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APPLYING GIS AND PRIMAVERA P6 FOR MONITORING CONSTRUCTION PROJECTS IN MALAYSIA

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ABSTRACT
In the field of construction, a wide range of complex tasks must be completed on schedule. Project managers often rely on software like PRIMAVERA and Microsoft Project (MSP) to plan and manage projects efficiently. However, these tools lack the ability to incorporate spatial information into project schedules. To address this limitation, advanced technology known as 4D Geographic Information Systems (4D GIS) has emerged as a promising solution. This technology allows for the integration of AutoCAD drawings with PRIMAVERA project schedules, providing a spatial and temporal dimension to project management. This thesis aims to investigate whether integrating ArcGIS with Primavera P6 enhances the success rate of construction projects and assesses the benefits of this integration. Additionally, the study examines the prevalence of ArcGIS usage in project management within the construction industry, with a specific focus on the types and sizes of companies that commonly utilize ArcGIS as a management tool. The research approach involves distributing questionnaires to 26 respondents, including engineers, project managers, educators, and engineering students. Through an analysis of the data collected and discussions with relevant stakeholders, this research seeks to clarify the potential advantages of incorporating 4D GIS technology into construction project management. Ultimately, this study contributes to our understanding of what makes a project management strategy successful and provides insights into how ArcGIS can be a valuable tool in the construction sector.

Keywords:
PRIMAVERA, Geographic Information Science (GIS), Project Management, ArcGIS

INTRODUCTION

One of the global industries with the fastest rate of growth is construction. At both the international and domestic levels, the construction industry is a significant industry branch. Numerous investment opportunities are presented by construction projects in a variety of associated industries. Therefore, for growing nations like Malaysia, the construction sector is a crucial economic indicator. Construction sector is essential to the nation's economic development and the creation of job opportunities (Annappa and Jamadar, 2017).

The construction project needs a proper scheduling, planning and monitoring of the work activities in order to be successful. Most construction projects face time and cost overruns due to a large number of uncertainties in the construction industry (Vyas and Birajdar, 2016). It is project manager's main duty to keep the expenditures connected with the work packages under control. Project managers can prevent schedule and cost overruns by employing an efficient project monitoring and management technique (Meng and Boyd, 2017).

Traditionally, just two factors are used to evaluate the planned cost of construction projects which is Planned expenditure and Actual expenditure. Although these components help the manager evaluate anticipated and actual spending, they do not provide information on the project's success. This

information is not sufficient because it offers no indication of the completed task (Tomar and Bansal, 2019).

In the construction industry, it is crucial for project managers to control and monitor the progress at each stage of the building job to prevent project cost and time overruns. It is possible with the right project management methodology (Radujković and Sjekavica, 2017). The development of tools and equipment, instruments for communication, approaches for effective management are all priorities for the construction sector. Construction project from government of Malaysia nowadays prefer construction company that implementing GIS as one of their monitoring tools. Malaysia has a small number of construction firms that practise GIS technology as their main application to manage and monitoring the construction project.

Therefore, it is crucial to study the advantages and subjecting the use of advances construction management tools such as ArcGIS. The main objectives of this paper are to identify whether the use of ArcGIS will increase the success rate of the construction project and to determine the advantages of using ArcGIS with Primavera P6 software.

Currently, the proposed construction work for typical building projects is communicated with the civil contractor through 2D CAD working drawings in a paper-based format. The contractor must be able to comprehend the working drawing, and it is his role to decide how and when to implement this plan according to the schedules with his planning team. The planner not only focuses on the work that needs to be done, but also considers needs such as equipment, plants, and other facilities that are necessary to finish the work in the time given. To enable the planning team to move forward with the time line scheduling for working drawings and all plans, a time frame is prepared (Kumar and Reshma, 2017).

Project managers employ conventional methods for scheduling processes, such as Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), bar charts and more. These are utilised for planning, which makes it difficult to make decisions because they do not provide the necessary spatial information and data. In the event that proper monitoring is not carried out, project managers will be under pressure to speed up project completion and cut costs without compromising project quality or timeliness (Vinayakumar et al., 2019).

Nowadays, there are advances software and systems to help project managers manage and monitor the construction project with more details and accurate results such as Geographic Information System (GIS) & Primavera P6 software. The Primavera P6 project management tool is made to help project managers create plans, allocate resources to tasks, monitor work progress, analyse workload, and manage budgets (Suvarna et al., 2018). Primavera allows for the creation of budgets based on resource rates and job allocation. The distribution of resources among projects and the assignment of work is the rate of each volume up to the level of tasks, which rolls up to the task level, then to the numerous summary tasks, and eventually for the project level, determines the estimated, planned expenses calculated labour hours. Primavera P6 was also used to generate WBS, timetables, and allocate costs to each activity. The programme assisted in assessing the Earned Value Method (EVM) and creating the project's CPM schedule (Nalawade et al., 2019).

The aforementioned management tools cannot provide precise visual information, such as drawings, for working operations. Hence, GIS software are the better management tool as it gives useful details about building construction by generating 4D output for a better visualisation. Four-dimensional demonstrating is what 4D modelling is all about, it includes three dimensions for the working project model and one dimension for the work schedule. 4D planner is a tool for visualising, imitating, and communicating that provides simultaneous access to drawing and schedule data (Kumar and Reshma, 2017).

Construction management focuses on the efficient organisation, planning, monitoring, control, and the marketing, production, accounting, and finance departments' fundamental business processes are reported to ensure that construction facilities are profitable. When compared to construction project management, which focuses more on working with stakeholders to produce a specific solution who combine the indicative subprocesses such as project planning, design coordination, management structure

establishment, estimating and tendering, project scoping, and budgeting for a particular project (Harris et al., 2021).

When discussing projects, the terms "project success" and "project management success" are most frequently used. These two project success factors are related but also different from one another. The main difference is the connection of project success with the overall result of project goals achievement, while project management success relates to traditional measurements such as time, cost and performance (Radujković and Sjekavica, 2017).

The large part of economic growth for every country depends on construction projects. However, a survey of the project documents reveals that, in the majority of cases, the projects are not completed on budget as planned, thus they normally lose their operational budget and simply fail (Shahhosseini et al., 2018). Despite the fact that there is no universal definition of what defines a successful project, researchers concur that a project manager's effective actions can lead to the success of the project. Success of construction projects is a big priority for most governments, users, and communities (Radujković and Sjekavica, 2017).

Construction projects often consume significant amounts of capital asset investment from the state budget, and Malaysia's construction industry is no exception (Shahhosseini et al., 2018). Therefore, it is crucial to always seek out innovative approaches to help improve the success of construction management, particularly by enhancing organisational and human resource capabilities (Radujković and Sjekavica, 2017).

In project-based industry sectors, particularly in construction, the value of project managers has been universally recognised (Meng and Boyd, 2017). The role of the project manager includes not just time, budget, and quality management, but also human resource, scope, communication, integration, procurement, and risk management. Thus, they bear the primary responsibility for the project's success (Radujković and Sjekavica, 2017). The project manager should therefore keep an eye on activities to be completed in time for the fulfilment of the plan as a planner, organiser, and overall project controller (Rwelamila, 1994).

The following is the result of a recent survey and analysis by the Economist Intelligence Unit, which was funded by Oracle, of 213 senior executives and project managers worldwide. The survey also included in-depth interviews with nine executives and project management experts.

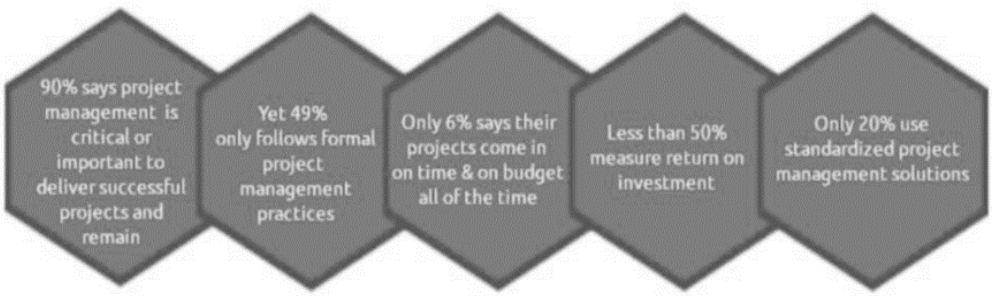

Figure 1: Outcome of the survey

Due to a construction project's varied and dynamic design, risk and opportunities are typically linked. Risk is defined as an unforeseen event that can happen over the course of a construction project (Smith et al., 2006). The generated Web-based GIS monitoring application gives data that helps the project managers or monitoring team to decide on a variety of options, as detailed in the next section (Thekulla et al., 2021). Moreover, to achieve the objective of on-time material delivery at the lowest supply chain cost, project managers can employ 4D BIM-GIS as a decision support base that serves as a

tool to determine the most advantageous site for a consolidation centre by providing the establishment costs of a consolidation centre in different locations (Deng et al., 2019).

A large variety of risks, including those related to finances and design that have a direct impact on overall performance and the achievement of the desired goals, are faced by the construction industry. Practical managerial abilities are absolutely necessary to deal with the unexpected and risky environment, which is seen as a constraint for project accomplishment due to the task's complexity (Sharma, 2011; Philbin, 2008; Hillson and Murray-Webster, 2007; Zwikael, 2011).

As a result of the unsatisfactory risk management techniques in the majority of Malaysia's construction industries, project managers view risk management as a proactive strategy for effective risk minimization and management. The risk propensity and risk management of Malaysian construction industry project managers are affected by organizational elements such communication, economic status, policy, and market status (Noor and Shaista, 2021).

For every project-based firm, choosing the ideal project manager is a difficult task. It is general knowledge that using effective leadership is a strategic move to create competitive advantages for project management (Meng and Boyd,2017). The top ten selection criteria for project managers included communication, technical proficiency, stakeholder management, budgeting, time management, educational background, planning, leadership, team building, and professional certification (Ahsan et al.,2013). To become competent, a project manager must be wise and perform honest constructive actions (Noor and Shaista, 2021).

Developed by Esri (Environmental Systems Research Institute), ArcGIS is a geographic information system (GIS) software used to create, organise, analyse, and visualise geospatial data. ArcGIS is created by Esri for mapping on desktop, mobile, and the web. "Science of Where" is their motto. ArcGIS's expertise thus is on location intelligence and analytics. The company's headquarters is in Redlands, California. The company was initially established in 1969 with a focus on land use development.

The interactive maps and 3D sceneries in ArcGIS Online enables the entire organisation to view, comprehend, and analyse the geographic data. It is simple to share content both inside and outside of an organisation. Companies can create private, invitation-only, or public groups that are accessible to everyone. Other than that, user can access 'ArcGIS Living Atlas of the World' which is a collection of dynamic data layers, analytics, maps, imagery and scenes from the ArcGIS community.

ArcGIS users come from a diverse range of backgrounds and industries. For example, ArcGIS is used by the government, schools, and businesses. However, the environmental, military, and land planning sectors have the most users. ArcGIS is also used in the construction industry especially in leading country, to manage and analyse data related to construction projects, such as land use, zoning, and site planning. Additionally, it can be applied to manage and examine data related to infrastructure projects, such as those involving roads, bridges, and utilities. It can also be used to manage digital maps and 3D models of construction sites and to monitor on the status of ongoing construction projects.

In order to get over the software's limitations, advanced technology like 4D GIS is important. Combination of schedules prepared in PRIMAVERA software and 2D drawings from AutoCAD can be applied in 4D GIS technology. Correlation between scheduled activities and accurate drawings in GIS can enhanced the identification of construction sequences and the detection of logical problems in project schedules. The produced 4D view improves the monitoring of a project's construction process (Chaitanya and Reshma, 2017).

For a more efficient evaluation and sharing of construction project schedule information, advanced visualisation techniques like 4D (3D geospatial + time component) and virtual reality should be used (Chaitanya and Reshma, 2017). This 4D GIS view makes it easier to grasp the planning process and execution of a construction project by improving visualisation of the project's progress and helps a planner to anticipate the construction process that would be carried out (Koo and Fischer, 2000). As a result, scheduling issues can be easily identified and smaller tasks can be done efficiently.

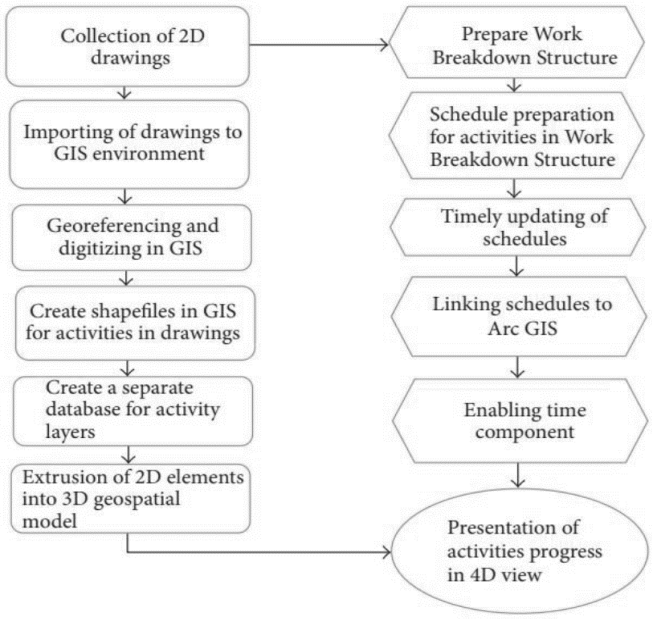

Figure 2: A flowchart for creating a 4D GIS model

The planning development tools are used to create schedules, such as start and end dates which are needed to be updated on a regular basis. Shapefiles prepared by the digitization process should have their own database with information about each activity stored in it. Linking of Schedules. GIS software must be linked to schedules that are updated after being created in planning software. Drawings and schedules must be tied together, meaning activity names and IDs should be the same for those activities. Creation of 3D Geospatial Model. ARCSCENE transforms the created activity layers into 3D layers. The created 3D file will have the same resource information as specified. Preparation of Final 4D Output. The displayed time line slider and the final outcome can both be seen in the produced 3D simulation. The created GIS-based planning and scheduling tool can be utilised for repetitive job tasks. The final product is known as a 4D drawing, which combines a 3D image with a time component (Chaitanya and Reshma, 2017).

This 4D system includes everyone involved in the project for better decision-making by enhancing knowledge of collaborative construction frameworks, analyses, and providing a means for graphically visualising the total construction process. Moreover, this 4D planning tool assist planners to reduces cost overruns of the projects by analysing limits, avoiding scheduling conflicts, and assessing various construction methods. Project planners can view the development of construction operations at any level of a project with 4D visualisation (Chaitanya and Reshma, 2017). As the project progresses, this 4D output assists the project manager in keeping track of the time estimates involved and speeds up decision-making because all relevant project information is contained in a single environment (Vinayakumar et al., 2019).

Primavera software was founded in 1983 by Joel Koppleman and Dick Faris in Philedalphia, USA. Over 75,000 businesses around the world rely on Primavera as their primary project management tool to successfully manage their projects, programmes, and portfolios. Project scheduling has always been Primavera's strongest suit, but as methods and techniques have evolved over time, Primavera has successfully transformed its core functionality from a planning tool to a better project portfolio management solution used by the entire project team and executives.

Using the Primavera system, notable iconic projects in Malaysia like KLCC, KLIA, Putrajaya, Cyberjaya, and LRT were successfully completed. Primavera has also been used by Petronas in Malaysia's oil and gas industry, in addition to the construction sector, as their preferred method of managing capital projects and maintenance/shutdown projects.

The main feature from Oracle Primavera is called Oracle Primavera P6. Primavera P6 is a construction project management software. Large-scale construction projects are scheduled and planned using it, and activities are scheduled, resources are allocated, progress is monitored, and project data is analysed. It is a tool that assist construction managers to efficiently managing and controlling the numerous parts of a construction project from beginning to end. For managing large-scale construction projects, Primavera P6 is known as one of the industry standards.

Primavera software scheduling is a process that includes estimating, sequencing the activities, allocating resources, and time. The idea of the construction scheduling is to finish the project on schedule and coordinate the resources with the given timeframe. Using Primavera software for scheduling provides effective control (E. Suresh Kumar, 2015).

Following are procedures to create schedule using Primavera P6. The first step in creating an efficient schedule for any project is obtaining the project's available information then create the full organisational structure of the company that is working out the project in Primavera P6. This is known as Enterprise project structure (EPS) (Anurag and Amitkumar, 2018).

Next is creating new project. The project is a strategy for developing a service or product and includes a number of different activity and related data, which were managed by their respective EPS divisions. By given dates for the beginning and end of the construction that is achievable, the project determines which global, resource, or project calendar to use. After that, project manager needs to do the work breakdown structure (WBS) which is work of identifying and categorizing each of the project's components. WBS is an organization of all the project work that needs to be done to execute a construction project. This will help to clearly identify deliverables, analysing and summarising project schedule and anticipated cost data at various level of detail (Anurag and Amitkumar, 2018).

The essential and critical work aspects of a project are segmented into the smallest subdivisions, which make up the WBS's top to bottom level. The detail of the activities that can be seen are such as ID, activity name, start and end times, calendar, activity codes, type of activity, limitations, costs, links between predecessor and successor, resources, and roles. The activities should be scheduled in a network by assigned succeeding activities that have a substantial relevance to the overall project activities (Anurag and Amitkumar, 2018).

After that, the calendar may be made and assigned to each activity. These calendars establish the number of hours that must be work during each day that also includes national holidays, project-specific workdays, non-workdays, and resource-vocation days (Anurag and Amitkumar, 2018).

The project duration is set in the original duration field during task planning. Only the project activities that have been finished can have their real duration entered. Then the Actual Start, Planned Start, Actual Finish, and Planned finish dates for project activities are all available in Primavera (Anurag and Amitkumar, 2018).

Primavera P6 software is highly beneficial for efficiently and effectively planning and scheduling projects. It recognises the floats that are available and figures out all potential critical pathways for the project. In order to explore different options, it can generate numbers of possible situations. This software can also split down any activities into smaller and clearly defined parts so the progress and completed task can be monitor and calculate the activity's completion percentage. Additionally, it evaluates risk, presents risk exposure values, and estimates how these risks will affect a project's schedule, duration, and budget (Vishal and Balasaheb,2017).

METHODOLOGY

This section presents the parts that were assessed along with the application of methods in order to collect the data and obtain the information that were need. The research method section describes the techniques used for data gathering or collecting as well as the analytical strategies used. The main assessment process determines whether the use of ArcGIS with Primavera P6 in monitoring and managing construction project in Malaysia, will enhance the probability of success of the project versus using the Primavera P6 software by itself. A survey on several articles and journals related to the implementation of ArcGIS in monitoring and managing construction project proves that the use of ArcGIS will give more advantages towards the project manager, construction company and client. The second stage of the process involves identifying with the study that has been included to make a more in analysis of writing. At this stage, a third procedure were applied to review the pilot study information and identify the factors of how and why ArcGIS software is used to monitor building projects. The fourth step were carried out with a focus on approach adjustments for all of the input information and sources from the pilot's ideas. The primary purpose and aim of this pilot study were to gather information and, in addition, to ensure that the chosen responder could clearly and effectively understand the element in the content. By doing this, the guarantee of the data gathered can be enhanced in achieving the aims. The fifth step are doing more extensive research in the area that is focused on obtaining data sources and information necessary to achieve the objectives. The sixth and last step are analysing the information that was gathered, hold a discussion, and research through the information.

Research Plan

Starting with the research title “Applying GIS And Primavera P6 For Monitoring Construction Projects in Malaysia”, everything falls together. Then, as part of the regular procedure for information gathering and analysis, a set of questionnaires was created and used in conjunction with the literature review, study of the info, and poll surveys. This assessment concentrate on the factors required to accomplishing the objectives along with the reliability and shortcomings of it.

Study Area

The study primarily focuses on universities and construction companies in Kuala Lumpur. This is because Kuala Lumpur hosts construction companies that use ArcGIS software for managing and monitoring construction projects, making it an ideal location for this topic: Applying ArcGIS and Primavera P6 in Monitoring Construction Projects.

Pilot Study

A pilot study is a small-scale exploratory investigation that is carried out in order to assess the viability, duration, potential risks, and study design before the completion of a larger research project. This will enhance data collection before the questionnaire's form and questions are applied and distributed to relevant respondents.

Data Collection

In order to gather data and information for the study, there will be two different types of data collection which is interview surveys and the distribution of questionnaires to appropriate respondents. To get the anticipated viewpoints and outcomes from the relevant respondents, it is important to collect as much information as possible relating to the topic.

Questionnaires

A questionnaire is a research tool used to collect data from respondents through a set of questions, which can be distributed via email, phone, computer, or face-to-face. The questions are designed for either qualitative or quantitative analysis, and respondents must have sufficient knowledge of ArcGIS and

Primavera P6 software. Before distribution, the questionnaire will be reviewed with the supervisor to ensure its relevance and clarity. Drawing on previous examples of similar surveys, the questionnaire will be divided into three main sections: the first will assess the success rate of construction projects using ArcGIS, the second will compare the advantages of ArcGIS over Primavera P6 for monitoring construction projects, and the third will explore the use of ArcGIS by companies of different sizes in Malaysia. This approach ensures that the research objectives are effectively addressed.

Data Analysis

The data were processed and placed into a pattern, group, and unit basis after being gathered through questionnaires and interviews. In order to complete this study, the data collected through questionnaires and interviews will be compiled and formatted into sources using Microsoft Word to ensure that the findings are clearer and more acceptable to the readers. The data from the questionnaire were gathered and evaluated using the percentage calculation.

RESULT AND CONCLUSION

With a total number of 26 respondent, 6 of them are reported being very familiar with ArcGIS, 9 respondents indicated that they are somewhat familiar with ArcGIS and 11 respondents are not familiar at all with ArcGIS. Which then make up a total 42.3% who are very familiar, 34.6% are somewhat familiar and 23.1% are not familiar at all. From the result obtain, we can see that people are getting aware about ArcGIS as a project management tools and more people might start using it in the future to improve their projects.

These percentages reveal that a significant portion of respondents (57.7%) have not used ArcGIS in construction projects. Among those who have used it, a combined 42.4% (19.2% significantly increased, 23.1% somewhat in-creased) reported positive impacts on the success rates. No respondents reported that ArcGIS had no impact. These findings offer valuable insights into the perceived effects of ArcGIS on construction project success rates among those who have experience with the software.

The recommendations for the use of ArcGIS in construction project management were diverse. None of the respondents recommended ArcGIS for small companies, while 8% favoured its use for medium-sized companies. 60%, recommended ArcGIS for large companies. None of the respondents opposed recommending ArcGIS for any company size. How-ever, a considerable percentage, 32%, expressed un-certainty about whether to make such recommendations. These various comments give an understanding of the various points of view regarding the suitability of ArcGIS for construction project management across different company sizes in Malaysia.

In the pursuit of enhancing construction project management practices in Malaysia, this study followed three main objectives to guide its research. Objective 1 sought to evaluate the potential impact of ArcGIS on project success rates. Objective 2 explored the advantages of combining ArcGIS with Primavera P6 software. Objective 3 delved into recommendations for ArcGIS usage across companies of varying sizes. The survey responses provided a mosaic of perspectives from lecturers, engineers, project managers, and students within the Malaysian construction industry.

First objective revealed that while 76.9% of respondents had not yet incorporated ArcGIS into their project management strategies, those who had experience with it acknowledged its potential to influence project success rates. The study emphasized the critical need for further exploration of ArcGIS adoption in construction projects, given its potential to enhance outcomes.

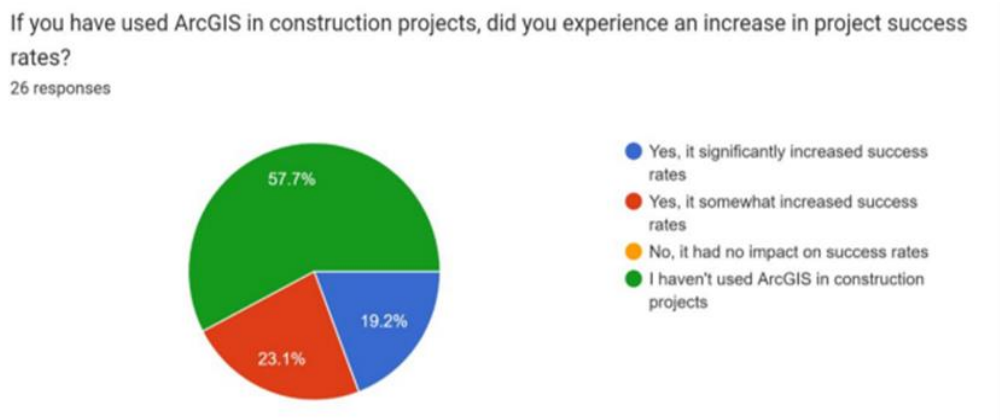

Figure 3: Usage of ArcGIS in constructions projects

For the second objective, it underlines the complexity of technology adoption decisions in construction project management. They provide a valuable foundation for further exploration of how these tools can be effectively utilized in diverse construction project contexts, offering construction professionals and decision-makers insights into the diverse perspectives surrounding the integration of ArcGIS and Primavera P6 in their project management practices.

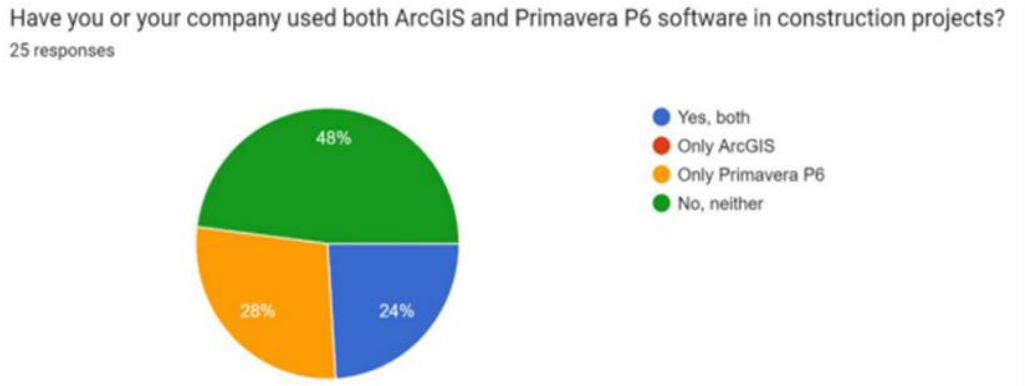

Figure 4: Usage of ArcGIS and Primavera P6 in construction projects

Meanwhile the third objective provided valuable insights into technology recommendations across varying company sizes. The mixed views on company size, coupled with factors like user-friendliness and cost influencing recommendations, underscored the multifaceted nature of technology adoption decisions. These findings offer guidance for construction firms in Malaysia as they make informed choices regarding the integration of technology, particularly ArcGIS, into their project management practices.

This study shows the complex structure of technology adoption in the Malaysian construction industry. The potential of ArcGIS to enhance project success rates, its perceived advantages when combined with Primavera P6, and the varied recommendations based on company size provide a comprehensive understanding of the intricate interplay of technology and construction project management. These insights are instrumental for practitioners and decision-makers in making informed choices that drive efficiency and success in construction projects in Malaysia.

RECOMMENDATIONS

To improve construction project management practices in Malaysia, companies should consider adopting ArcGIS due to its potential to enhance project success rates and its recognized benefits. Those with experience using the software have acknowledged its positive impact, suggesting that further research and case studies are necessary to assess its effectiveness across different construction contexts. Such studies can offer valuable insights to guide informed decision-making on its integration. Collaboration between construction companies, software providers, and government agencies is essential to develop tailored ArcGIS solutions that meet the specific needs of the Malaysian construction industry. Beyond adopting the technology, construction firms must also create clear integration strategies, carefully assessing organizational needs, evaluating the user-friendliness of the technology, and considering cost factors. Change management plans are also crucial for a smooth transition. Additionally, ongoing education and training programs are essential to equip construction professionals with the necessary skills to use ArcGIS and Primavera P6 effectively. These programs should highlight the advantages and practical applications of these tools in construction project management. Finally, fostering platforms for knowledge sharing through industry conferences, forums, and online communities will allow practitioners to exchange best practices and experiences, supporting informed decision-making and successful technology integration in construction projects across Malaysia.

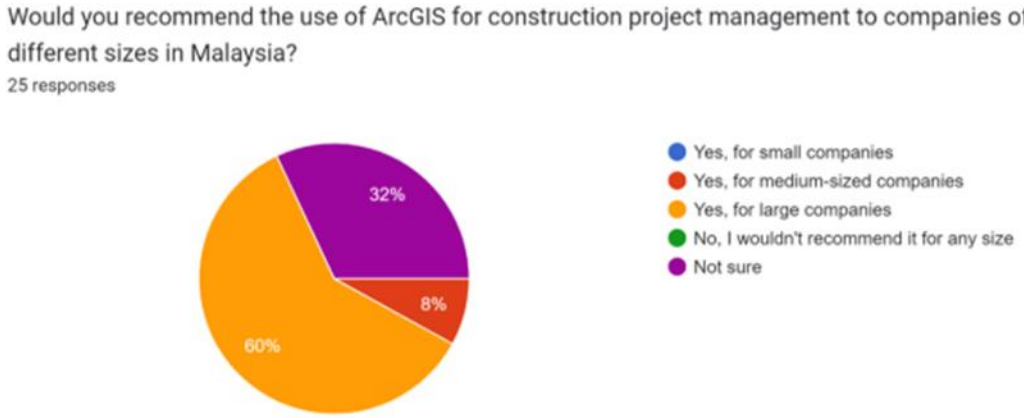

Figure 5: Recommendation from respondents

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