POLITEKNIK UNGKU OMAR

ANDRAS EX MACHINA (AeM) MACHINERY PLANNING APPLICATION

EKHSAN AQMAL BIN ABU HASAN

(01BCT20F3029)

CIVIL ENGINEERING DEPARTMENT

SESSION 2 2022/2023

POLITEKNIK UNGKU OMAR

ANDRAS EX MACHINA (AeM) MACHINERY PLANNING APPLICATION

EKHSAN AQMAL BIN ABU HASAN

(01BCT20F3029)

A report submitted in partial fulfillment of the requirements for the award of the degree of bachelor's in civil engineering technology with honors.

CIVIL ENGINEERING DEPARTMENT

SESSION 2 2022/2023

DECLERATION OF ORIGINAL AND OWNERSHIP

ANDRAS EX MACHINA (AeM) MACHINERY PLANNING APPLICATION

1. EKHSAN AQMAL BIN ABU HASAN (01BCT20F3029)

1. We, are students in the final year of our **Degree in Civil Engineering Technology, Civil Engineering Department, Politeknik Ungku Omar**

2. We acknowledge that 'The above project' and the intellectual property contained therein are the work of our original work/invention without taking
or imitating any intellectual property from any other party.

3. We agree to transfer ownership of the intellectual property of the 'Project' to the Politeknik Ungku Omar to meet the requirements for the award of the Bachelor's In Civil Engineering to me.

Made and truly acknowledged by the said.

a) EKHSAN AQMAL BIN ABU HASAN ....
(IC No: 980621-08-6131) EKHSAN AQMAL

In front of me, SUPERVISOR NAME
As project supervisor on date ....

TUAN HAJI
SUHAIZAM BIN
ROSLI @ SHUIB

ACKNOWLEDGEMENT

In the name of Allah SWT, most gracious, most merciful, peace and blessing be upon prophet Muhammad SAW, his family and his friend selected. Firstly, I want to offer my deepest gratitude must be towards Allah because of His grace and His guidance; I can complete this report "Andras Ex Machina (AeM) Machinery Planning Application".

Thank you to my family for their unconditional love, unwavering support, and constant encouragement. Their belief in me, their sacrifices, and their unwavering presence have been instrumental in shaping who I am today. Their guidance, wise counsel, and endless encouragement have been a constant source of inspiration, motivating me to strive for excellence and to overcome challenges with determinationand resilience. I am truly blessed to have such a loving and supportive family, and I am forever grateful for their unwavering faith in me.

Next, I would like to express my sincere gratitude and appreciation to my supervisor, Tuan Haji Suhaizam bin Rosli @ Shuib for his invaluable guidance, support, and expertise throughout my internship. His unwavering commitment, insightful feedback,and encouragement have been instrumental in shaping my professional growth and development during this period. I am truly grateful for his mentorship and the opportunities she provided for me to learn and excel.

I would also like to extend my heartfelt thanks to Pembinaan Tetap Teguh Sdn. Bhd., my intern company, for granting me the opportunity to be a part of their esteemed organization. The experience and knowledge gained during my internship have been invaluable in deepening my understanding of the construction industry. I am grateful to the entire team at East Coast Rail Link Section 3, Terengganu for their warm welcome, continuous support, and valuable insights shared with me throughout my internship journey.

Thank you.

ABSTRACT

Efficient planning, coordinated machinery movement, and stringent quality control are essential for successful large-scale infrastructure projects. This abstract presents the application of robust machinery planning software in the context of the East Coast Rail Link (ECRL) Project to demonstrate its effectiveness in improving systematic planning, optimizing machinery movement, and ensuring rigorous quality control. The East Coast Rail Link (ECRL) Project has successfully implemented a robust machinery planning application, the Andras Ex Machina (AeM) Planning Application, to improve systematic planning, optimize machinery movement, and ensure rigorous quality control. The application utilizes advanced algorithms and intuitive interfaces to streamline planning processes, allocate resources optimally, and minimize construction schedule bottlenecks. The core feature of the AeM Planning Application is its ability to facilitate efficient machinery movement, reducing downtime and enhancing overall project productivity. The high level of acceptance among project stakeholders for the Machinery Planning Application is attributed to its perceived usefulness, ease of use, and positive attitudes towards its adoption. This results in notable improvements in systematic planning, machinery movement, and quality control, empowering stakeholders to achieve optimal outcomes, meet project milestones, and deliver high-quality infrastructure within specified timelines.

Keyword: Quality Control, East Coast Rail Link (ECRL) Project, Machinery Planning application, Machinery Movement, Systematic Planning

ABSTRAK

Perancangan yang cekap, pergerakan jentera yang diselaraskan, dan kawalan kualiti yang ketat adalah penting untuk projek infrastruktur berskala besar yang berjaya. Abstrak ini membentangkan aplikasi perisian perancangan jentera yang teguh dalam konteks Projek Laluan Rel Pantai Timur (ECRL) untuk menunjukkan keberkesanannya dalam menambah baik perancangan sistematik, mengoptimumkan pergerakan jentera, dan memastikan kawalan kualiti yang ketat. Projek Laluan Rel Pantai Timur (ECRL) telah berjaya melaksanakan aplikasi perancangan jentera yang mantap, Aplikasi Perancangan Andras Ex Machina (AeM), untuk menambah baik perancangan sistematik, mengoptimumkan pergerakan jentera, dan memastikan kawalan kualiti yang rapi. Aplikasi ini menggunakan algoritma termaju dan antara muka intuitif untuk menyelaraskan proses perancangan, memperuntukkan sumber secara optimum dan meminimumkan kesesakan jadual pembinaan. Ciri teras Aplikasi Perancangan AeM ialah keupayaannya untuk memudahkan pergerakan jentera yang cekap, mengurangkan masa henti dan meningkatkan produktiviti projek secara keseluruhan. Tahap penerimaan yang tinggi di kalangan pihak berkepentingan projek untuk Aplikasi Perancangan Jentera adalah disebabkan oleh kesan kegunaannya, kemudahan penggunaan dan sikap positif terhadap penggunaannya. Ini menghasilkan peningkatan ketara dalam perancangan sistematik, pergerakan jentera, dan kawalan kualiti, memperkasakan pihak berkepentingan untuk mencapai hasil yang optimum, memenuhi pencapaian projek dan menyampaikan infrastruktur berkualiti tinggi dalam garis masa yang ditetapkan.

Kata kunci: Kawalan Kualiti, Projek Laluan Rel Pantai Timur (ECRL), aplikasi Perancangan Jentera, Pergerakan Jentera, Perancangan Sistematik

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF PROJECT

As the construction industry begin to flourish for the past 2020 to this day, some overseas company has carried out a drastic digital transformation of their service system, accelerated the online of the whole process, and committed to the service transformation from passive to active and from artificial to intelligent, leading the industry into a new era of digital service. (Chowdhury et al. 2021) asserted that the views of web-based tool users in terms of functionality, potency, and usability of the various platforms are often neglected. They anticipate that further enhanced; oration is to be further enhanced; the views of users must be known.

A virtual community according to (Shwu-Min Horng 2016-17) is the core element of social commerce (Liang et al. 2011-12), defined as a new form of electronic commerce that involves using social media to assist in online buying and selling of products and services (Shen and Eder 2011). At the front end of customers, several digitalize construction machinery company has sped up the integration of resources and data and puts all full cycle and full range service businesses such as working conditions, accessories, repair, maintenance, engineering, operator, and community into the "customer cloud" and "Eason". At the back end, relying on the "excavator index" formed by 480000 branding construction machinery has deeply excavates big data, continuously develops more and better value-added service projects, promotes the service from "passive" to "active" and from "artificial" to "intelligent", and improves the service value and efficiency.

Software companies such as Adobe, which made the switch from perpetual licenses to subscriptions, also experienced a sharp increase in their market value. These examples show that consumers do not necessarily want to own, but that the results achieved with them are important. The application focus should be to ease the user's request for services of their types of machinery, encrypting the types of machinery detail and description, projecting their work hours and mileage, and their trip record. The application shall have an 'order and delivery' system where the Site Supervisor and Site Engineer can calculate how much the machine does its delivery today and how much work has been done within its working hours. The application that shall be developed for the final year project will be called Andras Ex Machina (AeM) which is a derivation from the original word in the Greek language which means "Man from the Machine".

The main purpose of the research is to create a completely different planning application called Andras Ex Machina (AeM). The application functionality is to ease the task of the Site Supervisor, Site Engineer, Senior Engineer, Project Coordinator, Construction Manager, and Project Manager to do supervisory task commands to move the types of machinery according to the requested location without relying on social group chats to send commanding work. The command consists of two simple tasks: delivery of machinery toward its destination or work-tasking distribution among operators and lorry drivers. Both tasks must be organized by the Site Supervisor and Site Engineers to simplify the daily work report to the Project Manager and Construction Manager.

1.2 PROBLEM STATEMENT

The acceof beinglity of information on site planning maintenance entirety of the whole project is only limited to the Project Manager and the Project Coordinator as they're the one who is responsible to coordinate and plan all the work to ensure that the project is capable to be maintained as one of their revenue streams of profit while maintaining the efficiency and the effectiveness of the work in top condition. For the coordination and formulation of the site planning for the smaller sites, the request for proper machinery planning is deemed unnecessary to coordinate every machinery. However, for projects that require a long-distance land to cover such as railroad projects, indigenous road construction projects, and highway construction projects, every machinery's position must be reachable and easily be located for machinery’s maintenance and the purpose of repositioning or rescheduling the prior site planning in case of any location that needs immediate attention. This problem was deemed to be highlighted during the recent flood at the East Coast Rail Line (ECRL) Project Section 3 – Setiu, Terengganu as not only all sites are inaccessible due to the flood, but poor planning for types of machinery causing damage to the machinery such as Excavators (SANY Model 365, 215 and VOLVO Model 375), Bulldozers (SEM Model, CATERPILLAR Model and HAN TUI Model) Compactors, (SEM Model and CATERPILLAR Model) and Dumping Trucks (HOWO model).

Although there is a similar application that was used for tracking every machinery while checking their working hours and the engine starts action time log, not all personnel of construction workers are aware of the existence of the said application as most operators and lorry drivers were still taught by the conventional system that doesn’t have any modern or digitalized system. The company has very strict rules and restrictions toward mid-level construction staff making this unable for all personnel staff to view the said tracking app. Hence, limiting the requirement for the Site Supervisor and Site Engineer to be aware of any machinery’s supervisory task as the accessibility of the application is only limited to those who are directly connected to the company. Any action of repositioning without any notice or consent from the Site Supervisor or Site Engineer can cause several misunderstandings and confusion in the machinery operating work. This will hinder the progress and efficiency of the project if all the working staff have a miscommunication toward the base of command in the project.

1.3 OBJECTIVE OF THE PROJECT/STUDY

- To study the effectiveness of the current machinery control method.
- To develop a functional application that allows the task of coordinating the machinery.
- To know the effectiveness of the newly developed application.

1.4 SCOPE OF THE PROJECT/STUDY

The scope of this project is to study the coordination of site planning according to its types of machinery positioning. The location for the scope of the study for this project shall have been experimented at East Coast Rail Line (ECRL) Project Section 3, Setiu – Terengganu. The location of the site has a total span of 35.7 km, and the length of the site location would be for this final year project to test out the effectiveness of the newly developed application. It’s essential to properly coordinate the workforce that is available in the site location that spans over 5 km and beyond as confusion of command is one of the regular occurrences that often happens due to lack of supervisory. The site location that had been open due to the claimant chase has resulted in many site locations being done at once. The targeted machinery for this experiment shall be Excavators (SANY Model 365, 215, and VOLVO Model 375), Bulldozers (SEM Model, CATERPILLAR, Model, and HAN TUI Model) Compactors, (SEM Model and CATERPILLAR Model,) and Dumping Trucks (HOWO model).

The other significant scope of the study is to balance the machinery distribution according to the supervision’s workload. Workload is defined as the amount of work to be done by someone or something. The higher the workload requires; the larger the amount of machinery needed. hence, a proper distribution system is needed to balance out the types of machinery workforce under the guidance of each one of their designated Site Supervisor. The deviation of the site has been divided into 5 segments with a total span of 10.7 km. The site is categorized as follows; CH 121+000 – CH 123+000 (2.0 km), CH 123+001 – CH

125+000 (2.0 km), CH 125+001 – CH 127+000 (2.0 km), CH 127+001 – CH 128+000 (2.0 km), and CH 128+001 – CH 130+700 (2.7 km).

Figure 1.1: Total length of site location (10.7 km) from the East Coast Rail Line (ECRL) Project Section 3, Setiu – Terengganu

Studying the effectiveness of the application before and after the implementation of the application by the Site Supervisor, Site Engineer, and Operator is also one of the scopes of study for this paper. The current method of supervisory and task-planning is not so efficient wise as most command for work comes from social applications (WhatsApp) where the mix of command tasking for the staff and casual texting among staff is to the point of undetected in the group chat. This mixed-up situation is the most common problem when the needs for task work are often neglected. Site Engineers and Site Supervisors who must present their daily reports to the Project Manager or Construction Manager often find this information to be a hassle since most of the task command written in WhatsApp will end up either in the one of many group chats or scrolled up in a group chats. Sometimes, most of the commands written in the WhatsApp are often delayed due to being out of cellular network range. Any delayed information will be late to be updated with the current task causing it to decrease the efficiency of work.

CHAPTER 2

LITERATURE REVIEW

2.1 GAP ANALYSIS OF THE RELATED JOURNAL TO THE FIELD OF PRODUCT.

No.	Journal/Article	Related to Application	Related to Management	Related to other
1	What is Application Monitoring? – Arfan Sharif (2022)	/		
2	Application of Dempster–Shafer Theory in Condition Monitoring Applications: A Case Study – Chinmay R Parikh; Michael J Pont; N Barries Jones (2001)	/		
3	Mobile Marketing: From Marketing Strategy to Mobile Marketing Campaign Implementation – Matti Leppäniemi; Heikki Karjaluoto (2008)		/	
4	Althea Suite Order and Delivery Management Software		/	/
5	How Do You Connect Your CRM and Order Management System? – Chris Meabe (2021)			/
6	A Monitoring System for Real-Time Interference Control on Large Construction Sites – Berardo	/		

	Naticchia; Massimo Vaccarini; Alessandro Carbonari (2013)			
7	Development Of Mobile Safety Monitoring System for Construction Sites – Ung-Kyun Lee; Joo-Heon Kim; Hun-Hee Cho; Kyung-In Kang (2009)	/		
8	PHOTO-NET II: A Computer-Based Monitoring System Applied to Project Management – Jorge Abeid; Erez Allouche; David Arditi; Michael Hayman (2003)	/		
9	Machine Monitoring System: a decade in review – Maznah Iliyas Ahmad, Yusri Yusof, Md Elias Daud, Kamran Latiff, Aini Zuhra Abdul Kadir & Yazid Saif (2020)		/	
10	Smart Machinery Monitoring System with Reduced Information Transmission and Fault Prediction Methods Using Industrial Internet of Things – Ming Fong Tsai, Yen Ching Chu, Min Hao Li & Lien Wu Chen (2020)		/	
11	Designing and developing smart production planning and control systems in the industry 4.0 era: a methodology and case study – Olumide Emmanuel Oluyisola; Swapnil Bhalla; Fabio Sgarbossa; Jan Ola Strandhagen (2021)			/

12	Determinants Factor of Technical Efficiency in Machinery Manufacturing Industry in Malaysia – Muhammad Syafiq Abdul Latif; Mohd Fahmy-Abdullah; Lai Wei Sieng (2019)			/
13	Role Understanding and Effective Communication as Core Competencies for Collaborative Practice – Esther Suter, Julia Arndt, Nancy Arthur, John Parboosigh, Elizabeth Taylor & Siegrid Deutschlander (2009)		/	
14	Can Mixed Reality Enhance Safety Communication on Construction Site? An Industry Perspective – Fei Dai; Abiodun Olorunfemi; Weibing Peng; Dongpin Cao; Xiaochun Luo (2021)			/
15	Criteria for Selection of Elements of Simplified Accounting and Reporting System by Small Enterprises – Nadiya Volodymyrivna Khocha (2018)	/		
16	Stakeholder Benefit Assessment – Project Success through Management of Stakeholders – Agnar Johansen; Petter Eik Andersen; Anandasivakumar Ekambaram (2014)			/
17	Managing for Stakeholders: The Role of Stakeholder-Based Management in Project Success – Mahmoud Rajablu, Govindan Marthandan & Wan Fadzilah Wan Yusoff (2015)		/	

18	Assessment of Automation and integration Technology's Impact on Project Stakeholder Success – Li-Ren Yang; James T. O'Connor; Jieh-Haur Chen (2007)		/	
19	Towards the development of a cyber-physical measurement system (CPMS): A Case study of a bioinspired soft growing robot for remote measurement and monitoring application – Stanislao Grazioso; Annarita Tedesco; Mario Selvaggio; Stefano Debei; Sebastiano Chiodini (2021)		/	
20	Information technologies for remote monitoring of the Environment – Vladmir Krapivin; Anatolij M. Shutko (2012)	/		
21	Integration of building information modeling and web service application program interface for assessing building surroundings in early design stages – Jingming Li; Nianping Li; Kereshmeh Afsari; Jingqing Peng; Zhibin Wu; Haikiao Cui (2019)	/		
22	Application Programming Interface (API) Research: A Review of the Past Inform the Future – Joshua Ofoeda; Richard Boateng; John Effah (2019)	/		
23	Implications of Application Programming Interfaces for Third-	/		

	Party New App Development and Copycatting – Ling Xue; Peijian Song; Arun Rai; Cheng Zhang; Xia Zhao (2019)			
24	Method for Storing and Retrieval of history for Mobile Devices – Hassan Abolhassani (2016)	/		
25	BOSS: Building Operating System Services - Stephen Dawson-Haggerty; Andrew Krioukov; Jay Taneja; Sagar Karandikar; Gabe Fierro; Nikita Kitaev; and David Culler (2013)		/	
26	An Overview of Android operation System and Its Security Features – Rajinder Singh (2014)	/		
27	Operating System for mobile Computing – Sharon P. Hall; Eric Anderson (2009)	/		
28	A public safety application of GPS-enabled smartphones and the android operating system – John Whipple; William Arensman; Marian Starr Boler (2009)	/		
29	Location Based Services using Android Mobile Operating System – Amit Kushwaha; Vineet Kushwaha (2011)	/		

30	Information-centric networking for machine-to-machine data delivery: a case study in smart grid applications - Konstantinos V. Katsaros; Wei Koong Chai; Ning Wang; George Pavlou; Herman Bontius; Mario Paolone (2014		/	
	TOTAL	15	10	5

Table 2.1: Gap analysis of the related journal to the field of product

2.2 THE HISTORY OF MACHINERY

A machine is a physical system using power to apply force and control movement to perform an action. The term is commonly applied to artificial devices, such as those employing engines or motors, but also to natural biological macromolecules, such as molecular machines. Machines can be driven by animals and people, by natural forces such as wind and water, and by chemical, thermal, or electrical power, and include a system of mechanisms that shape the actuator input to achieve a specific application of output forces and movement. They can also include computers and sensors that monitor performance and plan movement, often called mechanical systems (Usher, Abbott Payson, 2016). Modern machines are complex systems that consist of structural elements, mechanisms and control components and include interfaces for convenient use. Examples include: a wide range of vehicles, such as trains, automobiles, boats, and airplanes; appliances in the home and office, including computers, building air handling and water handling systems; as well as farm machinery, machine tools and factory automation systems and robots.

The English word machine comes through Middle French from Latin ‘machina’, from Henry George Liddell, Robert Scott, book called “*Greek-English Lexicon”* (Blackwell, Christopher W., 2018) which in turn derives from the Greek (Doric μαχανά makhana, Ionic μηχανή mekhane 'contrivance, machine, engine', a derivation from μῆχος mekhos 'means, expedient, remedy'). The word mechanical (Greek: μηχανικός) comes from the same Greek roots. A wider meaning of 'fabric, structure' is found in classical Latin, but not in Greek usage. This meaning is found in late medieval French and is adopted from the French into English in the mid-16th century. In the 17th century, the word machine could also mean a scheme or plot, a meaning now expressed by the derived machination. The modern meaning develops out of specialized application of the term to stage engines used in theater and to military siege engines, both in the late 16th and early 17th centuries. The OED traces the formal, modern meaning to John Harris' Lexicon Technicum (Collison, Robert,1966), which has:

“Machine, or Engine, in Mechanicks, is whatsoever hath Force sufficient either to raise or stop the Motion of a Body. Simple Machines are commonly reckoned to be Six in Number, viz. the Ballance, Leaver, Pulley, Wheel, Wedge, and Screw. Compound Machines, or Engines, are innumerable.”

The Industrial Revolution was a period from 1750 to 1850 where changes in agriculture, manufacturing, mining, transportation, and technology had a profound effect on the social, economic, and cultural conditions of the times. It began in the United Kingdom, then subsequently spread throughout Western Europe, North America, Japan, and eventually the rest of the world. Starting in the later part of the 18th century, there began a transition in parts of Great Britain's previously manual labor and draft-animal-based economy towards machine-based manufacturing. It started with the mechanization of the textile industries, the development of iron-making techniques and the increased use of refined coal.

2.3 MECHANICAL SYSTEM IN MACHINERY

A mechanical system manages power to accomplish a task that involves force and movement. Modern machines are systems consisting of a power source and actuators that generate forces and movement, a system of mechanisms that shape the actuator input to achieve a specific application of output forces and movement, a controller with sensors that compare the output to a performance goal and then directs the actuator input, and an interface to an operator consisting of levers, switches, and displays. This can be seen in Watt's steam engine in which the power is provided by steam expanding to drive the piston. The walking beam, coupler and crank transform the linear movement of the piston into rotation of the output pulley. Finally, the pulley rotation drives the flyball governor which controls the valve for the steam input to the piston cylinder.

The adjective "mechanical" refers to skill in the practical application of an art or science, as well as relating to or caused by movement, physical forces, properties, or agents such as is dealt with by mechanics. Similarly, Merriam-Webster Dictionary defines "mechanical" as relating to machinery or tools. Power flow through a machine provides a way to understand the performance of devices ranging from levers and gear trains to automobiles and robotic systems. The German mechanician Franz Reuleaux wrote, "a machine is a combination of resistant bodies so arranged that by their means the mechanical forces of nature can be compelled to do work accompanied by certain determinate motion." Notice that forces and motion combine to define power. More recently, (J. J. Uicker et al., 2015) stated that a machine is "a device for applying power or changing its direction. “McCarthy and Soh describe a machine as a system that "generally consists of a power source and a mechanism for the controlled use of this power."

The mechanism of a mechanical system is assembled from components called machine elements. These elements provide structure for the system and control its movement. The structural components are, generally, the frame members, bearings, splines, springs, seals, fasteners and covers. The shape, texture and color of covers provide a styling and operational interface between the mechanical system and its users. The assemblies that control movement are also called "mechanisms." Mechanisms are generally classified as gears and gear trains, which includes belt drives and chain drives, cam and follower mechanisms, and linkages, though there are other special mechanisms such as clamping linkages, indexing mechanisms, escapements, and friction devices such as brakes and clutches. The number of degrees of freedom of a mechanism, or its mobility, depends on the number of links and joints and the types of joints used to construct the mechanism. The general mobility of a mechanism is the difference between the unconstrained freedom of the links and the number of constraints imposed by the joints. It is described by the Chebychev-Grübler-Kutzbach (Usher, Abbott Payson, 1988) criterion.

The Chebychev–Grübler–Kutzbach criterion determines the number of degrees of freedom of a kinematic chain, that is, a coupling of rigid bodies by means of mechanical constraints. These devices are also called linkages. The Kutzbach criterion is also called the mobility formula, because it computes the number of parameters that define the configuration of a linkage from the number of links and joints and the degree of freedom at each joint. Interesting and useful linkages have been designed that violate the mobility formula by using special geometric features and dimensions to provide more mobility than predicted by this formula. These devices are called over constrained mechanisms.

2.4 IMPACT OF MECHANIZATION AND AUTOMATION IN CONSTRUCTION

Mechanization is providing human operators with machinery that assists them with the muscular requirements of work or displaces muscular work. In some fields, mechanization includes the use of hand tools. In modern usage, such as in engineering or economics, mechanization implies machinery more complex than hand tools and would not include simple devices such as an un-geared horse or donkey mill. Devices that cause speed changes or changes to or from reciprocating to rotary motion, using means such as gears, pulleys or sheaves and belts, shafts, cams, and cranks, usually are considered machines.

After electrification, when most small machinery was no longer hand powered, mechanization was synonymous with motorized machines.

Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provides human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well. Automation plays an increasingly important role in the world economy and in daily experience.

The impact of modern construction project management in relation to the uprising of mechanized equipment and automation has been significant and transformative. The integration of advanced machinery and automation technologies has revolutionized the construction industry, leading to improvements in efficiency, productivity, safety, and overall project outcomes. Here are some key impacts:

i. Enhanced Productivity

Mechanized equipment and automation have dramatically increased the productivity of construction projects. Tasks that were previously time-consuming and labor-intensive can now be completed much faster with the help of advanced machinery. For example, the use of excavators, cranes, and bulldozers has significantly accelerated earthmoving and site preparation processes.

ii. Improved Accuracy and Precision

Automation technologies, such as robotic total stations and 3D laser scanning, enable precise measurement and layout of construction elements. This reduces errors and rework, leading to higher-quality outcomes. Automated systems can also assist in tasks like concrete pouring and bricklaying, ensuring accurate and uniform results.

iii. Cost Savings

By employing mechanized equipment and automation, construction projects can achieve cost savings in various ways. Increased productivity means projects are completed more quickly, reducing labor costs. Automation can also optimize material usage and minimize waste. Additionally, advanced machinery can perform tasks that would otherwise require large workforces, reducing labor expenses.

iv. Improved Safety

Mechanized equipment and automation have contributed to enhanced safety in construction sites. Robots and machines can handle hazardous or physically demanding tasks, reducing the risk of injuries to workers. Automation can also be used for remote monitoring of construction sites, identifying potential safety hazards, and preventing accidents.

v. Streamlined Project Management

Modern construction project management relies on advanced software and tools to streamline processes. Project management software allows for efficient scheduling, resource allocation, and communication between team members. Integrating mechanized equipment and automation into these systems enhances data exchange and real-time monitoring, enabling better decision-making and coordination among stakeholders.

vi. Increased Sustainability

Mechanized equipment and automation have a positive impact on construction project sustainability. Automated systems can optimize energy usage, reduce emissions, and minimize material waste. Additionally, the use of mechanized equipment allows for the implementation of eco-friendly practices, such as using electric-powered machinery instead of diesel-powered ones.

vii. Skill Requirements and Workforce Changes

The integration of mechanized equipment and automation in construction projects has changed the skill requirements for workers. While traditional manual labor is still essential, there is an increasing need for workers skilled in operating and maintaining advanced machinery and automation systems. Upskilling and reskilling programs become crucial to ensure the workforce can adapt to these changes.

The integration of mechanized equipment and automation into modern construction project management has had a profound impact on the industry. It has improved productivity, accuracy, safety, and sustainability while reducing costs and streamlining project management processes. As technology continues to advance, the construction industry will likely witness further innovations in mechanization and automation, leading to even greater benefits.

2.5 MACHINERY LIFE CYCLE

In industry, Product Lifecycle Management (PLM) is the process of managing the entire lifecycle of a product from its inception through the engineering, design, and manufacture, as well as the service and disposal of manufactured products. PLM integrates people, data, processes, and business systems and provides product information backbone for companies and their extended enterprises. PLM systems help organizations in coping with the increasing complexity and engineering challenges of developing new products for the global competitive markets.

Product lifecycle management (PLM) should be distinguished from 'product life-cycle management (marketing)' (PLCM). PLM describes the engineering aspect of a product, from managing descriptions and properties of a product through its development and useful life, whereas PLCM refers to the commercial management of the life of a product in the business market with respect to costs and sales measures. Product lifecycle management can be considered one of the four cornerstones of a manufacturing corporation's information technology structure. All companies need to manage communications and information with their customers (CRM-customer relationship management), their suppliers and fulfillment (SCM-supply chain management), their resources within the enterprise (ERP-enterprise resource planning) and their product planning and development (PLM).

One form of PLM is called people-centric PLM. While traditional PLM tools have been deployed only on the release or during the release phase, people-centric PLM targets the design phase. As of 2009, ICT development (EU-funded PROMISE project 2004–2008) has allowed PLM to extend beyond traditional PLM and integrate sensor data and real-time 'lifecycle event data' into PLM, as well as allowing this information to be made available to different players in the total lifecycle of an individual product (closing the information loop). This has resulted in the extension of PLM into closed-loop lifecycle management (CL2M).

Machine design refers to the procedures and techniques used to address the three phases of a machine's lifecycle:

- Invention, which involves the identification of a need, development of requirements, concept generation, prototype development, manufacturing, and verification testing.

- Performance engineering involves enhancing manufacturing efficiency, reducing service and maintenance demands, adding features, and improving effectiveness, and validation testing.
- recycle is the decommissioning and disposal phase and includes recovery and reuse of materials and components.

The product lifecycle management has a lot of benefits with the right practices. Documented benefits of product lifecycle management include:

Benefits of Product Lifecycle Management
1. Reduced time to market.
2. Increase full price sales.
3. Improved product quality and reliability
4. Reduced prototyping costs.
5. More accurate and timely request for quote generation
6. Ability to quickly identify potential sales opportunities and revenue contributions.
7. Savings through the re-use of original data
8. A framework for product optimization
9. Reduced waste.
10. Savings through the complete integration of engineering workflows
11. Documentation that can assist in proving compliance for RoHS or Title 21 CFR Part 11
12. Ability to provide contract manufacturers with access to a centralized product record.
13. Seasonal fluctuation management
14. Improved forecasting to reduce material costs.
15. Maximize supply chain collaboration.

Table 2.2: List of Beneficial of a Product Lifecycle Management

Many software solutions have been developed to organize and integrate the different phases of a product's lifecycle. PLM should not be seen as a single software product but a collection of software tools and working methods integrated together to address either single stages of the lifecycle or connect different tasks or manage the whole process. Some software providers cover the whole PLM range while others have a single niche application. Some applications can span many fields of PLM with different modules within the same data model. An overview of the fields within PLM is covered here. The simple classifications do not always fit exactly; many areas overlap, and many software products cover more than one area or do not fit easily into one category. It should also not be forgotten that one of the main goals of PLM is to collect knowledge that can be reused for other projects and to coordinate simultaneous concurrent development of many products. It is about business processes, people and methods as much as software application solutions. Although PLM is mainly associated with engineering tasks it also involves marketing activities such as product portfolio management (PPM), particularly with regards to new product development (NPD). There are several life-cycle models in each industry to consider, but most are rather similar. What follows below is one possible life-cycle model; while it emphasizes hardware-oriented products, similar phases would describe any form of product or service, including non-technical or software-based products.

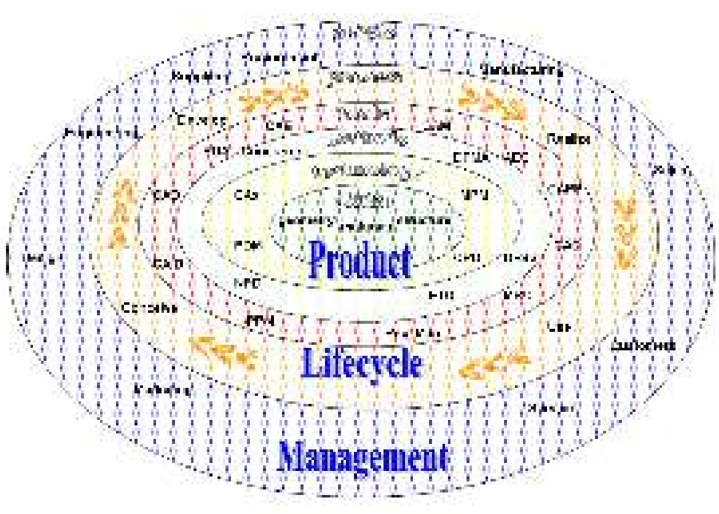

Figure 2.1: Product Lifecycle Management

2.6 RELATIONSHIP OF SITE PLANNING USING THE APPLICATION AND CONVENTIONAL METHOD.

According to (Kristiina Sulankivi, 2019), the functionality of the application is a systematic way to create an electronical planning schedule according to the modernize stimulation. Minimalizing the needs of weekly planning meeting just to briefly explain the work required to be done or which machinery is needed at any site etc. (Chitdrakantan Subramaniam, 2020) also states that mis understatement in the workplace be it on site or off site in the construction perimeter are unavoidable hence the requirement for communication is essential. The efficiency of work is also important as early planning narratives and sudden allocations of machinery can hinder the ongoing progress of the construction thus minimizing its own efficiency (Ali Abbas, Zia Ud Din, Rizwan Farooqui, 2016). The most essential part in every construction work is the project planning. A contractor may have an excellent networking of suppliers, high technology equipment, plants, and machineries as well as strong cash flows, however in order to be a competitive construction company nowadays, quality planning is required (Knutson, K, Schexnayder, C. J., C 2018 and Mayo, R 2018).

The concept of quality planning in construction projects is to guarantee efforts to accomplish the necessary level of quality for the outcome which are well planned and organized. It is vitally required for a construction company to have an effective quality management system as it helps organizations in improving customer satisfaction whilst providing the organization with a competitive advantage over fellow competitors within the industry. Similarly cited by John Joby, (2003) it is about obtaining customers' satisfaction that would lead to long term competitiveness and business survival for the companies by maintaining the quality of construction activities at a mandatory standard. In order to produce a quality planned project, proper planning techniques are required. Using the right techniques in planning, it helps in the analysis of the plan, organizes the information, and gives a crucial effect on the way in which the plan is communicated (Neale, R. H. 1989 and Neale, D. E. 1986).

2.7 ADVANTAGES AND DISADVANTAGES OF MONITORING APPLICATION

2.7.1 Advantages

The feature in the newly created application can come with a certain set of advantages. One of them is it’s possible to access the planning features at the palm of the user hand as this mobile application doesn’t harm the mobile system. It’s capable of being used in both online and offline mode. The system location for the bonded machinery requires a real-time GPS locator for the most accurate positioning possible. Operators can understand their positioning for their workspace easily without disturbance from the social notification, walkie talkie and cellular phone connection. This eliminates the need for personalized messages for each operator and driver upon the whereabout of their position is required to be standby or available for any sudden changes. Operators and lorry drivers that are issued emergency leave or unpaid leave can highlight their names and machinery identification code as a remainder to the app that they’re unavailable for today’s work. Meaning any possible rescheduling of the machinery positioning can be done in an efficient and effective matter.

2.7.2 Disadvantages

There are pros and cons to building or creating something new. The marketing for the application will be its down-right disadvantage as apps that are available other than this application may or might not be like the application general ideation as planned. The idea of creating this application may also be refutable as some high-leveled and mid-level construction staff would likely to prefer face to face planning as both would have their debauchery and different level of thinking due to lack of attendance or command ignorance from all manners. If the app that was created isn't free on the app store, they most likely won’t download it because they don't intend to pay for something that they may delete later. Almost all users don't like downloading apps that cost money as they very much prefer downloading the apps for free.

CHAPTER 3

METHODOLOGY

3.1 ITEMS/SOFTWARE REQUIRED FOR APPLICATION DEVELOPMENT.

Item/Software	**Description**	**Cost**
Computer	Used to develop an application and entering coding system for further improvement of the newly developed application.	RM 0
Programming Course	A quick programming course to create a simple application as a solution for the Application Development	RM100
Wix Space	An application software designed to tested out the developed application to see its functionality and effectiveness.	RM0
Android Credits and Apple Credits	A credential service that allows app builders to set a domain server for the application to be used by multiple personal/members.	RM500
Google Maps Application Programming Interface (API) Service	An application interface used to track the location of users/members that has been registered under its assigned codex location.	RM300
	Total	RM 900

Table 3.1: Item Costing for Application Development

3.2 THE FLOW CHART OF THE APPLICATION CREATION

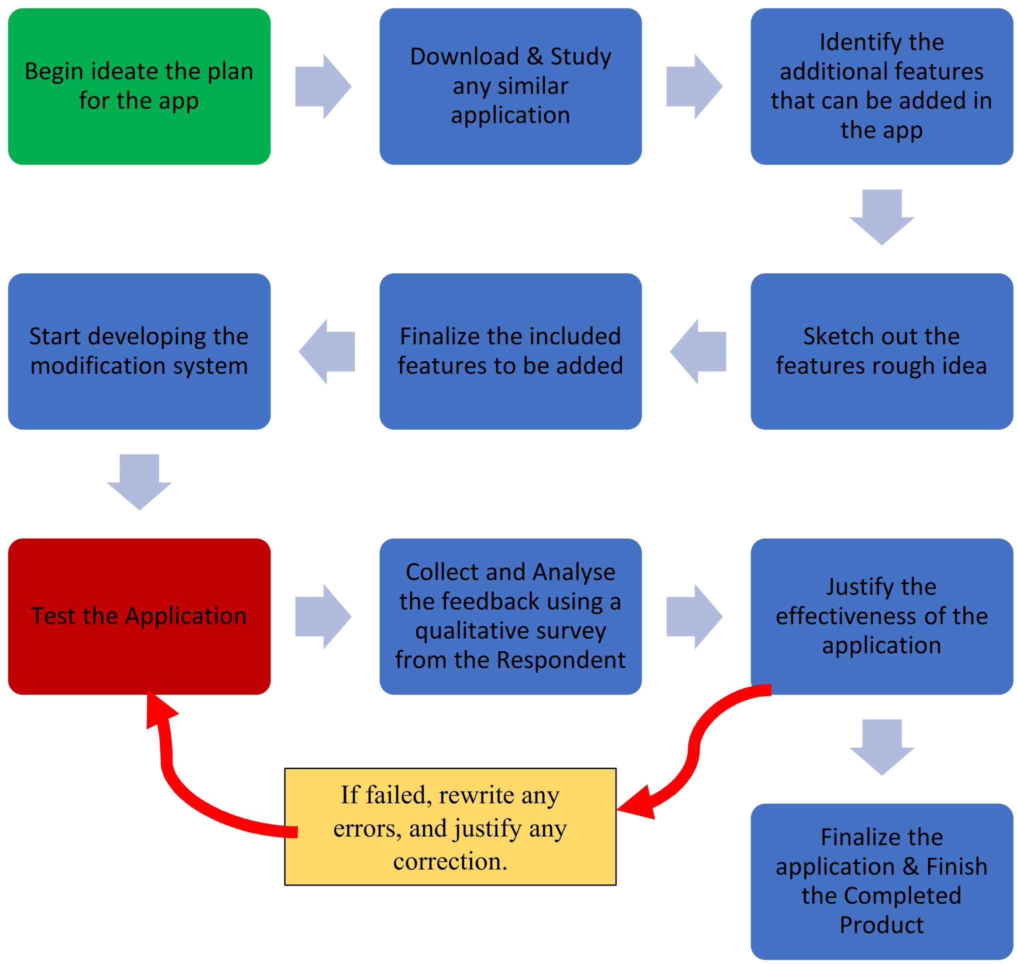

Figure 3.1: Flow chart of the early design and development of AeM Application

For Semester 7, the idea of application development progress starts with the ideation of the visible problem according to the targeted problems that we students had identified at the beginning of semester 7 during our internship. The process of ideation begins with the current problem that is visible within the construction site location. What was identified during this process was the apparent usage of mobile/phones as a means of communication for the construction staff in taking command. Although it's conventional, in some locations of the area at the construction site, there are several locations where the cellular mobile service network wouldn't work. Due to this, some employees (operators, drivers, site supervisors, and engineers) are hard to reach for any information relay. Cellular connection is always a problem, so the best possible outcome from this problem is to develop a new application that does not completely rely on internet connectivity and cellular mobile network coverage. It's very effective, cost-saving, and easy to be used by multiple personnel.

To understand how the developed app will function, the quickest way to understand how to develop a new app would be to try to download and test out a similar application that was already available in the mobile stream market. As a reference, the application known as SANY Cloud Service has what seems to be the most identical or the nearest to what the newly developed app will look like. This application's main purpose is to locate all its machinery that was bonded to the app using a real-time location GPS system. Its functionality was to know if the current machine that was running had already reached its time for maintenance. By studying the outline of the application, it is safe to say that the application that will be developed will have a notification system that alarms operators and lorry drivers upon receiving a command for machinery deliveries or tasks distributing work at its designated location.

Different from the referred app is that the newly developed application will come into version. The LITE version would be suitable for operators and lorry drivers as the main purpose of the light version would be receiving tasks for machinery deliveries or work-related tasks. The FULL version, however, would be suitable for site engineers and site supervisors as a digitalized means to carry out commands to the operators and lorry drivers when needed. The full version will have the ability to write command of any suitable task and can generate a complete daily site report to the project managers and construction managers. With this in mind, comes the part of writing a storyboard on how the application will work visually. It is important to visualize how the application will work as it will draft out how the application will be used step by step while minimizing it to be simple yet effective to be used by all levels of construction staff. The work of writing a storyboard will be done using a rough sketch from a paper with minimal visualization and design to be included as well.

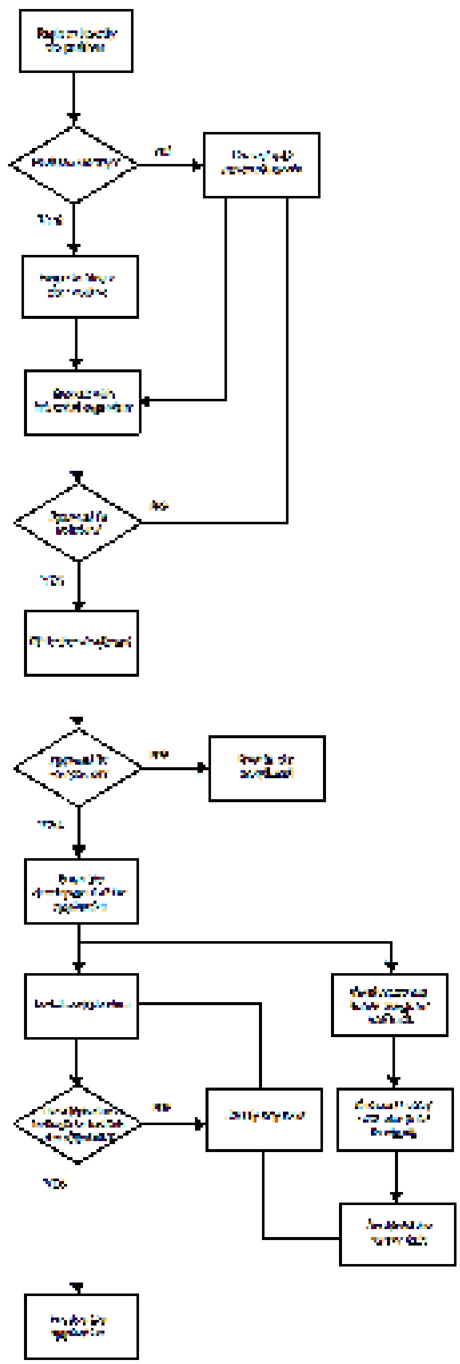

Figure 3.2: Flow chart of the Complete version of the AeM Application development

After a series of rough sketches are done, the iteration of how the app will function must be finalized to proceed in its development as soon as possible. During this phase, the objective of to test how effective this newly developed app is versus the current working method right now would be done using a series of questionnaires that will be handed out to the operators, lorry drivers, site engineers, and site supervisors. The questionnaire through purpose is to see whether the current working method is effective or not in order to catch up with the delayed progress in the current progress report from the main contractor. The outcome of the questionnaires will determine how effective the need for an application that only allows super visionary planning would be done.

After finalizing the outcome of the gathered data, the development of the application will begin as soon as possible to ease up and help all of the construction staff especially site engineers and site supervisors to lessen the burden of relying on a cellular mobile network or Internet connection for the task of giving commands/task to the operators and lorry drivers. The development shall hire an application developer/ programmer to develop the application using the storyboard below as a reference for how the usage of this application shall be done. Once the application has been developed completely, the developed app shall begin entering a testing phase where the application package (APK) shall be handed out to all working staff at the experimented location. The test will be conducted for one week to see whether the objective of this developed application has successfully reached or improvision of the application is required to further enhance the application usage or usefulness. Once the testing phase ended, a collection of the gathered data shall undergo data analysis phase to deter whether the application has proven useful to proceed the launching of the application and began the marketing phase to gather the support of the stakeholders.

3.3 THE APPLICATION STORYBOARD

3.3.1 Descriptive Storyboard

Below are the steps on how the Application operates.

1. Users shall register their account as Operator/Lorry Driver/Supervisor/Engineer.
    i. If login as Operator, they must register their machinery ID (For example: PTT 201), their posting location and their type of machinery.
    ii. If login as Lorry Driver, they must register their Lorry ID (For example: PTT 525) and their posting location.
    iii. If login as Supervisor/Engineer, they must register their posting location.
2. Once login into their account, all information of the enlisted detail will appear on their home screen. The enlisted details shall be as follows.
    i. Session for Trip Delivery.
    ii. Session for Material Order.
    iii. Session for Machinery Delivery.
3. Operator and Lorry Driver will have access to Session for Trip Delivery to record their entailed detail for today's work. The recorded details are as follows.
    i. Total trip for today.
    ii. Total distance traveled for the day.
4. Supervisors can list out their task details in the session room for the Operators and Lorry Drivers to be notified.
5. Under certain circumstances where all staff required to do Overtime from the usual working hours, Supervisors/Engineers will gain the ability to set working hour limit of the day. (For example: normal working hour (8 am – 5 pm) + 2 hour)
6. If Operators/Lorry Drivers are unable to follow the Overtime or having emergency during working hour, simply type "Early Leave" to notify the Supervisors of their absence. (Note: this functionality will not be available to those that are absent on the day. To avoid abuse of this functionality, users must notify the Supervisor directly to activate the button.)
7. For Supervisors and Engineers, they will gain access to Session for Material Order and Machinery Delivery that allow them to move or plan how they want to

rearrange their current schedule of work. They can also gain access to the record of details that were planned prior to the previous schedule.

8. Session of Material Order will allow Supervisors and Engineers to request their needs for material on site such as reinforcement steel bar, mesh steel bar, crusher run, sand and so on from the deviated category. The ordered material will be sent to the requested location by the suppliers available according to the registered supplier list.
9. Session of Machinery Delivery allows Supervisor and Engineer to request Operators and Lorry Driver to move the accordance to the requesting schedule of work's location. This act as a summarizer for today's work activities. This session also allows the movement of transporting machinery out of site using loaders as their mediator to be transported to a different location.
10. The apps will generate the details consistent with the details filled out by the Operators and Lorry Drivers into a simplified form of report for the Supervisor and Engineers to review at the end of the day.

3.3.2 Visualized Storyboard

1. Log into the application using phone numbers and reset the password.

2. Insert the worker's details. (Insert machinery ID)

3. Set the task description for the set location.

4. Choose the type of machinery that is required to be delivered.

5. Drag the pin to mark the location of delivery.

6. The app also includes service function in case of breakdown.

Figure 3.3: Simplified visual of the AeM Application

3.4 INITIAL DESIGN FOR THE APPLICATION INTERFACE DESIGN

The initial design for the application will be modeled as Figure 3.4 below.

Figure 3.4: Ideation of the AeM Application Interface Design

The application uses the combination of red code #FF2400 (Scarlet) (HTML Color Code) and white code #FEFCFF (Milk White) (HTML Color Code). The font that was used in the application is Roboto, Sans-Serif; Font Size at 10px; Font-Weight is at 400.

The interface design for the newly developed application will have a simplified design like the based model showing how easy it is to navigate and be used by all age groups. The technique used to create the application interface design is called the "Scratch your own itch" technique. The technique was born from a problem that the current project innovator must face in their own daily work life. The chances are that if current project innovators have this problem, they will try their absolute best to find a solution for it and for other people as well.

3.5 APPLICATION TESTING AMONG DIFFERENT LEVELS OF CONSTRUCTION STAFF

The standard technique of testing that will be validated for the usage of the application is using the quantitative questionnaire method. Using the questionnaire method for testing is one of the most demanding data collection tools for any research and development effort (Kenny, David A., 1987). The pretense of using a questionnaire is the basic means to identify if the questionnaire will generate enough responses for the respondent in advance. (Ikart, E.M. 2019) has stated that experienced researchers and survey methodologists have viewed this practice as something critical element.

The application testing will be done in a quantitative questionnaire that will be handed out to all levels of construction staff by using Google Forms. This method of data collection shall be done twice before the usage of applications and after the usage of the application for a week (7 days after the implementation of the application usage). The purpose of the questionnaire before the usage of the application is to determine whether the current method of work is plausible for the effective working method or unsatisfactory with the current working method. Whereas the questionnaire after the implementation of the application is to determine whether the application is suitable enough to be used for the long-term efficient planning process.

Figure 3.5: Google Form Software

After the testing of the application for 7 days another feedback response/questionnaire will be given to the applicant to see its effectiveness for the duration of 7 days (1 Week). The data then will be analyzed using Statistical Package for the Social Sciences (SPSS) for a more accurate data pool. SPSS Statistics is a statistical software suite developed by IBM for data management, advanced analytics, multivariate analysis, business intelligence, and criminal investigation. The software name originally stood for Statistical Package for the Social Sciences (SPSS), reflecting the original market, then later changed to Statistical Product and Service Solutions. (Hary Gunarto, 2019).

CHAPTER 4

DATA ANALYSIS

4.1 INTRODUCTION

In this chapter, the researcher will review the results obtained using the Statistical Package for Social Sciences (SPSS) software. Typically, the data from the questionnaire distributed to the respondent is entered into the SPSS software by the researcher. Starting with the respondent's demographic and moving on to the scale's content, which is structured in terms of a Likert scale. To analyze the data for the respondent's demographic, descriptive analysis will be used. However, prior to that, a reliability analysis was performed to determine the internal consistency of the questionnaire that was distributed to the respondents. Following that, the researcher conducted several hypothesis tests to test the relationship as well as the strength between the two variables, which are independent and dependent variables.

4.2 ANALYSIS OF DATA BEFORE APPLICATION USAGE

Construction logistics is a complex process that involves various tasks such as procurement, transportation, inventory management, and resource allocation. In recent years, the construction industry has witnessed a surge in the use of software and digital tools to improve efficiency and productivity. In this report, we will analyze the data related to construction logistics to identify the challenges and opportunities for software intervention.

The data used in this report is collected from the conducted survey where a total of 31 applicants gave their responses one week prior to the conducted experimental software implementation. The data includes information on the current state of construction logistics, the challenges faced by the industry, and the impact of technology on construction logistics.

Based on the questionnaire, most people have written their answers by giving their answers in properly data-like answers. Below are the results of conducting a survey that was implemented before the usage of the experimental application. (Refer to Appendix 1 & 2 for Questionnaires Form)

4.2.1 Demographic Information

All characteristics of respondents are explained in terms of frequencies and percentages in this section. This section discusses several demographic profiles, including the respondent's age, position, working experience in construction, department, and organization. Profiles for each of the items analyzed are shown in the table and pie chart below.

i. Position of work

There are 16 (51.6%) lorry driver respondents, 7 (22.6%) machinery operator respondents, 5 (16.1%) supervisor respondents and 3 (9.7%) engineer respondents in this study. The proportion of pie chart shows that most respondents came from lorry drivers by half the pie chart. This is due to the fact that most workers who responded were lorry drivers on the East Coast Rail Link (ECRL) Project.

Table 4.1: The Number of Respondents by Their Position of Work

No	Position	No of Respondent	Percentage (%)
1	Lorry Driver	16	51.6
2	Machinery Operator	7	22.6
3	Supervisor	5	16.1
4	Engineer	3	9.7
Total		31	100

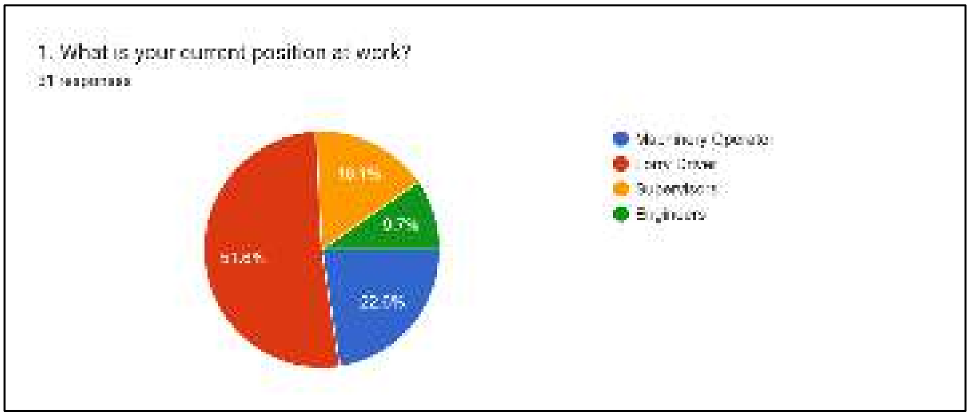

Figure 4.1: The pie chart for Respondent by Position of Work

ii. Working Location

There are 13 (41.9%) respondents from CH125 – CH126, 6 (19.4%) respondents from CH127 – CH28 and 12 (38.7%) respondents from CH129 – CH130 in this study. From the pie chart, we can conclude that the greatest number of workers are from CH125 – CH126 and CH129 – CH130.

Table 4.2: The Number of Respondents by Their Working Locations

No	Location	No of Respondent	Percentage (%)
1	CH125 – CH126	13	41.9
2	CH127 – CH128	6	19.4
3	CH129 - CH130	12	38.7
Total		31	100

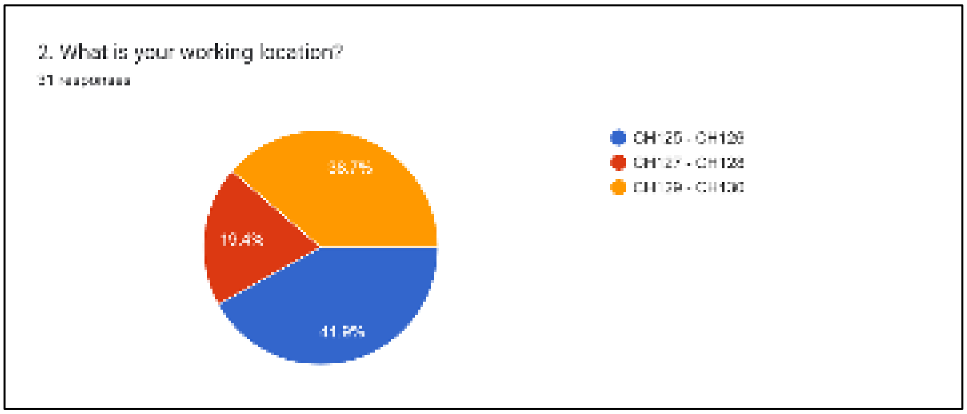

Figure 4.2: The pie chart for Respondent by Working Location

iii. Respondent's Age

Based on Figure 4.3, the analysis showed that the majority of respondents, a total of 11 (35.5%) are comprised of those aged between 31 to 35 years old. A total of 7 (22.6%) of respondents were aged 26 to 30 years old. An equal number of 6 (19.4%) of the respondents were aged 36 to 40 and 40 above respectively. Then, a total of 1 (3.2%) of respondents were aged below 21 to 25 years old as the only minority of the total respondent while the respondents at the age of 18 to 20 years old are nonexistent.

Table 4.3: The Number of Respondents by Their Working Locations

No	Age	No of Respondent	Percentage (%)
1	18 – 20	0	0
2	21 – 25	1	3.2
3	26 – 30	7	22.6
4	31 – 35	11	35.5
5	36 - 40	6	19.4
6	41 above	6	19.4
Total		31	100

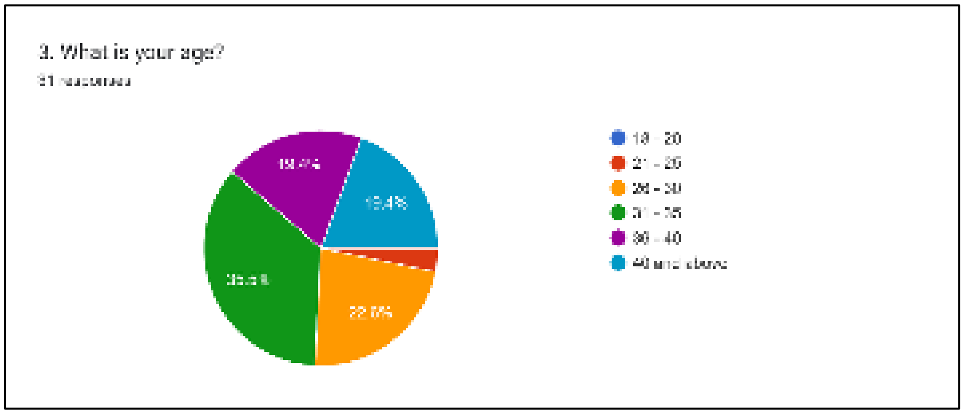

Figure 4.3: The pie chart for Respondents by Age

iv. Current working method effectiveness

Based on the Likert scale, the value of 1 represents "strongly agree" and the value of 5 represents "strongly disagree". According to Figure 4.4, 17 (54.8%) of the respondents say that the current working method is effective for them while 6 (19.4%) of the respondents are neutral towards the current working method.

Table 4.4: The Number of Respondents by Working Method Effectiveness

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	5	16.1
2	Agree	17	54.8
3	Neutral	6	19.4
4	Disagree	2	6.5
5	Strongly Disagree	1	3.2
Total		31	100

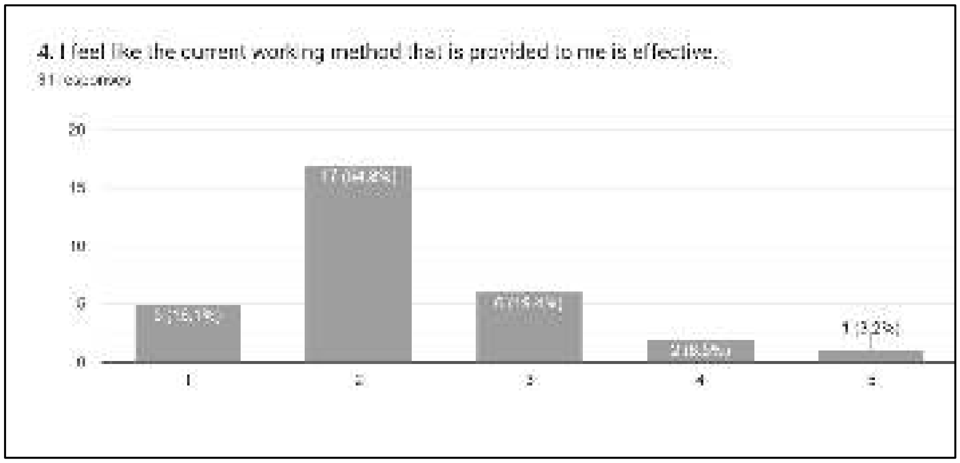

Figure 4.4: The bar chart for working method effectiveness.

v. **Understanding the Current Working Method**

Based on the Likert scale, the value of 1 represents “strongly agree” and the value of 5 represents “strongly disagree”. According to Figure 4.5, 14 (45.2%) of the respondents say that they understand what their task is while 12 (38.7%) of the respondents are undecided whether they understand their task from the given working method.

Table 4.5: The Number of Respondents by Understanding of Work

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	3	9.7
2	Agree	14	45.2
3	Neutral	12	38.7
4	Disagree	2	6.5
5	Strongly Disagree	0	0
Total		31	100

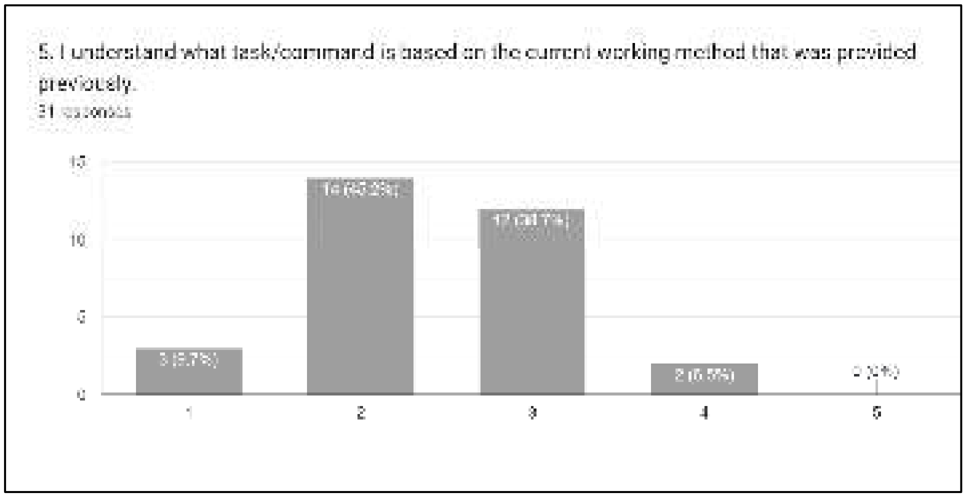

Figure 4.5: The bar chart for understanding the working method.

vi. Receiving Task and its frequency

Multi-option choices of operative response were recorded to see what medium the worker uses to receive their task. According to Figure 4.6, 27 (87.1%) out of the 31 respondents are using WhatsApp as their medium of task/command while 9 (29.0%) out of the 31 respondents still rely on face-to-face (direct order) to receive their task/command. 7 (22.6%) out of 31 respondents are using a walkie-talkie as their medium of task-receiving process and 5 (16.1%) out of 31 respondents preferred mobile calls to receive their tasks.

Table 4.6: The Frequency of Medium Usage for Task Response.

No	Medium	Number of Respondent	Percentage (%)	Frequency of Usage
1	WhatsApp	27	87.1	14
2	Mobile Call	5	16.1	22.6
3	Walkie – Talkie	7	22.6	22.6
4	Direct Order	9	29.0	9.7

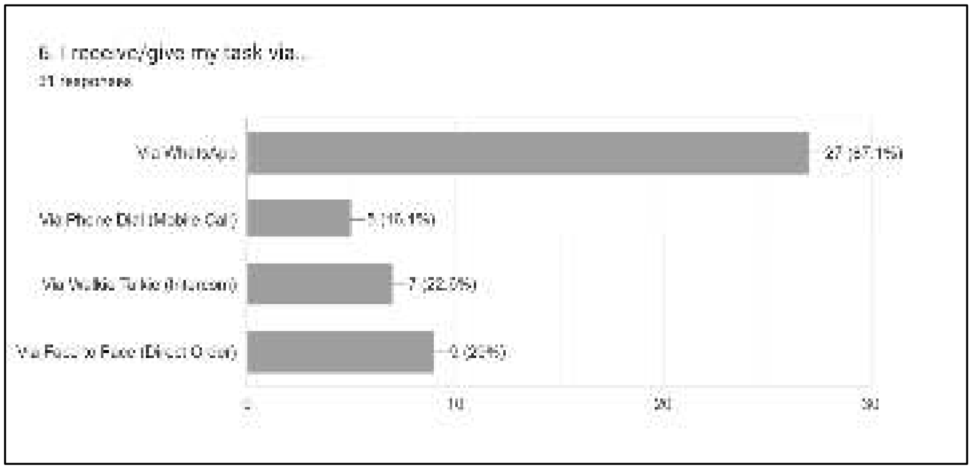

Figure 4.6: The bar chart for task medium

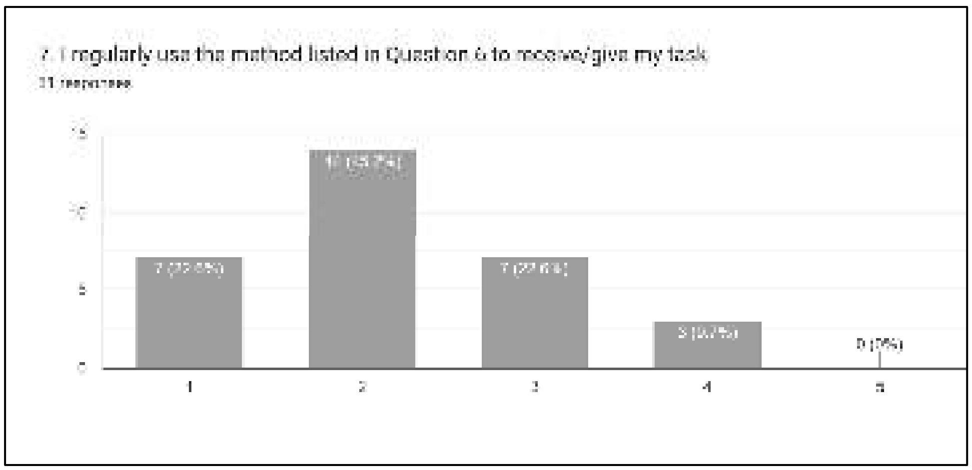

Figure 4.7: The bar chart for usage frequency

vii. Understanding of the task from the listed method

Based on the Likert scale, the value of 1 represents “strongly agree” and the value of 5 represents “strongly disagree”. According to Figure 4.8, 14 (45.2%) of the respondents say that they were neither understood nor confused about their command/task from the listed method while 9 (29.0%) of the respondents are say agree to understand the task given from the listed method.

Table 4.7: The Number of Respondents by Understanding their Task/Command via the listed medium.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	5	16.1
2	Agree	9	29.0
3	Neutral	14	45.2
4	Disagree	3	9.7
5	Strongly Disagree	0	0
Total		31	100

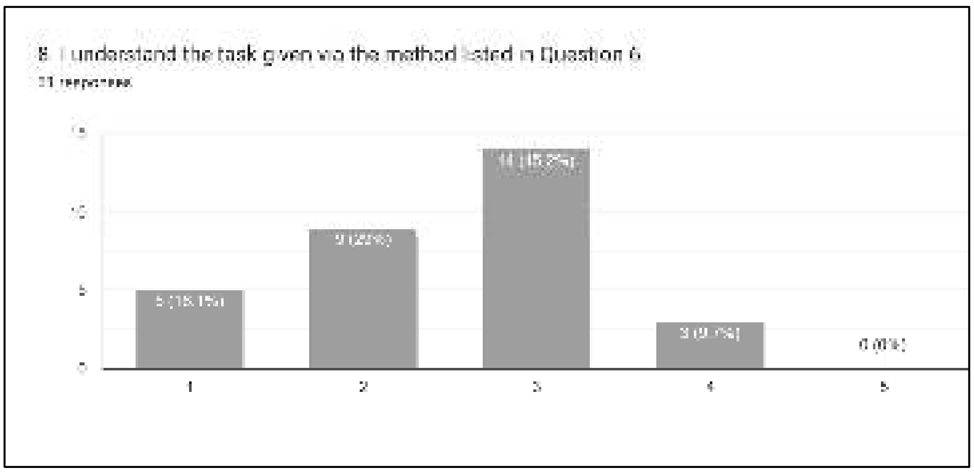

Figure 4.8: The bar chart for responses' understanding of task/command via the listed medium.

viii. willingness to test the newly developed app and feedback.

Based on the Likert scale, the value of 1 represents "strongly agree" and the value of 5 represents "strongly disagree". According to Figure 4.9, 13 (41.9%) of the respondents say that they're willing to test the newly developed application with the rate of feedback is 17 (54.8%) of the respondent while 11 (35.5%) of the respondents are undecided to test the newly developed application with the rate of feedback is 6 (19.4%) respondents.

Table 4.8: The Number of Respondents willing to test the newly developed application.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	3	9.7
2	Agree	14	41.9
3	Neutral	11	35.5
4	Disagree	3	9.7
5	Strongly Disagree	1	3.2
Total		31	100

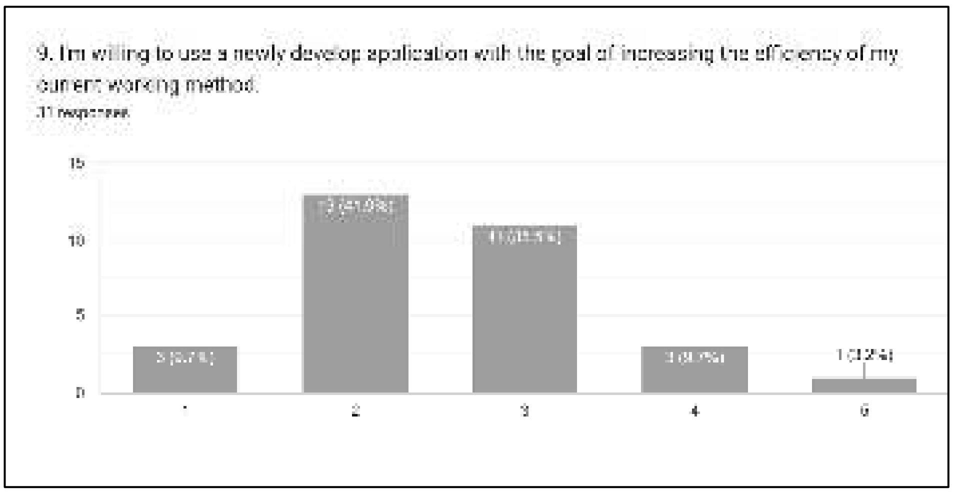

Figure 4.9: The bar chart for willingness to test new applications.

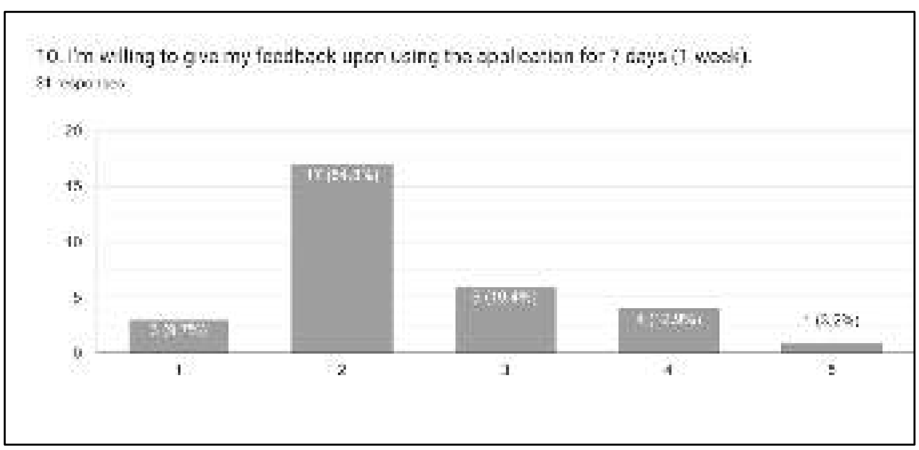

Figure 4.10: The bar chart for willingness to give feedback.

4.3 ANALYSIS OF DATA AFTER APPLICATION USAGE

After a total of seven days have passed for 31 respondents that have agreed to use the application, another form of questionnaire survey is handed out to them to enable them to provide feedback for the application that has been used for a week. Below is the data pool that was gathered from the survey and analyzed using the SPSS software.

i. **Improvement in the working method in AeM Application usage**

Based on the Likert scale, the value of 1 represents "strongly agree" and the value of 5 represents "strongly disagree". According to Figure 4.11, 27 (87.1%) of the respondents have acknowledged that their working method has increased significantly while 4 (12.9%) of the respondents denied saying that the AeM Application has improved their working method.

Table 4.9: Table of respondents toward working method improvement.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	20	64.5
2	Agree	7	22.6
3	Neutral	3	9.7
4	Disagree	1	3.2
5	Strongly Disagree	0	0
Total		31	100

Figure 4.11: The bar chart for improvement of the working method

ii. **Understanding the task given from AeM Application usage**

Based on the Likert scale, the value of 1 represents "strongly agree" and the value of 5 represents "strongly disagree". According to Figure 4.12, 26 (83.9%) of the respondents understand the AeM Application usage in the project while 5 (16.1%) of the respondents are hesitant about the AeM Application usage.

Table 4.10: Table of respondents toward working method improvement.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	11	35.3
2	Agree	15	48.4
3	Neutral	5	16.1
4	Disagree	0	0
5	Strongly Disagree	0	0
Total		31	100

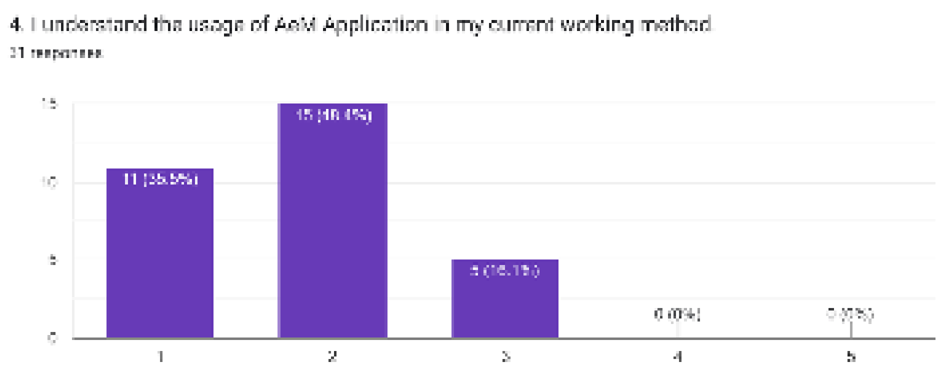

Figure 4.12: The bar chart for understanding the AeM application usage.

iii. **Simplicity of the AeM Application functionality**

Based on the Likert scale, the value of 1 represents "strongly agree" and the value of 5 represents "strongly disagree". According to Figure 4.13, 26

(83.9%) of the respondents say that the AeM Application is easy to use while 5 (16.1%) of the respondents are hesitant about the AeM Application usage.

Table 4.11: Table of respondents toward application's simplicity.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	11	35.3
2	Agree	15	48.4
3	Neutral	5	16.1
4	Disagree	0	0
5	Strongly Disagree	0	0
Total		31	100

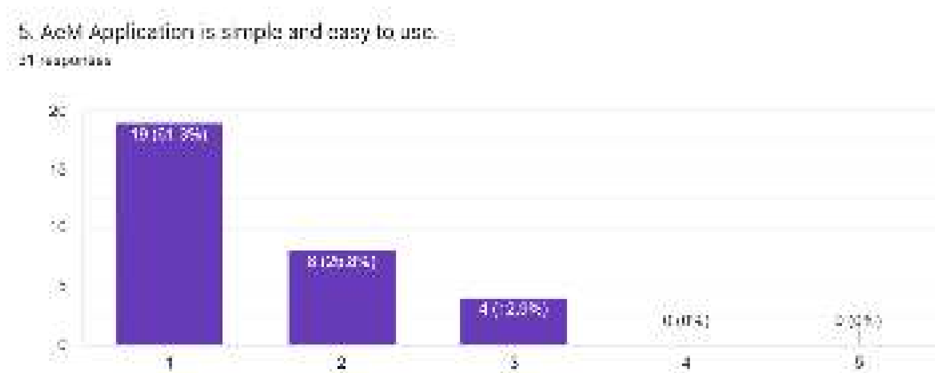

Figure 4.13: The bar chart for AeM Application's user simplicity.

iv. Frequency of AeM Application usage

Based on the Likert scale, the value of 1 represents "strongly agree" and the value of 5 represents "strongly disagree". According to Figure 4.14, 17 (54.9%) of the respondents use the AeM Application frequently while 6 (19.4%) of the respondents rarely use the AeM Application.

Table 4.12: Table of respondents toward application usage frequency.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	2	6.5
2	Agree	15	48.4
3	Neutral	8	25.8
4	Disagree	3	9.7
5	Strongly Disagree	3	9.7
Total		31	100

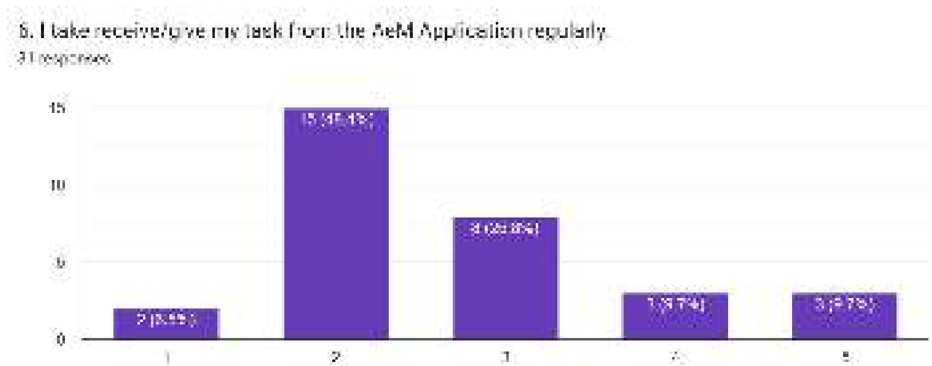

Figure 4.14: The bar chart for frequency usage of AeM Application.

v. Compatibility of AeM Application usage with other existing applications

Based on the Likert scale, the value of 1 represents “strongly agree” and the value of 5 represents “strongly disagree”. According to Figure 4.15, 10 (32.3%) of the respondents are neutral about the AeM application on their phone while 9 (29.0%) of the respondents disagree that the application doesn’t interfere with any existing application.

Table 4.13: Table of respondents toward apps' compatibility with existing apps.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	2	6.5
2	Agree	4	12.9
3	Neutral	10	32.3
4	Disagree	6	19.4
5	Strongly Disagree	9	29.0
Total		31	100

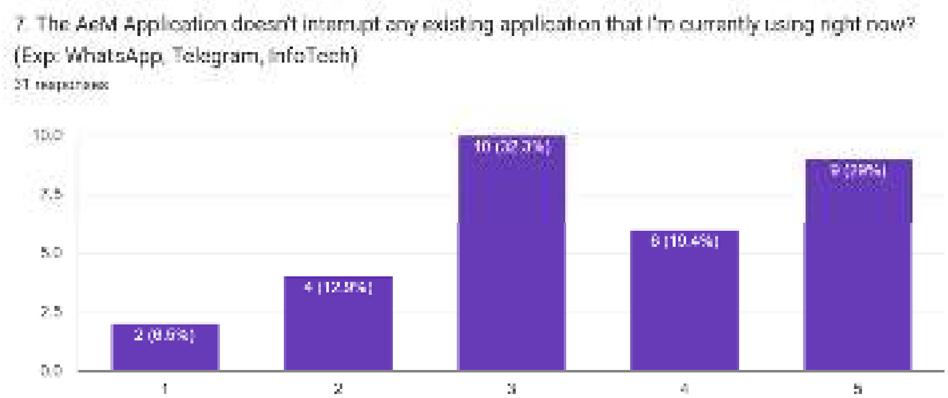

Figure 4.15: The bar chart for compatibility of application with existing application.

vi. Rating of AeM Application

Based on the Likert scale, the value of 1 represents "strongly agree" and the value of 5 represents "strongly disagree". According to Figure 4.16, 23 (74.4%) of the respondents rate the AeM Application as good and excellent while 1 (3.2%) of the respondents rate the AeM Application as bad.

Table 4.14: Table of respondents toward a rating of Aem Application.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	11	35.5
2	Agree	12	38.7
3	Neutral	7	22.6
4	Disagree	1	3.2
5	Strongly Disagree	0	0
Total		31	100

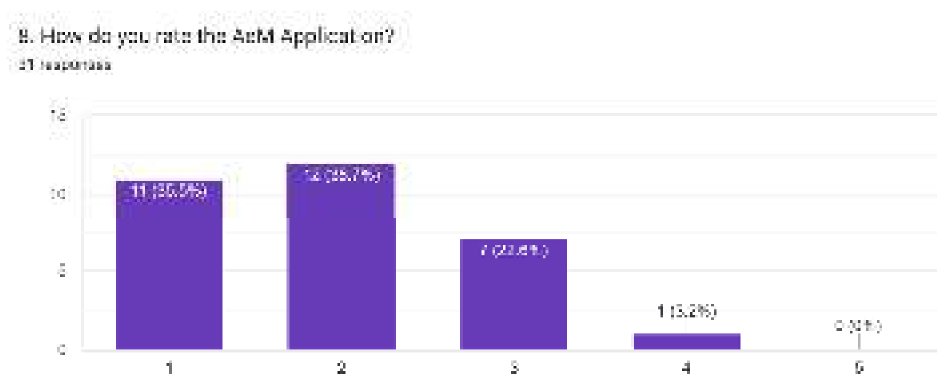

Figure 4.16: The bar chart for rating the AeM Application.

vii. Session's efficiency of AeM Application

Based on the Likert scale, the value of 1 represents "strongly agree" and the value of 5 represents "strongly disagree". According to Figure 4.16, 15 (48.4%) of the respondents say that the sessions in the AeM Application are very efficient for the project while 13 (41.9%) of the respondents say that the sessions in the AeM Application are neutral for the project.

Table 4.15: Table of respondents toward session's efficiency.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	2	6.5
2	Agree	4	12.9
3	Neutral	10	32.3
4	Disagree	6	19.4
5	Strongly Disagree	9	29.0
Total		31	100

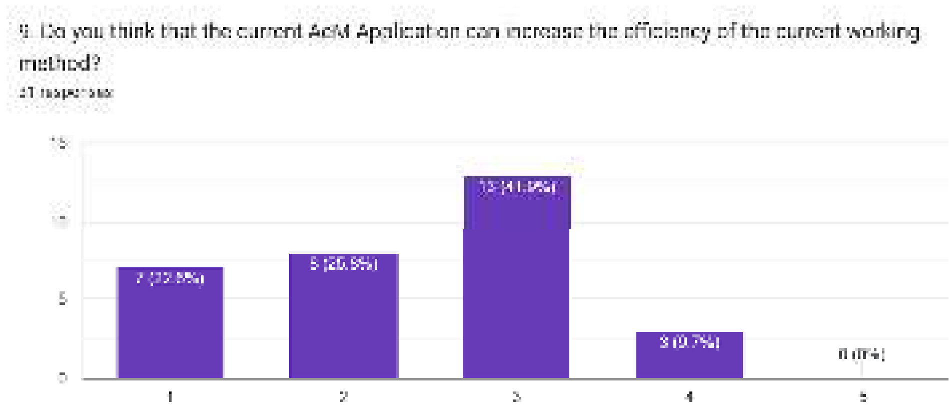

Figure 4.17: The bar chart for the session's efficiency.

viii. Overall experience and recommendation of AeM Application

Based on the Likert scale, the value of 1 represents "strongly agree" and the value of 5 represents "strongly disagree". According to Figure 4.17, 15 (48.4%) of the respondents are satisfied with the AeM Application's overall experience while 9 (29.0%) of the respondents are still neutral about the AeM Application's overall experience.

Table 4.16: Table of respondents toward overall user experience.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	7	22.6
2	Agree	15	48.4
3	Neutral	9	29.0
4	Disagree	0	0
5	Strongly Disagree	0	0
Total		31	100

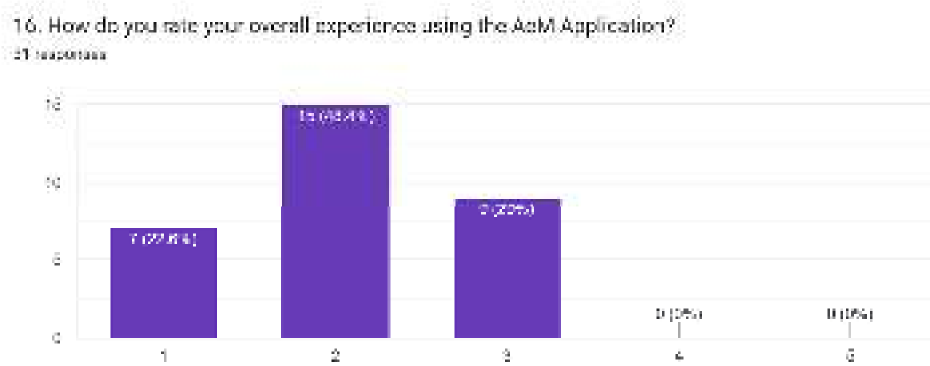

Figure 4.18: The bar chart for the user's overall experience.

Based on the Likert scale, the value of 1 represents "strongly agree" and the value of 5 represents "strongly disagree". According to Figure 4.18, 17 (54.8%) of the respondents would recommend their colleagues and employer to use this application while 11 (35.5%) of the respondents are unsure of recommending this application to their colleagues and employer.

Table 4.17: Table of respondents toward working method improvement.

No	Likert Scale	No of Respondent	Percentage (%)
1	Strongly Agree	8	25.8
2	Agree	9	29
3	Neutral	11	35.5

4	Disagree	2	6.5
5	Strongly Disagree	1	3.2
Total		31	100

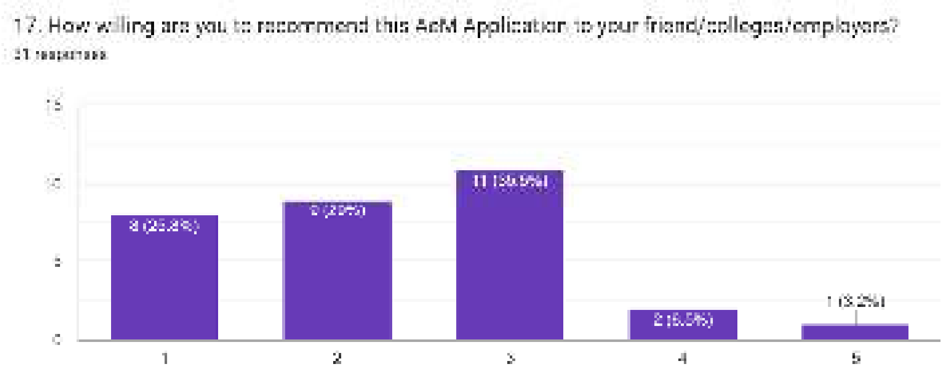

Figure 4.19: The bar chart for understanding the AeM application usage.

4.4 THE STATISTICAL ANALYSIS OF THE DATA COLLECTION

When conducting an analysis using SPSS for pre-test and post-test data, researchers typically want to examine if there is a significant difference or change between the two time points. Below is the step-by-step explanation of the analysis process for this project:

4.4.1 Data Preparation:

It’s important to ensure that the data of the questionnaire (both pre-test and post-test) is properly formatted in SPSS, with each participant's pre-test and post-test scores in separate variables or columns. Assign a unique identifier to each participant to link their pre-test and post-test scores. The unique identifier is marked as below:

- Working position
- Working location
- Respondents age
- Current working method

- Comprehension of the current working method
- Working method efficiency and effectiveness

4.4.2 Descriptive Statistics:

In order find the value of the descriptive statistics requires the researcher to calculate the descriptive data for both the pre-test and post-test scores. This includes measures such as mean, standard deviation, minimum, maximum, and possibly other statistics depending on your specific needs. Descriptive statistics provide an overview of the central tendency and variability of the scores at each time point.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
4. I feel like the current working method that is provided to me is effective.	31	1	5	2.26	.930
5. I understand what task/command is based on the current working method that was provided previously.	31	1	4	2.42	.765
7. I regularly use the method listed in Question 6 to receive/give my task.	31	1	4	2.19	.910
8. I understand the task given via the method listed in Question 6.	31	1	4	2.48	.890
9. I'm willing to use a newly develop application with the goal of increasing the efficiency of my current working method.	31	1	5	2.55	.925
10. I'm willing to give my feedback upon using the application for 7 days (1 week).	31	1	5	2.45	.961
Valid N (listwise)	31				

Table 4.18: Descriptive Statistics for Before Application Usage

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
3. I feel like my current working method has improved after the usage of AeM Application.	31	1	4	1.52	.811
4. I understand the usage of AeM Application in my current working method.	31	1	3	1.81	.703
5. AeM Application is simple and easy to use.	31	1	3	1.52	.724
6. I take receive/give my task from the AeM Application regularly.	31	1	5	2.68	1.077
7. The AeM Application doesn't interrupt any existing application that I'm currently using right now? (Exp: WhatsApp, Telegram, InfoTech)	31	1	5	3.52	1.235
8. How do you rate the AeM Application?	31	1	4	1.94	.854
9. Do you think that the current AeM Application can increase the efficiency of the current working method?	31	1	4	2.39	.955
10. How do you rate the current session "Session of Material Delivery"?	31	1	4	2.13	.763
11. Do you think that the current session "Session of Material Delivery" need to be improved/upgraded?	31	1	5	3.13	.991
12. How do you rate the current session "Session of Machinery Delivery"?	31	1	4	2.10	.746
13. Do you think that the current session "Session of Machinery Delivery" need to be improved/upgraded?	31	1	5	3.10	1.106
14. How do you rate the current session "Session of General Delivery"?	31	1	4	2.06	.772

15. Do you think that the current session "Session of General Delivery" need to be improved/upgraded?	31	1	5	3.10	1.106
16. How do you rate your overall experience using the AeM Application?	31	1	3	2.06	.727
17. How willing are you to recommend this AeM Application to your friend/colleges/employers?	31	1	5	2.32	1.045

Table 4.19: Descriptive Statistics for After Application Usage

4.4.3 Assumptions Check:

Before conducting inferential analyses, it's important to check the assumptions of the statistical tests. For paired data, the key assumption is that the differences between the pre-test and post-test scores should be approximately normally distributed. The researcher can assess this assumption by examining the distribution of the differences graphically or conducting a normality test, such as the Shapiro-Wilk test, using SPSS.

Reliability Statistics (Pre-Testing)				Reliability Statistics (Post-Testing)		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items		Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.470	.474	6		.631	.696	15

Table 4.20: Reliability Statistics of Pre-Test and Post-Test

4.4.4 Paired-Samples t-test:

To determine if there is a significant difference between the pre-test and post-test scores, researchers can use the paired-samples t-test. In SPSS, go to Analyze > Compare Means > Paired-Samples T Test. Select the pre-test variable and post-test variable as the paired variables. Specify any additional options or settings that are required for their analysis. SPSS will provide the t-value, degrees of freedom, and p-value, indicating the significance of the difference between the two time points.

4.4.5 Effect Size:

It's useful to calculate the effect size to estimate the magnitude of the difference between the pre-test and post-test scores. Cohen's d is a commonly used effect size measure for paired-samples t-tests. Calculate Cohen's d using the formula: d = (M2 - M1) / SDpooled, where M2 is the mean of the post-test scores, M1 is the mean of the pre-test scores, and SDpooled is the pooled standard deviation of the two time points. SPSS does not provide Cohen's d directly, so you may need to calculate it manually using the means and standard deviations.

4.4.6 Interpretation:

Examine the p-value obtained from the paired-samples t-test to determine if the difference between the pre-test and post-test scores is statistically significant. If the p-value is less than your chosen significance level (e.g., $p < 0.05$), you can conclude that there is a significant difference between the two time points. Consider the effect size (e.g., Cohen's d) to understand the practical significance or magnitude of the observed difference.

CHAPTER 5

DISCUSSION & CONCLUSION

5.1 THE IMPACT OF THE APPLICATION USAGE POST AND PRE-USAGE IN THE EAST COAST RAIL LINK (ECRL) PROJECT.

The East Coast Rail Link (ECRL) project involves complex machinery coordination and resource management. The implementation of a tracking machinery application can significantly impact the project's success by providing real-time visibility, optimizing operations, and enhancing overall efficiency. This analysis focuses on the impact of using a tracking machinery application by comparing the pre-usage and post-usage scenarios for the ECRL project.

5.1.1 Pre-Usage Scenario

Before the implementation of the tracking machinery application, the project faced several challenges. Machinery coordination was a manual and time-consuming process, leading to inefficiencies and potential conflicts between different project sites. Resource utilization was suboptimal, resulting in increased costs and extended project timelines. Quality control was limited due to the lack of real-time monitoring, leading to potential rework and compromised standards. Stakeholder communication and project visibility were limited, hindering collaboration and decision-making.

5.1.2 Impact of Post-Usage Scenario

i. Enhanced Machinery Coordination:

The tracking machinery application revolutionizes machinery coordination by providing real-time visibility into the location, availability, and status of machinery assets. Project stakeholders can efficiently plan and allocate machinery resources based on real-time data. This optimization minimizes conflicts, reduces downtime, and ensures efficient machinery movement across project sites. The application's scheduling and notification features enable seamless coordination, leading to improved workflows and enhanced project productivity.

ii. Optimal Resource Utilization:

The tracking machinery application enables project managers to monitor machinery usage patterns, identify underutilized resources, and make data-driven decisions for resource allocation. By analyzing real-time data, managers can allocate machinery to tasks based on actual requirements, eliminating unnecessary expenses and maximizing equipment utilization. The application's predictive maintenance capabilities further optimize resource utilization by identifying maintenance needs in advance, reducing breakdowns and associated downtime.

iii. Strengthened Quality Control:

Real-time monitoring provided by the tracking machinery application enhances quality control practices for the ECRL project. Project managers can track machinery performance, parameters, and metrics to identify deviations from quality standards promptly. The application's alerts and reporting features enable quick response to quality issues, minimizing rework and ensuring adherence to project specifications. This improved quality control contributes to delivering a high-quality infrastructure project within the defined timeline.

iv. Enhanced Stakeholder Communication and Project Visibility:

The tracking machinery application serves as a centralized platform for stakeholders to access project information, monitor progress, and collaborate effectively. Real-time updates on machinery movement, project milestones, and performance metrics improve communication and decision-making. Stakeholders can stay informed about project status, identify bottlenecks, and proactively address issues. This enhanced communication and project visibility foster a collaborative environment, enabling stakeholders to work together toward project success.

The adoption of a tracking machinery application has a transformative impact on the ECRL project, significantly improving machinery coordination, resource utilization, quality control, and stakeholder communication. The application's features and real-time data capabilities streamline operations, optimize resource allocation, ensure adherence to quality standards, and enhance project visibility. By comparing the pre-usage and post-usage scenarios, it becomes evident that the tracking machinery application revolutionizes the project's efficiency, productivity, and overall success. The application empowers project managers and stakeholders with actionable insights, enabling them to make informed decisions and achieve optimal outcomes for the ECRL project.

5.2 THE EFFECTIVENESS OF THE AEM MACHINERY PLANNING APP IN REAL-TIME PLANNING ON THE EAST COAST RAIL LINK (ECRL) PROJECT.

The AeM Machinery Planning App has proven to be highly effective in real-time planning for the East Coast Rail Link (ECRL) Project. Its capabilities and features have significantly contributed to streamlining operations, optimizing resource allocation, and ensuring timely project execution. Here are the key aspects that demonstrate the effectiveness of the app in real-time planning for the ECRL Project:

i. Real-time Visibility and Tracking:

The app provides real-time visibility into the location, availability, and status of machinery assets. This feature enables project managers and stakeholders to track machinery movement, monitor utilization, and identify potential bottlenecks or delays. Real-time tracking facilitates proactive decision-making, allowing for prompt adjustments in resource allocation and coordination, thereby optimizing project timelines.

ii. Streamlined Coordination and Scheduling:

The app enhances coordination and scheduling of machinery operations in real-time. It enables project managers to allocate machinery resources efficiently based on project demands and availability. By visualizing the project timeline and machinery utilization in real-time, stakeholders can avoid conflicts, optimize workflows, and ensure smooth progress across different project sites. This streamlined coordination reduces downtime, eliminates scheduling conflicts, and improves overall project efficiency.

iii. Optimized Resource Allocation:

The app supports data-driven decision-making for resource allocation. Real-time data on machinery usage patterns, performance, and availability empowers project managers to make informed decisions about resource deployment. By identifying underutilized or overburdened machinery, managers can optimize resource allocation, reduce costs, and improve operational efficiency. The app also facilitates predictive maintenance, ensuring machinery is serviced and maintained proactively, minimizing unexpected breakdowns and disruptions.

iv. Improved Productivity and Timeliness:

With real-time planning through the app, project teams can optimize machinery movement and workflow efficiency. By avoiding idle time, delays, and unnecessary movements, the app helps maximize productivity and ensures timely project completion. Real-time updates and alerts enable stakeholders to respond quickly to changes in project requirements, keeping the project on track and avoiding unnecessary rework or delays.

v. Data-Driven Decision Making:

The app collects and analyzes data on machinery performance, usage, and project progress. This data-driven approach enables project managers to assess productivity, identify areas for improvement, and make informed decisions for ongoing operations. By leveraging actionable insights from the app, stakeholders can implement targeted strategies to enhance productivity, address issues promptly, and optimize project outcomes.

The AeM Machinery Planning App has proven to be highly effective in real-time planning for the ECRL Project. Its real-time visibility, streamlined coordination, optimized resource allocation, and data-driven decision-making capabilities contribute to improved productivity, timely project execution, and overall project success. The app empowers project managers and stakeholders with actionable insights, facilitating efficient resource utilization, minimizing delays, and enhancing operational efficiency throughout the project lifecycle.

5.3 COMPARISON BETWEEN THE CURRENT WORKING METHOD IN CONVENTIONAL PLANNING METHOD AND DIGITAL PLANNING METHOD IN MACHINERY MOVEMENT.

5.3.1 Conventional Planning Method

The conventional planning method for machinery movement in the ECRL project involves manual processes and traditional communication channels. Here are the characteristics of the conventional planning method:

i. Manual Coordination:

Machinery movement is planned and coordinated manually, relying on phone calls, emails, or physical documents. This process is time-consuming and prone to human errors, miscommunication, and delays in decision-making.

ii. Limited Visibility:

Stakeholders have limited visibility into machinery availability, location, and utilization. Lack of real-time information makes it challenging to optimize resource allocation and respond quickly to changes or unforeseen events.

iii. Scheduling Challenges:

Scheduling machinery movement manually can be complex, especially when dealing with multiple project sites and resources. Conflicts and overlaps in schedules may occur, leading to inefficient resource utilization and potential delays.

iv. Communication Gaps:

Communication gaps and delays can occur due to reliance on manual communication channels. Misunderstandings and lack of clarity may result in coordination issues, affecting the smooth movement of machinery.

5.3.2 Digital Planning Method (Machinery Planning App)

The digital planning method, enabled by the Machinery Planning App, introduces automation and real-time data-driven decision-making. Here are the characteristics of the digital planning method:

i. Real-time Visibility:

The Machinery Planning App provides real-time visibility into machinery availability, location, and status. Project stakeholders can access up-to-date information, enabling them to make informed decisions and optimize resource allocation for machinery movement.

ii. Streamlined Coordination:

The app facilitates streamlined coordination by automating processes and providing a centralized platform for stakeholders to communicate and collaborate. Real-time updates and notifications ensure stakeholders are aware of changes, minimizing conflicts, and maximizing machinery efficiency.

iii. Optimal Resource Utilization:

With real-time data on machinery usage patterns and availability, the app allows project managers to optimize resource allocation. The app's data analytics capabilities provide insights into resource utilization, enabling stakeholders to identify underutilized or overburdened machinery, optimize workflows, and minimize downtime.

iv. Efficient Scheduling:

The app automates scheduling processes, simplifying the coordination of machinery movement. It considers project requirements, machinery availability, and predefined constraints, ensuring efficient scheduling and minimizing conflicts. Real-time updates and alerts help adapt schedules to changes in project timelines or priorities.

v. Improved Communication and Collaboration:

The app improves communication and collaboration among stakeholders by providing a centralized platform for sharing information and real-time updates. Instant messaging and notifications enhance coordination and ensure that all relevant parties are on the same page, reducing miscommunication and delays.

The comparison between the conventional planning method and the digital planning method (AeM Machinery Planning App) in machinery movement for the ECRL project highlights the benefits of adopting digital technology. The digital planning method offers real-time visibility, streamlined coordination, optimal resource utilization, efficient scheduling, and improved communication and collaboration. By leveraging automation, data-driven decision-making, and real-time updates, the AeM Machinery Planning App significantly enhances the efficiency, productivity, and accuracy of machinery movement in the ECRL project.

5.4 CONCLUSION

For the conclusion of this experimental application in the East Coast Rail Link (ECRL) project, the utilization of a machinery planning application, both pre-usage and post-usage, has brought significant advantages to the project. By comparing the two scenarios, it becomes evident that the application has revolutionized the project's efficiency, productivity, and overall success.

Before the usage of the machinery planning application, the ECRL project faced numerous challenges. Machinery coordination was a manual and time-consuming process, leading to inefficiencies and potential conflicts. Resource utilization was suboptimal, resulting in increased costs and extended project timelines. Quality control was limited due to a lack of real-time monitoring, leading to potential rework and compromised standards.

Stakeholder communication and project visibility were limited, hindering collaboration and decision-making.

However, the implementation of the machinery planning application brought about a transformation in the project's planning and execution. Real-time visibility and tracking capabilities enabled stakeholders to monitor machinery movement, availability, and status, facilitating efficient coordination and scheduling. This optimization minimized conflicts, reduced downtime, and ensured smooth progress across different project sites.

The application's data-driven approach empowered project managers to make informed decisions regarding resource allocation, resulting in optimized resource utilization and reduced costs. Real-time monitoring of machinery performance and quality control metrics improved the adherence to quality standards and minimized rework or delays.

Additionally, the machinery planning application significantly enhanced stakeholder communication and project visibility. It provided a centralized platform for accessing project information, monitoring progress, and collaborating effectively. Real-time updates and alerts fostered better communication and decision-making, enabling stakeholders to address issues promptly and keep the project on track.

Overall, the pre-usage and post-usage scenarios demonstrate the effectiveness of the machinery planning application in the ECRL project. It has streamlined operations, optimized resource allocation, ensured adherence to quality standards, and enhanced stakeholder collaboration. The application's real-time data capabilities and automation have contributed to improved productivity, reduced costs, and timely project completion.

The success of the machinery planning application in the ECRL project serves as a testament to the transformative power of technology and data-driven decision-making in large-scale infrastructure projects. Its implementation has not only addressed the challenges faced by the project but also laid the foundation for efficient planning, execution, and successful completion of the ECRL project.

6.0 REFERENCES

"What is PLM?". PLM Technology Guide. Archived from the original on 18 June 2013. Retrieved 25 February 2012.

Ahmad Y Hassan, Donald Routledge Hill (1986) – Islamic Technology: An illustrated history, p. 54. Cambridge University Press. ISBN 0-521-42239-6.

Ali Abbas, Zia Ud Din, Rizwan Farooqui, 2016 – Achieving Greater Project Success & Profitability through Pre-construction Planning: A Case-based Study.

Anderson, S. D., Molenaar, K. R., & Schexnayder, C. J. (2007) – Guidance for cost estimation and management for highway projects during planning, programming, and preconstruction (Vol. 574). Transportation Research Board.

Argyrous, G. (2005-11-23) – Statistics for Research: With a Guide to SPSS. London: SAGE. ISBN 978-1-4129-1948-7.

Bao, T. - "How Sender and Receiver Jointly Shape Message: An Empirical Study on Transactional Relationship in Electronic Word of Mouth," International Journal of Internet Marketing and Advertising, Vol. 9, No. 4:267- 285, 2015.

Berinsky, A. J., Huber, G. A., & Lenz, G. S. (2012). – Evaluating online labor markets for experimental research: Amazon.com's Mechanical Turk. Political Analysis, 20, 351–368.

Blackwell, Christopher W. (2018) – Liddell-Scott Lexicon in the CITE Architecture

Bogdan, R.C. and Biklen, S.K., - Qualitative Research, Boston: Allyn and Bacon, 1992.

Brunner, J. & Waschbusch, L.M. (2018). – Why equipment as a service makes sense. Retrieved from https://www.industry-of-things.de/warum-equipment-as-aservice-why-equipment-as-a-service-makes-sense-784495/ on 01/17/2021.

Bryman, Alan; Cramer, Duncan (2011) – Quantitative Data Analysis with IBM SPSS 17, 18 and 19: A Guide for Social Scientists. New York: Routledge. ISBN 978-0-415-57918-6.

C Subramaniam, S Ismail, 2020 – Project Communications Management in Malaysian Construction Industry.

Chiu, Y. C. (2010), - An introduction to the History of Project Management, Delft: Eburon Academic Publishers, p. 42, ISBN 978-90-5972-437-2, archived from the original on 2016-08-18.

Collison, Robert, - *Encyclopaedias: Their History throughout the Ages* (New York: Hafner, 1966).

Dutch, Steven (1999). - "Pre-Greek Accomplishments". Legacy of the Ancient World. Prof. Steve Dutch's page, Univ. of Wisconsin at Green Bay. Archived from the original on August 21, 2016.

Emmanuel M. Ikart – Survey Questionnaire Survey Pretesting Method: An Evaluation of Survey Questionnaire via Expert Reviews Technique.

Gunarto, Hary (2019) – Parametric & Nonparametric Data Analysis for Social Research: IBM SPSS. LAP Academic Publishing. ISBN 978-6200118721.

Henry George Liddell, Robert Scott, A Greek-English Lexicon, on Perseus project 2011-06-29 at the Wayback Machine

J. J. Uicker, G. R. Pennock, and J. E. Shigley, 2003 – Theory of Machines and Mechanisms, Oxford University Press, New York.

Janssen, J. & Laatz, W. (2005) – Statistical data analysis with SPSS for Windows (5th ed.). Berlin: Springer.

John, Joby (2003) – Fundamentals of Customer-Focused Management: Competing Through Service. Westport, Conn.: Praeger. ISBN 978-1-56720-564-0

Juran, J.M and Gryna, F.M. (1993) – Quality Planning and Analysis, McGraw Hill, New York, NY. pp. 3-5. Emerald.

Karniel, Arie; Reich, Yoram (2011) – Managing the Dynamic of New Product Development Processes. A new Product Lifecycle Management Paradigm. Springer. p. 13. ISBN 978-0-85729-569-9. Retrieved 25 February 2012.

Knutson, Kraig; Schexnayder, Clifford J.; Fiori Doctor, Christine M.; Mayo, Richard - Construction Management Fundamentals (McGraw-Hill Series in Civil Engineering)

Kristiina Sulankivi, 2019 – BENEFITS OF CENTRALIZED DIGITAL INFORMATION MANAGEMENT IN MULTIPARTNER PROJECTS.

Kurkin, Ondřej; Januška, Marlin (2010). "Product Life Cycle in Digital factory". Knowledge Management and Innovation: A Business Competitive Edge Perspective. Cairo: International Business Information Management Association (IBIMA): 1881–1886. ISBN 9780982148945.

Mahmuda Chowdhury, M. Reza Hosseini, Igor Martek, David John Edwards, Jun Wang (2021) – The effectiveness of web-based technology platforms in facilitating construction project collaboration: a qualitative analysis of 1,152 user reviews. Journal of Information Technology in Construction (ITcon), Special issue: 'Construction 4.0: Established and Emerging Digital Technologies within the Construction Industry (ConVR 2020)', Vol. 26, pg. 953-973, DOI: 10.36680/j.itcon.2021.051

Neale, Marie D.; McKAY, M. F.; Childs, G. H. (1 November 1986) - "The Neale Analysis of Reading Ability — Revised". British Journal of Educational Psychology. 56 (3): 346–356. doi:10.1111/j.2044-8279. 1986.tb03047. x.

Paipetis, S. A.; Ceccarelli, Marco (2010) – The Genius of Archimedes - 23 Centuries of Influence on Mathematics, Science and Engineering: Proceedings of an International Conference held at Syracuse, Italy, June 8-10, 2010. Springer Science & Business Media. p. 416. ISBN 9789048190911.

Pheng, L.S - (1998) ISO 900O and the Construction Industry, Practical Lessons, pp pp.1-5. Chandos Publishing Oxford Limited Publications.

Pheng, L.S., and Teo, J.A. - (2004), Implementing Total Quality Management in Construction Firms, Journal of Management in Engineering, Vol. 8, January, pp 8, 22. ASCE Publications.

Shwu-Min Horng, 2017 – A STUDY OF ACTIVE AND PASSIVE USER PARTICIPATION IN VIRTUAL COMMUNITIES.

Usher, Abbott Payson (1988) – A History of Mechanical Inventions. USA: Courier Dover Publications. p. 98. ISBN 978-0-486-25593-4. Archived from the original on 2016-08-18.

Wopata, M. (2020) – Equipment as a Service Market Report 2020-2025. Hamburg: IoT Analytics GmbH.