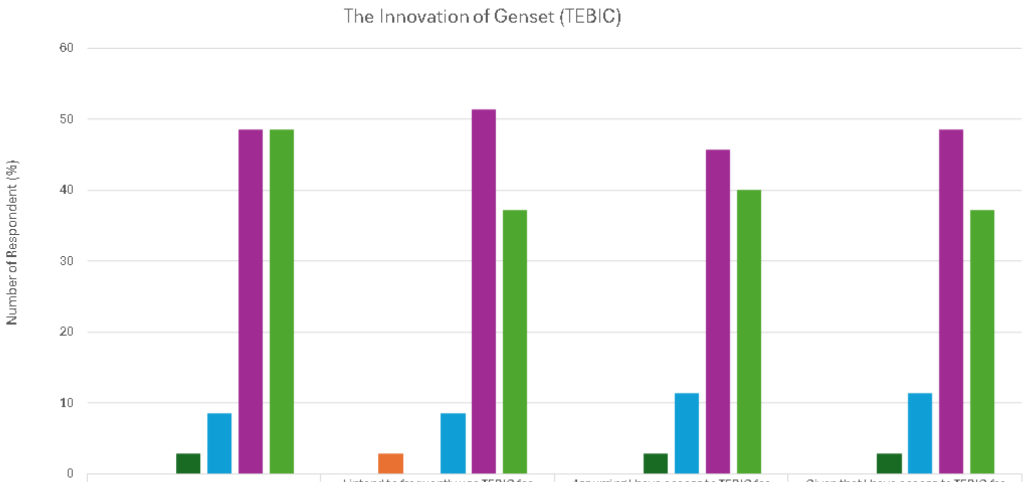
In Figure 4.5, respondents have low confidence and perceived control when it comes to using the current genset methods. Most respondents either "Disagree" or "Somewhat Disagree" with statements about their capability to use these methods effectively, including their knowledge, resources, and control over these methods. Notably, 45.71% of respondents disagree with their ability to confidently use the current genset methods, with similar trends seen across other statements, indicating high levels of disagreement or partial disagreement.

On the other hand, Figure 4.6 indicates a significantly different pattern for the TEBIC innovation. Respondents show much higher confidence and perceived control. An impressive 42.86% agree, and 37.14% strongly agree that they can confidently use TEBIC to reduce work delays. Additionally, the majority agree or strongly agree that they possess the necessary knowledge (65.71%), resources (51.43%), and control (48.57%) to use TEBIC effectively. These findings suggest a notable improvement in perceived behaviour control with the adoption of TEBIC, indicating that respondents feel more capable and assured in addressing work delays with the new technology compared to the current genset methods.



	I intend to use the current way for reduce works delay in construction sites.	I intend to frequently use the current way to reduce works delay in construction sites.	Assuming I have access to the current way for reduce works delay in construction sites, I intend to adopt it.	Given that I have access to the current way for reduce works delay in construction site, I predict that I would adopt it.
Strongly Disagree	42.86	42.86	37.14	40
Disagree	45.71	37.14	45.71	45.71
Somewhat Disagree	11.42	20	17.14	14.29
Somewhat Agree	0	0	0	0
Agree	0	0	0	0
Strongly Agree	0	0	0	0

Figure 4.7: Data collection from Questionnaire of Behavior Intention (BI) for Pre-Development



	I intend to use TEBIC to reduce works delay in construction sites.	I intend to frequently use TEBIC for reduce works delay in construction sites.	Assuming I have access to TEBIC for reduce works delay in construction sites, I intend to adopt it.	Given that I have access to TEBIC for reduce works delay in construction site, I predict that I would adopt it.
Strongly Disagree	0	0	0	0
Disagree	0	2.86	0	0
Somewhat Disagree	2.86	0	2.86	2.86
Somewhat Agree	8.57	8.57	11.43	11.43
Agree	48.57	51.43	45.71	48.57
Strongly Agree	48.57	37.14	40	37.14

Figure 4.8: Data collection from Questionnaire of Behavior Intention (BI) for Post-Development

The data in Figures 4.7 and 4.8 demonstrates respondents' intentions regarding the use of existing genset technology compared to the new TEBIC technology to minimize delays in construction projects. Figure 4.7 captures their views on the current genset, while Figure 4.8 focuses on their intentions towards TEBIC.

In Figure 4.7, most respondents show significant disapproval of the current genset technology, with 42.86% strongly disagreeing and 45.71% disagreeing with using the current method. There is no indication of agreement or strong agreement among respondents, highlighting a clear dissatisfaction with the current technology and a need for better solutions.

On the other hand, Figure 4.8 reveals a positive shift in attitude towards the TEBIC technology. Most respondents express strong intentions to adopt TEBIC, with 48.57% strongly agreeing and another 48.57% agreeing. This significant increase in positive responses compared to the current genset suggests that respondents see TEBIC as a much more effective solution for reducing construction delays.

In summary, the comparison between the two tables shows a clear transition from disapproval of the current genset technology to strong support for the TEBIC innovation. The data indicates that TEBIC is perceived as a superior solution for minimizing delays in construction projects, suggesting a high likelihood of its successful adoption and use in the industry.

Table 4.2: Paired samples t-test for TEBIC Existing Method

Paired Different			
Pair	Mean	T	Significant (two tailed)
The effectiveness of performing tasks	3.4000	14.394	<.001
To reduce work delays in construction site	3.4286	17.716	<.001

The mean differences for both pairs are around 3.4, which indicates a substantial improvement in the measured outcomes. The T-values of 14.394 and 17.716 for these pairs are both quite high, which strongly suggests that the observed differences are not due to random chance. These T-values correspond to p-values less than 0.001, reinforcing the high statistical significance of the results. This statistical significance implies that the observed improvements in task performance effectiveness and the reduction in work delays are very likely to be the result of the development interventions, rather than being attributable to variability or other external factors. In other words, the data strongly supports the conclusion that the interventions had a meaningful and positive impact on the outcomes.

4.3 DISCUSSION

The conclusion of this thesis successfully addresses the primary objectives set forth at the beginning of the study. It first identifies the causes of project delays in construction settings, offering a detailed analysis of the various factors contributing to these setbacks. These factors include logistical inefficiencies, equipment malfunctions, and mismanagement of operational timelines. By pinpointing these specific issues that impede project progress, the study provides a targeted approach to enhancing construction site productivity and reliability. This foundational understanding is crucial as it informs the subsequent development of innovative solutions aimed at mitigating these delays.

One such solution proposed and developed in the thesis is the chronometer and buzzer system specifically designed to regulate and manage the time settings on gensets at construction sites. This innovation aims to provide a reliable and user-friendly tool that ensures precise time management, thereby helping to reduce inefficiencies and prevent delays associated with genset operations. The design process, guided by user-centered principles, ensures that the system meets the practical needs of the construction workforce. By incorporating feedback from end-users, the system was tailored to address common pain points and operational challenges faced in the field, ensuring its relevance and effectiveness.

Finally, the thesis concludes with a thorough evaluation of the chronometer's effectiveness. Through rigorous testing and empirical analysis, the study demonstrates that the chronometer and buzzer system significantly improve time management and operational efficiency on construction sites. This comprehensive evaluation involved field trials, user feedback, and performance metrics that collectively validate the system's impact. The results showed a marked reduction in downtime and enhanced coordination among site activities, validating the initial hypotheses and highlighting the system's practical benefits. The findings contribute valuable insights into both the academic field and practical applications, emphasizing the importance of innovative approaches in addressing complex operational issues in construction projects. This research underscores the potential for technology-driven solutions to transform industry practices, offering a viable pathway to improved project outcomes and operational excellence.

In conclusion, the comparative analysis between the "Current Genset" and the "Genset Innovation (TEBIC)" clearly demonstrates a marked preference for the latter. The data collected from users underscore a significant shortfall in the current gensets' ability to meet expectations related to efficiency, innovation, productivity, and the provision of crucial information. A substantial majority of respondents indicated dissatisfaction with the performance and reliability of current gensets, highlighting specific areas where these systems fail to address operational demands effectively.

Conversely, TEBIC received overwhelmingly positive feedback across all assessed metrics. Users reported high levels of satisfaction with TEBIC's performance, noting its superior ability to minimize delays, enhance productivity, and streamline task execution. This high approval rating is indicative of TEBIC's success in addressing and overcoming the operational challenges that current gensets face. The innovative features and user-friendly design of TEBIC not only meet but exceed user needs, proving its effectiveness as a transformative solution in the realm of construction site management.

To further bolster TEBIC's effectiveness and ensure its sustained success, several strategic initiatives can be implemented. Establishing a continuous feedback loop is paramount; this will facilitate the prompt identification and resolution of any issues that users encounter, ensuring that the system evolves in line with user needs. Comprehensive training programs and robust support systems will be essential in maximizing the benefits that TEBIC offers, empowering users to utilize the system to its fullest potential. Moreover, incorporating user feedback for feature enhancements, such as integrating remote monitoring capabilities, can significantly enhance user experience and operational efficiency. Additionally, assessing the scalability of TEBIC will be crucial in extending its benefits to larger projects and different environments. Developing and closely monitoring key performance indicators (KPIs) will provide measurable insights into TEBIC's impact and areas for improvement. Fostering user engagement through regular updates and interactive platforms can also keep users invested and informed. Finally, continuous investment in research and development will ensure that TEBIC remains at the cutting edge of genset innovation, consistently offering advanced solutions that drive productivity and efficiency on construction sites.

In summary, TEBIC represents a significant advancement over current gensets, aligning closely with user needs and operational demands. By implementing these strategies, TEBIC can maintain its competitive edge, ensuring it continues to be an asset in enhancing construction site productivity and operational efficiency. The positive reception and proven effectiveness of TEBIC highlight its potential to set new standards in genset technology and construction site management.

4.4 CONCLUSION

The demographic analysis highlights a predominantly experienced, all-male cohort primarily from Sunway Construction, which could impact the study's findings. The lack of gender diversity and the relatively young demographic might reflect certain organizational or industry trends, suggesting a need for further investigation to gain a thorough understanding of the workforce dynamics.

The change in respondents' perceptions before and after the innovation demonstrates the significant impact of TEBIC technology on their work environment. The initial dissatisfaction with the current genset technology starkly contrasts with the overwhelmingly positive reception of TEBIC, showing that the innovative solution effectively addresses previously unmet needs in reducing work delays and improving task performance. The considerable improvement in perceived usefulness and ease of use, as indicated by the data, underscores TEBIC's potential to revolutionize construction site operations.

Statistical analysis further confirms TEBIC's effectiveness, with notable improvements in task performance and delay reduction directly linked to the innovation. The high T-values and low p-values emphasize the strength of these findings, validating that the development interventions have had a substantial and positive effect. This points to a promising future for TEBIC's adoption, setting the stage for more efficient and productive construction site management.

CHAPTER 5
CONCLUSION

5.1 INTRODUCTION

The conclusion of this thesis effectively addresses the main objectives set at the beginning of the study. First, it identifies the causes of project delays in construction settings, offering a detailed analysis of the various factors that contribute to these delays. These factors include logistical inefficiencies, equipment breakdowns and mismanagement of operational timelines. This fundamental understanding is important as it informs the further development of innovative solutions aimed at reducing these delays. By identifying specific issues that impede project progress, this study provides a targeted approach to improving construction site productivity and reliability.

One such solution proposed and developed in the thesis is a chronometer and buzzer system specifically designed to regulate and manage time settings on gensets at construction sites. This innovation aims to provide a reliable and user-friendly tool that ensures accurate time management, thereby helping to reduce inefficiencies and prevent delays associated with genset operations. The design process, guided by user-centered principles, ensures that the system meets the practical needs of the construction workforce. By incorporating feedback from end users, the system has been tailored to address common pain points and operational challenges encountered in the field, ensuring relevance and effectiveness.

Finally, this thesis concludes with a comprehensive evaluation of the chronometer's effectiveness. Through rigorous testing and empirical analysis, studies show that chronometers and buzzer systems significantly improve time management and operational efficiency on construction sites. This comprehensive evaluation involves field testing, user feedback and performance metrics that collectively validate the system's impact. The results show a significant reduction in downtime and improved coordination between site activities, confirming the initial hypothesis and highlighting the practical benefits of the system. These findings contribute valuable insights into both academic fields and practical applications, emphasizing the importance of innovative approaches in addressing complex operational issues in construction projects. This research outlines the potential of technology-driven solutions to transform industry practices, offering a viable path to improving project outcomes and operational excellence.

5.2 RECOMMENDATION

Based on the findings of this research, it is recommended to integrate remote monitoring capabilities into genset systems to significantly improve user experience and operational efficiency. The technology provides real-time data on performance metrics such as fuel consumption, temperature and power output, allowing users to identify and address potential issues immediately. Additionally, including an additional button for 30-minute or 1-hour adjustment on the genset timer can greatly increase user comfort and flexibility, allowing for better fuel consumption management and operational efficiency.

Furthermore, it is important to assess scalability and develop key performance indicators (KPIs) to ensure the long-term success and adaptability of the genset system. Scalability assessment helps assess whether the current system can handle increased load or expanded operations without compromising performance. Developing KPIs such as uptime, fuel efficiency and maintenance frequency provides valuable insight into genset operational health, guiding strategic decisions and proactive maintenance.

Finally, fostering user involvement and investing in research and development (R&D) are key strategies to keep TEBIC at the forefront of genset innovation. Engaging users through forums, surveys and live interactions provides valuable feedback that drives product improvement. At the same time, investment in R&D is essential to develop advanced technologies and innovative solutions that differentiate TEBIC from competitors, ensuring sustainable growth and leadership in the industry. Combining strong user engagement with robust R&D investment will ensure TEBIC remains agile, responsive and on the cutting edge of genset technology.

5.3 CONCLUSION

In conclusion, the comparative analysis between "Current Genset" and "Genset Innovation (TEBIC)" clearly shows a significant preference for the latter. Data collected from users underscores the significant shortfalls in the ability of current gensets to meet expectations related to efficiency, innovation, productivity, and the provision of important information. Many respondents expressed dissatisfaction with the performance and reliability of current gensets, highlighting specific areas where these systems fail to effectively handle operational demands.

In contrast, TEBIC received very positive feedback across all metrics evaluated. Users report high levels of satisfaction with TEBIC's performance, citing its superior ability to minimize delays, increase productivity and streamline task execution. This high approval rating demonstrates TEBIC's success in addressing and overcoming operational challenges faced by current gensets. TEBIC's innovative features and user-friendly design not only meet but exceed user needs, proving its effectiveness as a transformative solution in the field of construction site management.

To further strengthen TEBIC's effectiveness and ensure its continued success, several strategic initiatives can be implemented. Creating a continuous feedback loop is important; this will facilitate the immediate identification and resolution of any issues faced by users, ensuring that the system evolves in line with user needs. A comprehensive training program and robust support system will be essential in maximizing the benefits offered by TEBIC, empowering users to use the system to its full potential. Additionally, incorporating user feedback for feature enhancements, such as integrating remote monitoring capabilities, can significantly improve user experience and operational efficiency.

Additionally, assessing the scalability of TEBIC will be important in extending its benefits to larger projects and different environments. Developing and closely monitoring key performance indicators (KPIs) will provide quantifiable insight into TEBIC's impact and areas for improvement. Fostering user engagement through regular updates and interactive platforms can also keep users invested and informed. Finally, continued investment in research and development will ensure TEBIC remains at the forefront of genset innovation, consistently offering cutting-edge solutions that drive productivity and efficiency on construction sites.

In short, TEBIC represents a significant advance over current gensets, aligned with user needs and operational demands. By implementing this strategy, TEBIC can maintain its competitive edge, ensuring it continues to be an asset in improving construction site productivity and operational efficiency. TEBIC's positive reception and proven effectiveness highlight its potential to set new standards in genset technology and construction site.

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APPENDIX

PRE- QUESTIONNAIRE

Section 1 of 6

A study on The Current Way to generate electrical power using 20KV genset

Assalamualaikum and Greetings,

Dear respected respondent,

You are invited to take part in this survey which aim to find answers about **current way to generate electrical power** for my final year project. The information obtained from this survey would be utilized for research purpose only and this document would not be misused.

This questionnaire consists of five (5) sections, namely:

Section A: Demographic Profile
Section B: Perceived Usefulness (PU)
Section C: Perceived Ease of Use (PEU)
Section D: Perceived Behavior Control (PBC)
Section E: Behavior Intention (BI)

I humbly request you to answer the survey as voluntarily and honestly as possible. Thank you for spending your time to provide answers to the survey.

Muhammad Razis bin Rashidin
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Sunway Construction Internship
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Section 2 of 6

Section A: Demographic Profile

Description (optional)

A1. Gender *

- ◯ Male
- ◯ Female

A2. Age *

- ◯ 21-30 years
- ◯ 31-40 years
- ◯ 41-50 years
- ◯ 51-60 years
- ◯ 60 years and above

A3. Company *

- ◯ Sunway Construction
- ◯ Waitatt Sdn Bhd
- ◯ Binachuan

A4. Work Experience *

- ◯ < 2 years
- ◯ 3 years to 5 years
- ◯ 6 years to 10 years
- ◯ > 10 years

		Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
No	The opinion from respondent regarding the worker in construction.	1	2	3	4	5	6
B1	The current way enables me to accomplish tasks more quickly.						
B2	The current way has improved the quality of innovations within our operating hours.						
B3	The current way makes it easier to reduce works delay in construction sites.						
B4	The current way has improved the operating productivity.						
B5	The use of the current way increases the effectiveness of performing tasks.						
B6	The current way provides thorough information for my purposes.						
B7	The advantages of the current						

	way in reduce works delay outweigh the disadvantages.						

		Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
No	The opinion from respondent regarding the worker in construction.	1	2	3	4	5	6
C1	Learning to operate the current way is easy for me.						
C2	My interaction with the current way is understandable and clear.						
C3	I find it easy to get the current way to do what I want it to do.						
C4	Overall, the current way is easy to use.						
C5	The current way is easy to navigate.						

		Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
No	The opinion from respondent regarding the worker in construction.	1	2	3	4	5	6
D1	I am able to confidently use the current way for reduce works delay in construction sites.						
D2	I have the knowledge to use the current way for reduce works delay in construction sites.						
D3	I have the resources to use the current way for reduce works delay in construction sites.						
D4	I have control over using the current way for reduce works delay in construction sites.						

		Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
No	The opinion from respondent regarding the worker in construction.	1	2	3	4	5	6
E1	I intend to use the current way for reduce works delay in construction sites.						
E2	I intend to frequently use the current way to reduce works delay in construction sites.						
E3	Assuming I have access to the current way for reduce works delay in construction sites, I intend to adopt it.						
E4	Given that I have access to the current way for reduce works delay in construction site, I predict that I would adopt it.						

END QUESTION / THANK YOU

POST- QUESTIONNAIRE

Section **1** of 6

A study on The E-Buzzer Innovation for Chronometer on Light Machines (20kV Genset) at Construction Industry (TEBIC)

Assalamualaikum and Greetings,

Dear respected respondent,

You are invited to take part in this survey which aim to find answers about **TEBIC** for my final year project. The information obtained from this survey would be utilized for research purpose only and this document would not be misused.

This questionnaire consists of five (5) sections, namely:

Section A: Demographic Profile
Section B: Perceived Usefulness (PU)
Section C: Perceived Ease of Use (PEU)
Section D: Perceived Behavior Control (PBC)
Section E: Behavior Intention (BI)

I humbly request you to answer the survey as voluntarily and honestly as possible. Thank you for spending your time to provide answers to the survey.

Muhammad Razis bin Rashidin
Student of Bachelor in Civil Engineering Technology with Honours
Sunway Construction Internship
0137469619 / razis611@gmail.com
(FYP Supervisor: Puan Azizah bt Haron @ Hassan)
(Sunway Supervisor: Tan Khai Kim)

		Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
No	The opinion from respondent regarding the worker in construction.	1	2	3	4	5	6
B1	TEBIC enables me to accomplish tasks more quickly.						
B2	TEBIC have improved the quality of innovations within our operating hours.						
B3	TEBIC have improved the quality of innovations within our operating hours.						
B4	TEBIC have improved the operating productivity.						
B5	The use of the TEBIC increases the effectiveness of performing tasks.						
B6	TEBIC provides thorough information for my						

	purposes.						
B 7	The advantages of TEBIC in reduce works delay outweigh the disadvantages.						

		Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
No	The opinion from respondent regarding the worker in construction.	1	2	3	4	5	6
C 1	Learning to operate TEBIC is easy for me.						
C 2	My interaction with TEBIC is understandable and clear.						
C 3	I find it easy to get TEBIC to do what I want it to do.						
C 4	Overall, TEBIC is easy to use.						
C 5	TEBIC is easy to navigate.						

		Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
No	The opinion from respondent regarding the worker in construction.	1	2	3	4	5	6
D1	I am able to confidently use TEBIC for reduce works delay in construction sites.						
D2	I have the knowledge to use TEBIC for reduce works delay in construction sites.						
D3	I have the resources to use TEBIC for reduce works delay in construction sites.						
D4	I have control over using TEBIC for reduce works delay in construction sites.						

		Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
No	The opinion from respondent regarding the worker in construction.	1	2	3	4	5	6
E1	I intend to use TEBIC to reduce works delay in construction sites.						
E2	I intend to frequently use TEBIC for reduce works delay in construction sites.						
E3	Assuming I have access to TEBIC for reduce works delay in construction sites, I intend to adopt it.						
E4	Given that I have access to TEBIC for reduce works delay in construction site, I predict that I would adopt it.						

END QUESTION / THANK YOU

ARDUINO CODING

Coding | Arduino 1.8.19

File Edit Sketch Tools Help

Coding

```
#include <math.h>

int digit_pin[] = {6, 9, 10, 11}; // PWM Display  digit pins from left to right

int speakerPin = 15;

#define DIGIT_ON  LOW
#define DIGIT_OFF  HIGH

int segA = 2;
int segB = 3;
int  segC = 4;
int segD = 5;
int segE = A0; //pin 6 is used bij display 1 for  its pwm function
int segF = 7;
int segG = 8;
//int segPD = ;


int  button1=13;
int button2=12;
int button3=16;
int button4=17;

int  countdown_time = 60;

struct struct_digits {
    int digit[4];
  };


void  setup() {
  pinMode(segA, OUTPUT);
  pinMode(segB, OUTPUT);
  pinMode(segC, OUTPUT);
  pinMode(segD, OUTPUT);
  pinMode(segE, OUTPUT);
  pinMode(segF, OUTPUT);
  pinMode(segG, OUTPUT);

  for (int i=0; i<4;  i++) {
    pinMode(digit_pin[i], OUTPUT);
  }

  pinMode(speakerPin,  OUTPUT);

  pinMode(button1,INPUT_PULLUP);
```

Coding | Arduino 1.8.19

File Edit Sketch Tools Help

Coding §

```
void  setup() {
  pinMode(segA, OUTPUT);
  pinMode(segB, OUTPUT);
  pinMode(segC, OUTPUT);
  pinMode(segD, OUTPUT);
  pinMode(segE, OUTPUT);
  pinMode(segF, OUTPUT);
  pinMode(segG, OUTPUT);

  for (int i=0; i<4;  i++) {
    pinMode(digit_pin[i], OUTPUT);
  }

  pinMode(speakerPin,  OUTPUT);

  pinMode(button1,INPUT_PULLUP);
  pinMode(button2,INPUT_PULLUP);
  pinMode(button3,INPUT_PULLUP);
  pinMode(button4,INPUT_PULLUP);
}


void  playTone(int tone, int duration) {
  for (long k = 0; k < duration * 1000L; k  += tone * 2) {
    digitalWrite(speakerPin, HIGH);
    delayMicroseconds(tone);
    digitalWrite(speakerPin, LOW);
    delayMicroseconds(tone);
  }
}


void  lightNumber(int numberToDisplay) {

#define SEGMENT_ON  HIGH
#define SEGMENT_OFF  LOW

  switch (numberToDisplay){

  case 0:
    digitalWrite(segA,  SEGMENT_ON);
    digitalWrite(segB, SEGMENT_ON);
    digitalWrite(segC, SEGMENT_ON);
    digitalWrite(segD, SEGMENT_ON);
    digitalWrite(segE, SEGMENT_ON);
    digitalWrite(segF,  SEGMENT_ON);
    digitalWrite(segG, SEGMENT_OFF);
```

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Coding

```
void  lightNumber(int numberToDisplay) {

#define SEGMENT_ON  HIGH
#define SEGMENT_OFF  LOW

  switch (numberToDisplay){

  case 0:
    digitalWrite(segA,  SEGMENT_ON);
    digitalWrite(segB, SEGMENT_ON);
    digitalWrite(segC, SEGMENT_ON);
    digitalWrite(segD, SEGMENT_ON);
    digitalWrite(segE, SEGMENT_ON);
    digitalWrite(segF,  SEGMENT_ON);
    digitalWrite(segG, SEGMENT_OFF);
    break;

  case  1:
    digitalWrite(segA, SEGMENT_OFF);
    digitalWrite(segB, SEGMENT_ON);
    digitalWrite(segC, SEGMENT_ON);
    digitalWrite(segD, SEGMENT_OFF);
    digitalWrite(segE, SEGMENT_OFF);
    digitalWrite(segF, SEGMENT_OFF);
    digitalWrite(segG, SEGMENT_OFF);
    break;

  case 2:
    digitalWrite(segA,  SEGMENT_ON);
    digitalWrite(segB, SEGMENT_ON);
    digitalWrite(segC, SEGMENT_OFF);
    digitalWrite(segD, SEGMENT_ON);
    digitalWrite(segE, SEGMENT_ON);
    digitalWrite(segF,  SEGMENT_OFF);
    digitalWrite(segG, SEGMENT_ON);
    break;

  case  3:
    digitalWrite(segA, SEGMENT_ON);
    digitalWrite(segB, SEGMENT_ON);
    digitalWrite(segC, SEGMENT_ON);
    digitalWrite(segD, SEGMENT_ON);
    digitalWrite(segE,  SEGMENT_OFF);
    digitalWrite(segF, SEGMENT_OFF);
    digitalWrite(segG,  SEGMENT_ON);
```

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Verify

Coding

```
void SwitchDigit(int  digit) {
  for (int i=0; i<4; i++) {
    if (i == digit) {
      digitalWrite(digit_pin[i],  DIGIT_ON);
    } else {
      digitalWrite(digit_pin[i], DIGIT_OFF);
    }
  }
}


struct struct_digits IntToDigits(int n){
  struct struct_digits  dig;
  int zeros=0;
  int d;
  for (int i=0; i<4; i++) {
    d=n/pow(10,3-i);
    zeros += d;
    n = n - d*pow(10,3-i);
    if (zeros!=0 || i==3) {
      dig.digit[i]=d;
    } else {
      dig.digit[i]=10;
    }
  }
  return dig;
}

void PrintNumber(int n, int time) {
  struct struct_digits  dig;

  dig = IntToDigits(n);

  for (int i=0; i<= time/20; i++) {
    if (digitalRead(button2)==LOW) {
      return;
    }
    for (int j=0;  j<4; j++) {
      SwitchDigit(j);
      lightNumber(dig.digit[j]);
      delay(5);
    }
  }
}
```