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The Study of LiDAR Technology in Improving the Construction Teams Productivity

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Abstract

In the new global economy, Malaysia recognizes the emergence of LiDAR in the market applied in various fields that can benefit users in management natural resources and become central issue for construction industry. The potential of LiDAR in Malaysian forestry is huge and knowledge and technology are required to process LiDAR data. However, other teams and construction businesses have never utilised LiDAR before, and in some cases, even those that are using the technology were not getting the most out of their survey data. Therefore, the objectives of this research were to study problems of LiDAR technology practice in construction team productivity, to study the solutions for LiDAR technology practice problem for construction team productivity and to evaluate the relationship between the main problems with the main solutions for LiDAR technology practice in construction team productivity. The research area was located in Johor Bahru. This study surveys covered 217 perceptions of Grade 7 contractors in Johor Bahru. The respondents were given a questionnaire by face-to-face meeting and in a link of google form through WhatsApp and Email. A total of 93 (43%) respondents have given feedback in the questionnaire. Descriptive statistics with frequency and crosstabs by SPSS software was used to analyse the data for all objectives. This research found that the main problem was lack of established standard and the main solutions such as be open to improve, combined with the appropriate software, remote operation from a third-person perspective and data can easily transfer recorded as the highest frequency. Meanwhile, the correlation between the main problems and main solutions with the strongest relationship was lack of long-term philosophy and planning with incorporate a system and a way of working that goes beyond the tools. This study may help G7 contractors adopt LiDAR technology to successfully complete construction projects and advance the Malaysian construction industry by improving construction team productivity.

1. Introduction

The construction company is usually seen as problematic and inefficient in its operations. Construction have demonstrated that using an industrialized residential platform approach is an efficient means of meeting stringent customer standards (Uusitalo & Lavikka, 2020). Due to lack of technology advancement, the expectation of clients could not be fulfilled. The application of the LiDAR technology in construction concept, it is claimed, will provide a solution to all of these issues Some of these concerned responses also contain observations regarding potential advances. Concerns are classified into four subthemes: Something is wrong with technology; its usage frequently disconnects or hollows out a community; society must catch up and better manage the challenges and potential of technology; and, despite present trends, there is cause to hope for brighter days (Vogels, Rainie & Anderson, 2020).

1.1 Research Background

In the new global economy, Malaysia recognizes the emergence of LiDAR in the market applied in various fields that can benefit users in management natural resources and become central issue for construction industry (Ismail & Manaf, 2011). LiDAR, or Light Detection and Ranging, is a surveying method that uses laser light pulses to collect “points” (3D coordinates) from the earth’s surface. Millions of these points are collected and together, they form a point cloud. It has the potential to simplify projects and increase productivity in construction firms. LiDAR has various benefits over other technologies and survey methodologies, including the capacity to penetrate dense forest canopy and detect sublevels, delivering precise, highly detailed information on forest structure at a three-dimensional level (Sofia *et al.*, 2022). LiDAR is a crucial construction tool that may be used at any point of a project's life cycle. Some of the ways LiDAR simplifies operations and offers up new opportunities on the jobsite (Anderson, 2021). With LiDAR, construction workers have an accurate view of the site from the start of a project, significantly reducing the time and cost of developing proper construction plans (SITECH Marketing, 2022).

1.2 Problem Statements

The barriers to implementing LiDAR in Malaysia construction companies were found to be similar to those in developed countries, and they were as follows, it can be an expensive solution, but it is very suitable for large and complex projects in construction industry (ACI USA Inc, 2023). Transferring research LiDAR into turn-key systems and lowering their prices are important steps to support practical LiDAR applications. Over the last two decades, developments in industrial lasers have increased LiDAR system dependability while decreasing system development and operational costs. Recent wind energy advancements have expedited the development of low-cost, turnkey Doppler LiDAR. Micro pulse LiDAR are now available for regular monitoring of aerosols and water vapour (Wang & Menenti, 2021). There are not many studies analyse on the solution of the relationship between the main caused regarding expensive pieces of equipment in LiDAR to helped improve process and team work productivity in construction project management. Among the latest studies related to LiDAR are, landscape and mapping using LiDAR technology to help urban developer in Malaysia. That research aims to sustainable landslide hazard mitigation. The results of the paper m*et al*l of their aim and objective (Okoli *et al.*, 2023). This indicates that there are no recent studies analyse on the solution of the relationship between the main caused regarding expensive pieces of equipment in LiDAR to helped improve process and team work productivity in construction project management.

1.3 Research Questions

From the problem statement, the research questions follow. This study aimed to address the following research questions:

1. What the problems of LiDAR technology practice in construction team productivity?
2. What the solutions for LiDAR technology practice problem in construction team productivity?
3. What the relationship between the main problems with the main solutions for LiDAR technology practice in construction team productivity?

1.4 Research Objectives

This research has three main objectives:

1. To study problems of LiDAR technology practice in construction team productivity.
2. To study the solutions for LiDAR technology practice problem for construction team productivity.
3. To evaluate the relationship between the main problems with the main solutions for LiDAR technology practice in construction team productivity.

1.5 Research Hypothesis

The hypothesis based on the research objective made. Those are the research hypothesis:
H0: There is no relationship significant between main problems with main solutions for LiDAR technology practice in construction team productivity.
H1: There is relationship significant between main problems with main solutions for LiDAR technology practice in construction team productivity.

1.6 Research Scope

This research is based on the problem stated in the LiDAR technology practice in construction team productivity. The research area is located in Johor Bahru. This research emphasised the level of project management among selected Construction Company G7 grade in Johor Bahru. The speed with which LiDAR can survey and interpret information, similar to archaeology, is transforming the way construction sites currently function (lidarradar.com, 2023). It demonstrates that constructing activities are fast increasing in Johor, requiring preparation and planning to further grow Johor Bahru's construction sector. As a result, every construction firm in Johor Bahru must be attentive and concerned in order to succeed in every strategy devised by the government. LiDAR technology is ideal for use in any project that will be deployed in a construction project. This indicates that construction exertion is high in the country and is a factor in the selection of study areas in the entire state of Johor, Malaysia (Johari & Mahmud, 2023). The project manager among Construction Company G7 grade in Johor Bahru is the respondents. This because of the maximum level at which the contractor is permitted to perform projects, as well as the type of work for which they have been qualified to do projects which displays the technology required by a certain building company based on their expertise (Johari & Mahmud, 2023). There are a total of 528 G7 grade construction companies registered with CIDB in Johor Bahru (CIDB, 2022).

1.7 Significance of Study

The research is necessary to determine the project management practices of LiDAR technology in improving the construction team productivity. For top management within construction organizations, this research offers a pathway to consistently bolster company performance and uphold a positive reputation by leveraging the manifold advantages of LiDAR technology. Contractors stand to benefit significantly, gaining precise insights into project sites right from inception, thereby drastically reducing time and cost investments in developing comprehensive construction plans. This approach minimizes project delays, ultimately elevating profitability. Equally crucial, this research holds promise for laborers, empowering them with insights to efficiently navigate and maintain project operations. Construction workers adept in LiDAR technology become valued for their proficiency. Moreover, for students and educators, this research serves as a valuable future reference, facilitating the acquisition of novel insights and comprehension concerning LiDAR technology's role in augmenting construction team productivity through improved project management practices.

2. Literature Review

2.1 The Problems of Lidar Technology Practice in Construction Team Productivity

Based on case studies by Westling *et al.* (2020) LiDAR is a continuously evolving technology, and construction businesses are always exploring novel ways to employ UAVs (and the IoT). Construction companies may continuously come in under budget and prevent high-risk situations by harnessing tools such as LiDAR and UAVs.

a) Lack of LiDAR Awareness

Teams and construction companies have never utilised LiDAR before, and in other cases, even those that do use the technology are not making the most of their survey data (Ball, 2020). They also have some difficulty in understanding the key differences between various LiDAR technologies also to use in the construction industry. That complexity requires a deep understanding of the technology and skills to process data and detect discrepancies and inaccuracies (Aerial, 2021).

b) High Operating Costs in Some Applications

LiDAR is inexpensive for large-scale applications, but can be expensive for collecting data in small areas (lidarradar.com, 2023). Sofia *et al.* (2022) stated it also significantly higher investment in equipment (compared to other technologies) makes data collection in small areas economical for large-scale deployments, but can be costly. The high market prices of terrestrial LiDAR systems and limited big data management for computer systems have negatively affected the use of this technology by private companies and the public. Therefore, there is a need to establish interdisciplinary collaborations that meet the demands of businesses and promote the advancement of scientific research (Beland *et al.* 2019).

a) Unskilled Labour and The Low Level of Education of The Site Employee

Other teams and construction companies have never utilised LiDAR before, and in some cases where vegetation is very dense, the pulses may not be able to reach the ground beneath the canopy (Aerial, 2021). Due to the sheer volume of data sets and the complexity of the data collected, analysing the data can require technical proficiency and increase overall costs (lidarradar.com, 2023). LiDAR is inherently complex and requires a deep understanding of sensors which still lacked among the labour (FlyGuys.com, 2023).

b) Insufficient Training for Workers

It is evident that the training needs for contractors and workers, as well as within each of these communities, are quite different. Any LiDAR training course must first determine if the training is directed at the service provider or the end user community, and then determine whether the training is aimed at particular members of the category (Hopkinson *et al.,*2007). These observations suggest a need for LIDAR training. The community is more professional than academic regarding experience was considered more important than educational background for those undergoing LIDAR training.

c) Lack of Established Standards

LiDAR is a young industry, consequently there are no established standards. Each LiDAR sensor uses its own data format and network interface, and each sensor requires a specific driver and a different framework to decode the data. In practice, this tends to limit the number of manufacturers evaluated, and may lead to a shortage of better and/or cheaper alternatives (Dubois, 2022).

d) Lack of Identification and Control of Waste

LiDAR system obtained did not follow the same trend. In other words, reliable, practical, inexpensive, and the generally accepted method of ensuring and evaluating the quality of LiDAR data is clear. And on the other hand, a commonly used technique for quality assessment is LiDAR data-to-data comparison ground control point (Habib & Rens, 2010).

e) Lack of A Long-Term Philosophy and Planning

LiDAR practice requires a long-term strategy and philosophy. Compared to LiDAR intensity photographs, LiDAR depth maps are more resistant to long-term changes. Additionally, it was noted that fresh indoor navigation datasets with high quality LiDAR are required, and further research should be done on t he complementarity of LiDAR depth and LiDAR intensity (Peltomaki *et al.*, 2021).

f) Insufficient Information Administration

By contrasting LiDAR information loss with terrestrial laser scanning (TLS) and field measurements, it is possible to understand how it affects the estimation accuracy of grassland structural and functional features (Zhao *et al.* 2022). LiDAR data are resistant to weather and other atmospheric influences; therefore, their elevation information is also a valuable resource for accurately classifying surface features (Zhang *et al.* 2023).

g) Stringent Requirements and Approvals During Contracting

LiDAR technology have seen dramatic improvements in recent years, revolutionising how to solve these problems locally. However, it is frequently challenging to combine information to address regional, state, and national challenges due to inconsistent and various product specifications as well as fluctuating data quality (ICSM, 2010).

h) High Turnover of Workforce

Construction has a high rate of employee turnover, hence management's readiness to provide proper training declines, which has a big impact on workload design and distribution (Gao & Low, 2014). Previous research revealed that there are knowledge gaps among the personnel (Antah *et al*, 2022). They also look into the challenges of hiring specialists with geospatial technology skills, such LiDAR. Additionally, there is a communication gap and lack of expertise between incompetent staff and those who specialise in computer programming.

i) Lacks the Accuracy of Static Sensors

The drawback is that mobile LiDAR is less accurate than static sensors. Handheld sensors often attain 5-30mm precision, depending on the object being scanned, due to requirements for programmatic stitching and a tendency towards less expensive laser scanners (Westling *et al.*, 2020). Because of this, the deployment of various technologies depends on liability and tolerance standards.

2.2 The Solutions for LiDAR Technology Practice Problem for Construction Team Productivity

Infrared light is used by LiDAR, a sort of optical technology, to measure distances, locate objects, and map out areas. One of the most practical and adaptable technologies available today. It might be used to practically any sector, including robotics, smart automobiles, logistics, forestry, agriculture and construction (Dubios, 2023).

a) Incorporate A System and A Way of Working That Goes Beyond the Tools

Combining LiDAR readings with those from other active and passive sensors provides additional observational possibilities (Stephens *et al.*, 2002). Currently, LiDAR data are frequently integrated with cloud radar and radiometer observations to characterise cloud macro- and microphysical features. Using LiDAR in conjunction with other sensor readings might increase atmospheric monitoring capabilities in a variety of different areas (Nehrir *et al.*, 2017).

b) Keep in Mind that Putting in Place LiDAR Technology Practice Will Take Time

Based on ArcGIS (2022), managing LiDAR data is often part of a bigger data management effort that also includes elevation data in most organisations. Almost all LiDAR projects, including bare-earth digital terrain models (DTMs) and first-return digital surface models (DSMs), need the generation of elevation surfaces from 3D points. Within an organisation, elevation data may often originate from a variety of projects, with the same region covered by numerous data collectors in certain situations, which might complicate data administration.

c) Highly Adaptable to Remote-Working Practices

Using a LIDAR-based model on a project promotes teamwork, and the technology is very adaptable to remote-working practises. The growing use of BIM in civil engineering and construction raises the value of this sort of investment. BIM techniques are used to compile all of the data collected by LiDAR. LiDAR can help to inform BIM schematics and relate them to actual space. Stakeholders may be brought on board early in the project, and teams working collaboratively throughout the planning phase can increase efficiency and quality. Data may be easily transferred, reducing the chance of mistakes due to misunderstanding (Cropp, 2021).

d) The Potential for Significant Automation

Light Detection and Ranging (LiDAR) technology improvements in laser scanning have made it possible for several important high-accuracy inspection processes that have the potential to be automated, with a particular focus on 3D model reconstruction and geometric quality inspection. A "point cloud" is a collection of thousands to millions of places in 3D space that represent solid stuff and are the result of highly accurate distance measurements from the LiDAR sensor (Westling *et al.*, 2020). The move towards mobile LiDAR, which permits quick scanning whether handheld, vehicle-mounted, or aerial has been made possible by recent breakthroughs in algorithm development. Using a backpack-sized device and handheld LiDAR, for instance, a single operator may quickly scan whole floors of buildings (Rodríguez *et al.,* 2019).

e) Great Sensor for Identifying Objects

From case study by McManamon (2019), LiDAR is an excellent sensor for object recognition. LiDAR can function at wavelengths that are familiar to the human eye. Radar pictures may be challenging for the typical person to identify things due to the reflectance properties of microwave radar. These wavelengths exhibit higher specular scattering, which produces pictures that are mostly made up of clusters of brilliant spots. Visible optical radiation makes items easily recognizable to people. By lighting the world at shorter wavelengths than the available night time radiation, an active sensor can see at night. This results in greater diffraction-limited resolution at night for a given aperture size.

f) Free Access to LiDAR Data Through Online Surface

Many of the data requirements will be included in the statement of work (SOW) if data acquisition is to be handled by a contractor. Wherever feasible, the SOW should specify the formats, projections, datums, post-processing (classification) requirements, accuracy criteria, and intended derived outputs (such as mass points, contours, and DEMs). Creating these guidelines is an essential step that should be considered carefully (Carter *et al.*, 2012).

g) Teleoperation of Heavy Equipment

The provision of routes for third-person teleoperation of large pieces of machinery and equipment in sectors like mining and construction is one of the most fascinating rising trends in terms of applications and usage of LiDAR. while combined with the appropriate software, LiDAR offers the singular capacity for remote operation from a third-person perspective, in real-time, delivering great levels of precision and lowering accident rates while operating large machinery (Dubois, 2023).

h) Support Digitalization and Sustainability in The Construction Industry

LiDAR technology is being used in tablets and smartphones, opening up new scan-to-BIM possibilities. Waste audits will be required for rehabilitation projects due to the commitment to circularity. This is a difficult undertaking that would benefit from using both current procedures and technological advancements. This essay seeks to show how everything is connected and can be used effectively together (Mêda, Calvetti & Sousa, 2023).

i) LiDAR for Diagnosis and Renovation

LiDAR technology is used in the construction sector for a variety of purposes, including terrain modelling, building infrastructure, and monitoring bridges. Hardware-wise, specialised LiDAR devices and sensors that are integrated into topographical tools or that are a component of unmanned aerial vehicles (UAVs) are among the most popular. When used in conjunction with laser scanning of historic structures, point clouds from LiDAR may be used to, among other things, discover faults and distinctive forms. The research's scope is the application of LiDAR technology incorporated in mobile devices for interior construction and refurbishment procedures (Mêda, Calvetti & Sousa, 2023).

j) Using aerial LiDAR in Construction to Plan Ahead of the Terrain

For landscapes and grounds with a significant quantity of overgrowth, aerial LiDAR is appropriate. It has the ability to produce an exact 3D map of the scanned areas. The information is then put into a programme for building that enables thorough simulations, especially for construction build and better costing. LiDAR technology is especially helpful when there may be multiple breaks in the aerial system's connection to the ground. It is essential to remember that a building business cannot anticipate the terrain without LiDAR (ACI USA, 2023).

3. Research Methodology

3.1 Research Design

a) Procedure of Research

The method used for conducting this research, detailed in Appendix A, involves five phases. These phases collectively outline the overall research process.

b) Research Method

This study employs a quantitative approach to fulfill its objectives. Quantitative methodology presents its discoveries in numerical form. It involves formulating specific questions and conducting surveys structured around the study's objectives.

c) Respondent

This research used Table of Krejcie & Morgan (1970) in determining the sample size. In addition, the population in this research is the contractors who registered in Grade 7 as well as the population size, is estimated at around 528 respondents in Johor Bahru (CIDB, 2022). Therefore, the sample size is around 217.

d) Research Instrument

The questionnaire was primarily used to evaluate the agree level of contractors to the problems of LiDAR technology practice in construction team productivity, the solutions for LiDAR technology practice problem in construction team productivity as well as the relationship between problems with solutions for LiDAR technology practice in construction team productivity. Likert five-point scales are used as contexts for questions, varying from strongly agree to strongly disagree. There are 3 sections which include Section A, Section B, Section C and Section D. Section A is regarding background of the respondents. Section B is about the problems of LiDAR technology practice in construction team productivity. Section C is regarding the solutions for LiDAR technology practice problem in construction team productivity (Refer to Appendix B or questionnaire form).

3.2 Pilot Study

The researcher had conducted a pilot study before performing the full study and distributing an online questionnaire to the respondents. In the pilot study, a total of 11 respondents in Johor Bahru have answered the online questionnaire provided. According to Bullen (2021), after the survey questionnaire design is completed, 5 to 10 respondents from the target population are selected.

a) Reliability Analysis

Cronbach's alpha was used to determine the reliability of multiple-question Likert scale surveys. These questions assess latent variables, which are hidden or unobservable such as a person's conscientiousness, neurosis, or openness (Glen, 2021). The following rule of thumb: "$\alpha > 0.9$ – Excellent, $\alpha > 0.8$ – Good, $\alpha > 0.7$ – Acceptable, $\alpha > 0.6$ – Questionable, $\alpha > 0.5$ – Poor, and $\alpha < 0.5$ – Unacceptable". According to the results of the reliability analysis on the data gathered, the Cronbach's Alpha is 0.997. As shown in Table 1, indicating that the questionnaire is reliable and the items have reasonably high internal consistency:

Table 1: *Reliability test*

Number of Questions	Number of Respondents	Alpha Cronbach's Value
82	11	0.997

3.3 Data Collection

The data was collected and gathered by way of an online questionnaire distributed among 93 of Grade 7 contractors in Johor Bahru. The questionnaire was designed by manual form set (face to face meeting) and online by using the google form. The link of google form shared on the platform such as Website and Email.

3.4 Data Analysis

The gathered data underwent analysis using the Statistical Package for Social Sciences (SPSS) software. Within this study, frequency analysis served to explain the basic features of the data. Employing a simple descriptive analysis technique, the mean was calculated, while crosstab analysis was utilized to explore relationships. The researcher opted to use frequency analysis for Sections A (background of the respondents), B (the problems of LiDAR technology practice in construction team productivity), and C (the solutions for LiDAR technology practice problem in construction team productivity). Both Sections B and C employed a 5-point Likert Scale to gauge the agreement level among Grade 7 contractors. Results, including the average response (mean), were derived from this Likert Scale. For the analysis of objective 3, which aimed to assess the strength of the relationship between the primary problems and the main solutions to LiDAR technology practice in construction team productivity, the researcher utilized crosstabulation (Crosstab). Crosstab analysis was deemed appropriate due to the ordinal nature of the data, focusing on the main problems and the solutions regarding LiDAR technology practice in construction team productivity. This method allowed the researcher to estimate the relative risk of an event based on specific characteristics' presence or absence. Additionally, it facilitated the testing for significant differences in the column proportions within the crosstab (IBM, 2014).

4. Results and Discussion

The results and discussion section presents data and analysis of the study. A total 217 sets of questionnaires were distributed to the respondents. In the 217, a total of 93 sets of questionnaires were returned with answers and all of the returned questionnaires were used for data analysis purposes. The response rate for this study was 42%, which was significantly higher than the average response rate for this type of survey, which is approximately 30% (Lindemann, 2021).

a) Section A: Respondent's Background

The section describes the sample characteristics of the typical respondents and encloses the general pattern of the responses. Besides, the table of summary of the data analysis in Section A had shown in Table 2. The percentage of the female respondent is higher than male respondents with a total percentage of 54.8% with a total of 51 respondents. The percentage for age for between 18 to 29 years old, is the highest, with 67.7% equal to 63 respondents. Furthermore, the highest race are Malays, with 48.4% and 45 respondents Furthermore, the highest qualifications for degree are the highest, with 60.2% and 56 respondents. Next, the highest percentage for years of service in the construction industry is between 1 to 5 years with 55.9% and a total of 52 respondents. The percentage for job title for construction manager is the highest, with 20.4% equal to 19 respondents.

Table 2 *Summary of data analysis in section A*

No.	Background of Respondents	Frequencies	Percent (%)
1	Gender		
	Male	42	79
	Female	51	21
2	Age		
	Between 18 to 29 years old	63	67.7
	Between 30 to 49 years old	28	30.1
	Between 50 to 59 years old	5	5.4
	60 years old and above	0	0
2	Race		
	Malay	45	48.4
	Indian	32	34.4
	Chinese	14	15.1
	Bumiputera Sabah	1	1.1
	Rungus	1	1.1
4	Highest Qualifications		
	Primary/ Secondary	3	3.2
	Diploma	25	26.9
	Degree	56	60.2
	Masters/ Ph.D.	9	9.7
5	Years of service in the construction		
	industry	52	55.9
	Between 1 to 5 years	33	35.5
	Between 6 to 10 years	6	6.5
	Between 11 to 20 years	2	2.2
	21 years and above		
6	Job Title		
	CEO	1	1.1
	Head of Manager	5	5.4
	Operation Manager	15	16.1
	Project Manager	9	9.7
	Construction Manager Engineer	19	20.4
	Architect	17	18.3
	Quantity Surveyor	7	7.5
	Others	11	11.8
		9	9.7

b) Section B: The problems of LiDAR technology practice problem in construction team productivity (Objective 1)

The analysis of mean is based on Table 3, the mean average score is categorized into three levels; low, moderate and high.

Table 3 *Assessment level based on mean score (Ibrahim, 2013)*

Mean Score Range	Mean Score Level	
1.00-2.33	Low	(Not Agree/ Not Helpful/ Unsatisfied/ None/ Sometimes/Not Sure)
2.34-3.66	Moderate	(Agree/ Helpful/ Satisfied)
3.67-5.00	High	(Strongly Agree/ Fully Satisfied/ Really Helpful)

Based on Table 4, the majority of respondents achieved high agreement level (refer Table 3) that the problems of LiDAR technology practice in construction team productivity is lack of established standard with the highest mean value, 3.7733. Next, followed by high insufficient training for workers, lack of identification and control of waste and lack of a long-term philosophy and planning which the mean value is 3.7677, 3.7599 and 3.7183 respectively. Furthermore, some of respondents strongly agreed (high of agreement level) that the problems are high turnover of workforce with a mean value of 3.7133. According to the data analysis of the returned questionnaires, the respondents achieved high agreement level that unskilled labor and the low level of education of the site employee (3.7097) is one of the problems. Based on the data analysis of the questionnaires returned from respondents, the respondents agreed (high of agreement level) that the problems of LiDAR technology practice in construction team productivity is insufficient information administration (3.681), lacks the accuracy of static sensors (3.6954) and (moderate of agreement level) stringent requirements and approvals during contracting (3.6452). According to the feedback given by the respondents, they also chose to be agreed (moderate of agreement level) that high operating costs in some applications (3.6416) and lack of LiDAR awareness (3.6344) is problems of LiDAR technology practice in construction team productivity.

Table 4 *Mean analysis of problems LiDAR Technology practice in construction team productivity*

No.	Problems of LiDAR technology in construction team productivity	Mean	Agreement	Ranking
Lack of LiDAR awareness		3.6344	Moderate	11
1.	Do notunderstand what it is LiDAR technology.	3.5914	Moderate	2
2.	Hard to get the required information.	3.5914	Moderate	2
3.	Lack of campaign of LiDAR technology.	3.7204	High	1
High Operating Costs in Some Applications		3.6416	Moderate	10
4.	Equipment cost more than the project.	3.7097	High	1
5.	Cost operation increased.	3.7097	High	1
6.	Companies make no profit.	3.5054	Moderate	3
Unskilled Labor and The Low Level of Education of The Site Employee		3.7097	High	6
7.	Incapabilities to handle the equipment.	3.6559	Moderate	2
8.	Lack of understanding in LiDAR technology	3.6559	Moderate	2
9.	Unsuitable nonstandard work arrangements.	3.8172	High	1
Insufficient Training for Workers		3.7677	High	2
10.	Producing less work.	3.8387	High	1
11.	Lower level of performance.	3.6882	High	5
12.	Time lost because repeated activities.	3.7204	High	4
13.	Quality issues increased.	3.8387	High	1
14.	Multiple work errors.	3.7527	High	3
Lack of Established Standard		3.7733	High	1
15.	Use own format.	3.7812	High	2
16.	Limit number of manufacturers evaluated.	3.8817	High	1
17.	Unreliable data management.	3.7527	High	3
18.	Unsecure data management.	3.6774	High	4
Lack of Identification and Control of Waste		3.7599	High	3
19.	Lack of inspection processes.	3.8925	High	1
20.	High operation management cost.	3.6882	High	3
21.	Lack of inspection technology.	3.6989	High	2
Lack of A Long-Term Philosophy and Planning		3.7183	High	4
22.	Not making decisions based on long- term vision.	3.5914	Moderate	5

23. Weak support of top management.	3.7849	High	1
24. Weak commitment of top management.	3.6989	High	4
25. Not focusing what customer needs.	3.7849	High	1
26. Ineffectively manage the data.	3.7312	High	3
Insufficient Information Administration	3.681	High	7
27. Lack of lessons learned.	3.6344	Moderate	3
28. No sense of wanting to change.	3.7634	High	1
29. No exposure of LiDAR technology.	3.6452	Moderate	2
Stringent Requirements and Approvals During Contracting	3.6452	Moderate	9
30. Lengthy client approvals.	3.6667	High	1
31. Bureaucracy in governmental organizations.	3.6129	Moderate	3
32. Policy inconsistencies.	3.6559	Moderate	2
High Turnover of Workforce	3.7133	High	5
33. Results of low-quality work.	3.7097	High	2
34. Demotivation.	3.7634	High	1
35. Adequate training decreases.	3.6667	High	3
Lacks the Accuracy of Static Sensors	3.6954	High	8
36. Less accurate data.	3.7097	High	1
37. Simply carry out tasks.	3.6667	High	3
38. Separate ways utilizing various control points.	3.7097	High	1

According to the analysis of the research, the problems of LiDAR technology practice in construction team productivity is lack of established standard with the highest mean value, 3.7733. Therefore, the problems of LiDAR technology practice in construction team productivity, namely lack of established standard had caused the problems of LiDAR technology practice in construction team productivity. Meanwhile, the lowest mean of the problems of LiDAR technology practice in construction team productivity is 3.6344, which is lack of LiDAR awareness. This is because a majority of the respondents think that lack of LiDAR awareness does not influence to LiDAR technology practice in construction team productivity. Based on the results of the overall analysis, several studies in the construction sector have been carried out with the aim of enhancing the labor productivity of construction practitioners (Tam *et al.,* 2021). A significant factor affecting the quality, time, and cost of building projects is low construction labor productivity (Mahamid, 2013).

c) Section C: The Solution of LiDAR Technology Practice Problem in Construction Team Productivity (Objective 2)

Based on Table 5, the majority of respondents achieved high agreement level (refer Table 3) that solutions to the solutions of LiDAR technology practice in construction team productivity is using aerial LiDAR in construction to plan ahead of the terrain' with the highest mean of 4.3900. Followed by LiDAR for diagnosis and renovation, support digitalization and sustainability in the construction industry and great sensor for identifying objects which the mean value is 3.8968, 3.8923 and 3.8494. Furthermore, some of respondents strongly agreed (high of agreement level) that the potential for significant automation with a mean value of 3.8423. According to the data analysis of the returned questionnaires, the respondents also strongly agreed (high of agreement level) that teleoperation of heavy equipment (3.8423) is one of the solutions. According to a study of the data from the questionnaires that were handed back by respondents, the respondents gave a resounding consensus (high of agreement level) that the solutions of LiDAR technology practice in construction team productivity is teleoperation of heavy equipment (3.8423), highly adaptable to remote-working practices (3.8065), keep in mind that putting in place lidar technology practice will take time (3.7957) and incorporate a system and a way of working that goes beyond the tools (3.7769).

Table 5 *Mean analysis of solutions to LiDAR technology practice in construction team productivity*

No	Solution to LiDAR Technology Practice Problem in Construction Team Productivity	Mean	Agreement Level	Ranking
Incorporate A System and A Way of Working That Goes Beyond the Tools		3.7769	High	10
1.	A vision that is clear.	3.7097	High	4
2.	Vision must include goals.	3.8495	High	1
3.	Vision must include objectives.	3.7527	High	3
4.	Be open to improve.	3.7957	High	2
Keep in Mind that Putting in Place LiDAR Technology Practice Will Take Time		3.7957	High	9
5.	Each party must play a role.	3.7957	High	3

6.	Follow the mission.	3.7097	High	4
7.	Follow the vision.	3.8602	High	1
8.	Keep practice the new technology.	3.8172	High	2
Highly Adaptable to Remote-Working Practices		3.8065	High	8
9.	Data can easily transfer.	3.8065	High	2
10.	Highly adaptable to remote-working practices	3.8495	High	1
11.	Implement planning phase efficiency.	3.7634	High	3
The Potential for Significant Automation		3.8423	High	5
12.	Allowing the sector to function more confidently.	3.7634	High	3
13.	Lessen challenges during conflict settlement.	3.8602	High	2
14.	Effective method for gathering the information	3.9032	High	1
Great Sensor for Identifying Objects		3.8494	High	4
15.	Excellent sensor for object recognition.	3.7849	High	3
16.	Operates at quick capture rates.	3.9032	High	1
17.	Detailed texture data.	3.8602	High	2
Free Access to LiDAR Data Through Online Surface		3.8387	High	7
18.	Free LiDAR data online.	3.8602	High	1
19.	Company sponsored LiDAR.	3.8172	High	3
20.	Government sponsored LiDAR.	3.8387	High	2
Teleoperation of Heavy Equipment		3.8423	High	6
21.	Combined with the appropriate software.	3.8280	High	3
22.	Remote operation from a third- person perspective.	3.8387	High	2
23.	Saving a lot of time.	3.8602	High	1
Support Digitalization and Sustainability in The Construction Industry		3.8923	High	3
24.	Use tablets.	3.9240	High	1
25.	Use smartphones.	3.8602	High	4
26.	Every employee understands their job.	3.9032	High	2
27.	Aware of employee's skilled.	3.8817	High	3
LiDAR for Diagnosis and Renovation		3.8968	High	2
28.	Invest in knowledge.	3.8172	High	5
29.	Invest in technologies.	3.9247	High	2
30.	Listen point of views all employees.	3.8387	High	4
31.	Discover faults at early stage of project.	3.9032	High	3
32.	Discover distinctive forms at early stage of project.	4.000	High	1
Using Aerial LiDAR in Construction to Plan Ahead of The Terrain		4.3900	High	1
33.	Produce exact 3D map of the scanned areas.	4.4500	High	1
34.	Provide rapid assessments at the outset of a project.	4.3600	High	2
35.	Maintenance for every project.	4.3600	High	2

The solutions to LiDAR technology practice in construction team productivity is using Aerial LiDAR in construction to plan ahead of the terrain with the highest mean value, 4.3900. Therefore, the solutions to LiDAR technology practice in construction team productivity, namely using Aerial LiDAR in construction to plan ahead of the terrain could be the best solutions to solve the problems. Meanwhile, the lowest mean is 3.7769, which is incorporate a system and a way of working that goes beyond the tools. This is because the majority of respondents believe that incorporate a system and a way of working that goes beyond the tools is not the best way to practice LiDAR technology in construction team productivity. The finding relates to ACI USA (2023), LiDAR technology is especially helpful when there may be multiple breaks in the aerial system's connection to the ground. It is essential to remember that a building business cannot anticipate the terrain without LiDAR. Especially in industry, the application of LiDAR technology incorporated in mobile devices for interior construction and refurbishment procedures (Mêda, Calvetti and Sousa, 2023).

d) Section D: Strength of Relationship Between the Main Problems with Main Solutions to The Practice Problems of Lidar Technology in the Productivity of Construction Team Productivity (Objective 3)

Table 6 shows the approximate significance for the variables. There are two types of hypotheses in this study which is H0 and H1. H0: There is no relationship significant between main problems with main solutions for LiDAR technology practice in construction team productivity. H1: There is relationship significant between main problems with main solutions for LiDAR technology practice in construction team productivity. The researcher only chose to take 5 main problems out of 11 main problems and take all the main solutions to LiDAR technology practice in construction team productivity to make this connection (McCombes *et al.*, 2022). These specific variables were chosen due to their substantial consensus among the survey respondents and their significant importance in attaining the study's objectives. Moreover, the identified variables are widely recognized among the participants. Similarly, the second objective, solution of LiDAR technology practice problem in construction team productivity, specifically selecting those with the highest strength value for each item (McCombes *et al.*, 2022).

Table 6 *Crosstab analysis (Kamakura et al.(1997)*

Appr.Significant	Value	Explanation
< 0.05	< 0.5	There is a relationship between the variables and the relationship is strong (H_1 is accepted)
> 0.05	> 0.5	There is no association between the variables and the relationship is weak (H_0 is accepted)

Table 7 and Figure 1 shows the value and approximate significance of the relationship between problems and solutions. The first problem is 'Lack of established standard'. The strongest value is 'vision must include objectives' with a value of 0.395, less than 0.5 and the approximate significant is 0.000 less than 0.05. This result can be concluded as the hypothesis is accepted (H1). The second problem is 'Insufficient training for workers'. The strongest value is 'combined with the appropriate software' with a value of 0.311, less than 0.5 and the approximate significant is 0.000 less than 0.05. This result can be concluded as the hypothesis is accepted (H1). Next, 'lack of identification and control of waste' is the third problem. The strongest value is 'Remote operation from a third- person perspective' with a value of 0.297, less than 0.5 and the approximate significant is 0.000 less than 0.05. This result can be concluded as the hypothesis is accepted (H1). Next, 'Lack of a long-term philosophy and planning'. The strongest value is 'Data can easily transfer' with a value of 0.345, less than 0.5 and the approximate significant is 0.001 less than 0.05. This result can be concluded as the hypothesis is accepted (H1). And the last main problem, 'High turnover of workforce'. The strongest value is 'Remote operation from a third- person perspective' with a value of 0.269, less than 0.5 and the approximate significant is 0.009 less than 0.05. This result can be concluded as the hypothesis is accepted (H1).

Table 7 *Relationship analysis for main problems with main solutions*

Main Problems	Main Solution	Approximate Significant	Value	Hypothesis	Ranking
1. Lack of Established Standard -Limit number of manufacturers evaluated	1. Using Aerial LiDAR in Construction to Plan Ahead of The Terrain				
	Produce exact 3D map of the scanned areas.	0.085 (No)	0.074 (Strong)	H0	-
	Maintenance for every project.	0.000 (Yes)	0.473 (Strong)	H1	17
	Provide rapid assessments at the outset of a project.	0.000 (Yes)	0.464 (Strong)	H1	16
	2. LiDAR for Diagnosis and Renovation				
	Discover distinctive forms at early stage of project.	0.117 (No)	0.157 (Strong)	H0	-
	Invest in technologies.	0.000 (Yes)	0.461 (Strong)	H1	15
	Discover faults at early stage of project.	0.000 (Yes)	0.483 (Strong)	H1	19
	3. Support Digitalization and Sustainability in The Construction Industry				
	Use tablets.	0.112 (No)	0.100 (Strong)	H0	-

	Every employee understands their job	0.000 (Yes)	0.450 (Strong)	H1	14
	Use smartphones	0.000 (Yes)	0.429 (Strong)	H1	4
	4. Great Sensor for Identifying Objects				
	Operates at quick capture rates.	0.233 (No)	0.077 (Strong)	H0	-
	Detailed texture data	0.000 (Yes)	0.547 (Strong)	H1	20
	Excellent sensor for object recognition	0.000 (Yes)	0.476 (Strong)	H1	18
	5. The Potential for Significant Automation				
	Effective method for gathering the information.	0.233 (No)	0.077 (Strong)	H0	-
	Lessen challenges during conflict settlement.	0.000 (Yes)	0.408 (Strong)	H1	2
	Allowing the sector to function more confidently	0.000 (Yes)	0.433 (Strong)	H1	6
	6. Teleoperation of Heavy Equipment				
	Saving a lot of time.	0.140 (No)	0.147 (Strong)	H0	-
	Remote operation from a third- person perspective	0.000 (Yes)	0.434 (Strong)	H1	8
	Combined with the appropriate software	0.000 (Yes)	0.441 (Strong)	H1	5
	7. Free Access to LiDAR Data Through Online Surface				
	Free LiDAR data online	0.112 (No)	0.101 (Strong)	H0	-
	Government sponsored LiDAR.	0.000 (Yes)	0.411 (Strong)	H1	3
	Company sponsored LiDAR	0.000 (Yes)	0.434 (Strong)	H1	9
	8. Highly Adaptable to Remote-Working Practices				
	Highly adaptable to remote-working practices	0.190 (No)	0.074 (Strong)	H0	-
	Data can easily transfer.	0.000 (Yes)	0.435 (Strong)	H1	10
	Implement planning phase efficiency	0.000 (Yes)	0.433 (Strong)	H1	7
	9. Keep in Mind that Putting in Place LiDAR Technology Practice Will Take Time				
	Follow the vision	0.085 (No)	0.082 (Strong)	H0	-
	Keep practice the new technology	0.000 (Yes)	0.437 (Strong)	H1	11
	Each party must play a role	0.000 (Yes)	0.449 (Strong)	H1	12
	10. Incorporate A System and A Way of Working That Goes Beyond the Tools				
	Vision must include goals.	0.166 (No)	0.089 (Strong)	H0	-
	Be open to improve.	0.000 (Yes)	0.449 (Strong)	H1	13
	Vision must include objectives.	0.000 (Yes)	0.395 (Strong)	H1	1
2. Insufficient Training for Workers - Producing	1. Using Aerial LiDAR in Construction to Plan Ahead of The Terrain				
	Produce exact 3D map of the scanned areas.	0.301 (No)	0.061 (Strong)	H0	-
	Maintenance for every project.	0.000 (Yes)	0.456 (Strong)	H1	18

less work	Provide rapid assessments at the	0.000 (Yes)	0.505 (Weak)	H1	20
	2. LiDAR for Diagnosis and Renovation				
	Discover distinctive forms at early stage of project.	0.248 (No)	0.054 (Strong)	H0	-
	Invest in technologies.	0.000 (Yes)	0.396 (Strong)	H1	8
	Discover faults at early stage of project.	0.000 (Yes)	0.413 (Strong)	H1	13
	3. Support Digitalization and Sustainability in The Construction Industry				
	Use tablets.	0.301 (No)	0.043 (Strong)	H0	-
	Every employee understands their job	0.000 (Yes)	0.368 (Strong)	H1	4
	Use smartphones	0.000 (Yes)	0.439 (Strong)	H1	15
	4. Great Sensor for Identifying Objects				
	Operates at quick capture rates.	0.642 (No)	0.042 (Strong)	H0	-
	Detailed texture data	0.000 (Yes)	0.455 (Strong)	H1	17
	Excellent sensor for object recognition	0.000 (Yes)	0.447 (Strong)	H1	16
	5. The Potential for Significant Automation				
	Effective method for gathering the information.	0.642 (No)	0.042 (Strong)	H0	-
	Lessen challenges during conflict settlement.	0.000 (Yes)	0.358 (Strong)	H1	3
	Allowing the sector to function more confidently	0.000 (Yes)	0.405 (Strong)	H1	9
	6. Teleoperation of Heavy Equipment				
	Saving a lot of time.	0.670 (No)	0.020 (Strong)	H0	-
	Remote operation from a third- person perspective	0.000 (Yes)	0.382 (Strong)	H1	6
	Combined with the appropriate software	0.000 (Yes)	0.311 (Strong)	H1	1
	7. Free Access to LiDAR Data Through Online Surface				
	Free LiDAR data online	0.248 (No)	0.054 (Strong)	H0	-
	Government sponsored LiDAR.	0.000 (Yes)	0.374 (Strong)	H1	5
	Company sponsored LiDAR	0.000 (Yes)	0.382 (Strong)	H1	7
	8. Highly Adaptable to Remote-Working Practices				
	Highly adaptable to remote-working practices	0.248 (No)	0.051 (Strong)	H0	-
	Data can easily transfer.	0.000 (Yes)	0.352 (Strong)	H1	2
	Implement planning phase efficiency	0.000 (Yes)	0.405 (Strong)	H1	10
	9. Keep in Mind that Putting in Place LiDAR Technology Practice Will Take Time				
	Follow the vision	0.369 (No)	0.045 (Strong)	H0	-
	Keep practice the new technology	0.000 (Yes)	0.503 (Weak)	H1	19
	Each party must play a role	0.000 (Yes)	0.408 (Strong)	H1	11
	10. Incorporate A System and A Way of Working That Goes Beyond the Tools				
	Vision must include goals.	0.369 (No)	0.043	H0	-

			(Strong)		
	Be open to improve.	0.000 (Yes)	0.408 (Strong)	H1	12
	Vision must include objectives.	0.000 (Yes)	0.437 (Strong)	H1	14
3. Lack of Identification and Control of Waste - Lack of inspection processes	1. Using Aerial LiDAR in Construction to Plan Ahead of The Terrain				
	Produce exact 3D map of the scanned areas.	0.081 (No)	0.105 (Strong)	H0	-
	Maintenance for every project.	0.000 (Yes)	0.544 (Weak)	H1	18
	Provide rapid assessments at the	0.000 (Yes)	0.505 (Weak)	H1	16
	2. LiDAR for Diagnosis and Renovation				
	Discover distinctive forms at early stage of project.	0.271 (No)	0.078 (Strong)	H0	-
	Invest in technologies.	0.000 (Yes)	0.453 (Strong)	H1	10
	Discover faults at early stage of project.	0.000 (Yes)	0.508 (Weak)	H1	17
	3. Support Digitalization and Sustainability in The Construction Industry				
	Use tablets.	0.394 (No)	0.066 (Strong)	H0	-
	Every employee understands their job	0.000 (Yes)	0.364 (Strong)	H1	4
	Use smartphones	0.000 (Yes)	0.472 (Strong)	H1	11
	4. Great Sensor for Identifying Objects				
	Operates at quick capture rates.	0.153 (No)	0.65 (Weak)	H0	-
	Detailed texture data	0.000 (Yes)	0.472 (Strong)	H1	12
	Excellent sensor for object recognition	0.000 (Yes)	0.410 (Strong)	H1	7
	5. The Potential for Significant Automation				
	Effective method for gathering the information.	0.153 (No)	0.065 (Strong)	H0	-
	Lessen challenges during conflict settlement.	0.000 (Yes)	0.388 (Strong)	H1	6
	Allowing the sector to function more confidently	0.000 (Yes)	0.482 (Strong)	H1	14
	6. Teleoperation of Heavy Equipment				
	Saving a lot of time.	0.315 (No)	0.073 (Strong)	H0	-
	Remote operation from a third- person perspective	0.000 (Yes)	0.297 (Strong)	H1	1
	Combined with the appropriate software	0.000 (Yes)	0.358 (Strong)	H1	3
	7. Free Access to LiDAR Data Through Online Surface				
	Free LiDAR data online	0.246 (No)	0.078 (Strong)	H0	-
	Government sponsored LiDAR.	0.000 (Yes)	0.377 (Strong)	H1	5
	Company sponsored LiDAR	0.000 (Yes)	0.297 (Strong)	H1	2
	8. Highly Adaptable to Remote-Working Practices				
	Highly adaptable to remote-working practices	0.045 (No)	0.095 (Strong)	H0	-
	Data can easily transfer.	0.000 (Yes)	0.429 (Strong)	H1	8

	Implement planning phase efficiency	0.000 (Yes)	0.482 (Strong)	H1	15
	9. Keep in Mind that Putting in Place LiDAR Technology Practice Will Take Time				
	Follow the vision	0.134 (No)	0.105 (Strong)	H0	-
	Keep practice the new technology	0.000 (Yes)	0.477 (Strong)	H1	13
	Each party must play a role	0.000 (Yes)	0.528 (Weak)	H1	19
	10. Incorporate A System and A Way of Working That Goes Beyond the Tools				
	Vision must include goals.	0.145 (No)	0.099 (Strong)	H0	-
	Be open to improve.	0.000 (Yes)	0.528 (Weak)	H1	20
	Vision must include objectives.	0.000 (Yes)	0.432 (Strong)	H1	9
4. Lack of A Long-Term Philosophy and Planning - Weak support of top managemen t.	1. Using Aerial LiDAR in Construction to Plan Ahead of The Terrain				
	Produce exact 3D map of the scanned areas.	0.101 (No)	0.096 (Strong)	H0	-
	Maintenance for every project.	0.000 (Yes)	0.401 (Strong)	H1	2
	Provide rapid assessments at the	0.000 (Yes)	0.480 (Strong)	H1	14
	2. LiDAR for Diagnosis and Renovation				
	Discover distinctive forms at early stage of project.	0.112 (No)	0.101 (Strong)	H0	-
	Invest in technologies.	0.000 (Yes)	0.516 (Weak)	H1	18
	Discover faults at early stage of project.	0.000 (Yes)	0.434 (Strong)	H1	7
	3. Support Digitalization and Sustainability in The Construction Industry				
	Use tablets.	0.175 (No)	0.122 (Strong)	H0	-
	Every employee understands their job	0.000 (Yes)	0.452 (Strong)	H1	10
	Use smartphones	0.000 (Yes)	0.407 (Strong)	H1	4
	4. Great Sensor for Identifying Objects				
	Operates at quick capture rates.	0.072 (No)	0.110 (Strong)	H0	-
	Detailed texture data	0.000 (Yes)	0.509 (Weak)	H1	17
	Excellent sensor for object recognition	0.000 (Yes)	0.462 (Strong)	H1	12
	5. The Potential for Significant Automation				
	Effective method for gathering the information.	0.072 (No)	0.110 (Strong)	H0	-
	Lessen challenges during conflict settlement.	0.000 (Yes)	0.452 (Strong)	H1	11
	Allowing the sector to function more confidently	0.000 (Yes)	0.504 (Weak)	H1	15
	6. Teleoperation of Heavy Equipment				
	Saving a lot of time.	0.101 (No)	0.095 (Strong)	H0	-
	Remote operation from a third- person perspective	0.000 (Yes)	0.427 (Strong)	H1	5
	Combined with the appropriate software	0.000 (Yes)	0.465 (Strong)	H1	13
	7. Free Access to LiDAR Data Through Online Surface				
	Free LiDAR data online	0.045 (Yes)	0.101	H0	-

			(Strong)		
	Government sponsored LiDAR.	0.000 (Yes)	0.401 (Strong)	H1	3
	Company sponsored LiDAR	0.000 (Yes)	0.427 (Strong)	H1	6
	8. Highly Adaptable to Remote-Working Practices				
	Highly adaptable to remote-working practices	0.324 (No)	0.074 (Strong)	H0	-
	Data can easily transfer.	0.001 (Yes)	0.345 (Strong)	H1	1
	Implement planning phase efficiency	0.000 (Yes)	0.504 (Weak)	H1	16
	9. Keep in Mind that Putting in Place LiDAR Technology Practice Will Take Time				
	Follow the vision	0.153 (No)	0.071 (Strong)	H0	-
	Keep practice the new technology	0.000 (Yes)	0.523 (Weak)	H1	20
	Each party must play a role	0.000 (Yes)	0.436 (Strong)	H1	9
	10. Incorporate A System and A Way of Working That Goes Beyond the Tools				
	Vision must include goals.	0.045 (Yes)	0.100 (Strong)	H0	-
	Be open to improve.	0.000 (Yes)	0.436 (Strong)	H1	9
	Vision must include objectives.	0.000 (Yes)	0.522 (Weak)	H1	19
5. High Turnover of Workforce - Demotivation	1. Using Aerial LiDAR in Construction to Plan Ahead of The Terrain				
	Produce exact 3D map of the scanned areas.	0.58 (No)	0.162 (Strong)	H0	-
	Maintenance for every project.	0.000 (Yes)	0.460 (Strong)	H1	11
	Provide rapid assessments at the	0.000 (Yes)	0.467 (Strong)	H1	12
	2. LiDAR for Diagnosis and Renovation				
	Discover distinctive forms at early stage of project.	0.069 (No)	0.170 (Strong)	H0	-
	Invest in technologies.	0.000 (Yes)	0.424 (Strong)	H1	5
	Discover faults at early stage of project.	0.000 (Yes)	0.408 (Strong)	H1	4
	3. Support Digitalization and Sustainability in The Construction Industry				
	Use tablets.	0.153 (No)	0.126 (Strong)	H0	-
	Every employee understands their job	0.000 (Yes)	0.457 (Strong)	H1	10
	Use smartphones	0.000 (Yes)	0.445 (Strong)	H1	8
	4. Great Sensor for Identifying Objects				
	Operates at quick capture rates.	0.135 (No)	0.125 (Strong)	H0	-
	Detailed texture data	0.000 (Yes)	0.493 (Strong)	H1	13
	Excellent sensor for object recognition	0.000 (Yes)	0.388 (Strong)	H1	3
	5. The Potential for Significant Automation				
	Effective method for gathering the information.	0.135 (No)	0.125 (Strong)	H0	-
	Lessen challenges during conflict	0.000 (Yes)	0.439	H1	7

settlement.		(Strong)		
Allowing the sector to function more confidently	0.000 (Yes)	0.527 (Weak)	H1	17
6. Teleoperation of Heavy Equipment				
Saving a lot of time.	0.175 (No)	0.110 (Strong)	H0	-
Remote operation from a third- person perspective	0.009 (Yes)	0.269 (Strong)	H1	1
Combined with the appropriate software	0.000 (Yes)	0.373 (Strong)	H1	2
7. Free Access to LiDAR Data Through Online Surface				
Free LiDAR data online	0.153 (No)	0.128 (Strong)	H0	-
Government sponsored LiDAR.	0.000 (Yes)	0.432 (Strong)	H1	16
Company sponsored LiDAR	0.000 (Yes)	0.449 (Strong)	H1	9
8. Highly Adaptable to Remote-Working Practices				
Highly adaptable to remote-working practices	0.273 (No)	0.081 (Strong)	H0	-
Data can easily transfer.	0.000 (Yes)	0.499 (Strong)	H1	14
Implement planning phase efficiency	0.000 (Yes)	0.527 (Weak)	H1	18
9. Keep in Mind that Putting in Place LiDAR Technology Practice Will Take Time				
Follow the vision	0.219 (No)	0.078 (Strong)	H0	-
Keep practice the new technology	0.000 (Yes)	0.521 (Weak)	H1	16
Each party must play a role	0.000 (Yes)	0.550 (Weak)	H1	19
10. Incorporate A System and A Way of Working That Goes Beyond the Tools				
Vision must include goals.	0.024 (Yes)	0.116 (Strong)	H0	-
Be open to improve.	0.000 (Yes)	0.550 (Weak)	H1	20
Vision must include objectives.	0.000 (Yes)	0.501 (Weak)	H1	15

Since there is still no study that analyses the relationship of the issues. Figure 1 shows diagram of relationship analysis of main problems (illustrate from Table 7 finding). According to ACI USA (2023), LiDAR technology has gained popularity in the construction sector since it has improved team and process productivity. It is more difficult to ensure a project's safety when the processes are inefficient.

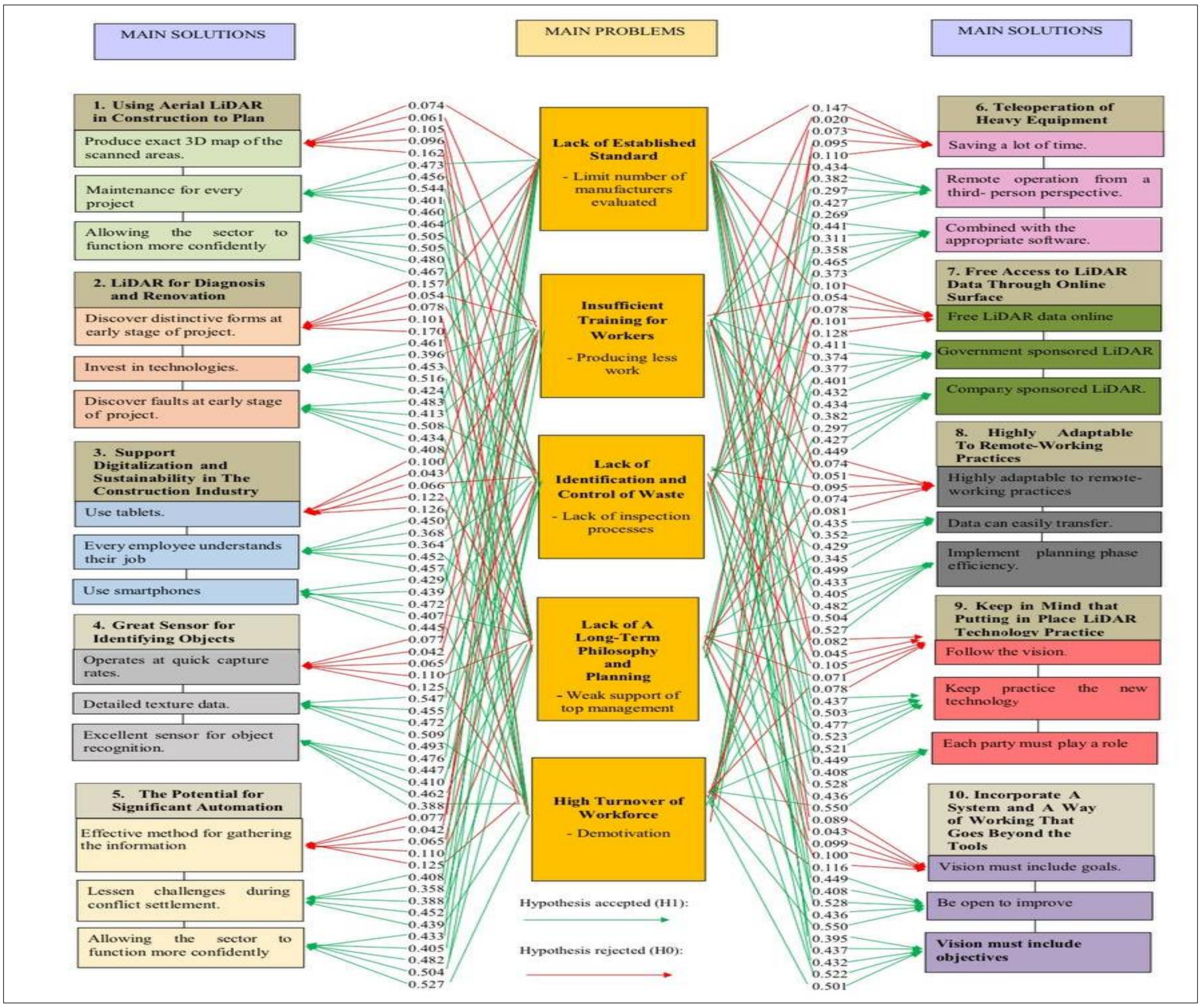

Fig. 1 The relationship analysis between main problems with main solutions

5. Conclusion and Recommendations

5.1 Result and Discussion

The purpose of this research was to meet the three objectives that were set at the beginning of the research. According to the objectives that have been set, the recommendations and conclusions already been discussed. In line with the established objectives, the implications of these recommendations and conclusions on the broader scope of the project will now be assessed and contextualized.

5.2 Proposal Statement Solution for Problems

Based on the study, researchers have some of suggestion to resolve the problems and solutions to LiDAR technology practice in construction team productivity. This suggestion is applied for the government and other authorities in construction to LiDAR technology practice in construction team productivity.

i. For contractors to engage in this LiDAR technology practice, it is essential for Malaysian regulatory bodies like CIDB to focus on creating a comprehensive guideline specifying the necessary criteria they need to meet.

ii. At construction sites, it's the responsibility of authorities to ensure that employees adhere to the standards and regulations governing LiDAR technology practices.

iii. To guarantee the effectiveness of LiDAR technology practice in construction, it is advisable for relevant authorities to acquire advanced technology from affluent nations.

5.3 Recommendations for Future Research

Researcher makes research to identify the main problems with main solutions to LiDAR technology practice in construction team productivity. Based on the research, there are some suggestions to make the research going further. Such as:

i. Recognize the contentment within the organization and the likelihood of employee engagement or enthusiasm toward adopting LiDAR technology practice in construction team productivity.

ii. Recognize the varieties and approaches of technology capable of enhancing LiDAR technology practice within the construction sector in Malaysia.

iii. Explore a wider and more varied range of research avenues to investigate the influence of LiDAR technology practices on the construction industry and their correlation with various selected locations, whether interconnected or disparate.

5.4 Closure

The research successfully achieved all its objectives by analyzing the data collected from the returned questionnaires. Meeting these aims was crucial for the research's success. Based on this study, Grade 7 contractors agreed upon strength of relationship between the main problems with main solutions to LiDAR technology practice in construction team productivity. The identified problems can be effectively addressed through the proposed strategies. This underscores the significant importance of LiDAR technology practice in construction team productivity presently. As LiDAR technology practice in construction team productivity is relatively novel in construction, there's a need for guidance, incentives, and effective strategies to manage it and make informed decisions. In conclusion, this research emphasizes the hope that stakeholders responsible for addressing these issues will employ successful strategies. By doing so, the construction industry has the potential for enhanced prosperity and success if managed accordingly.

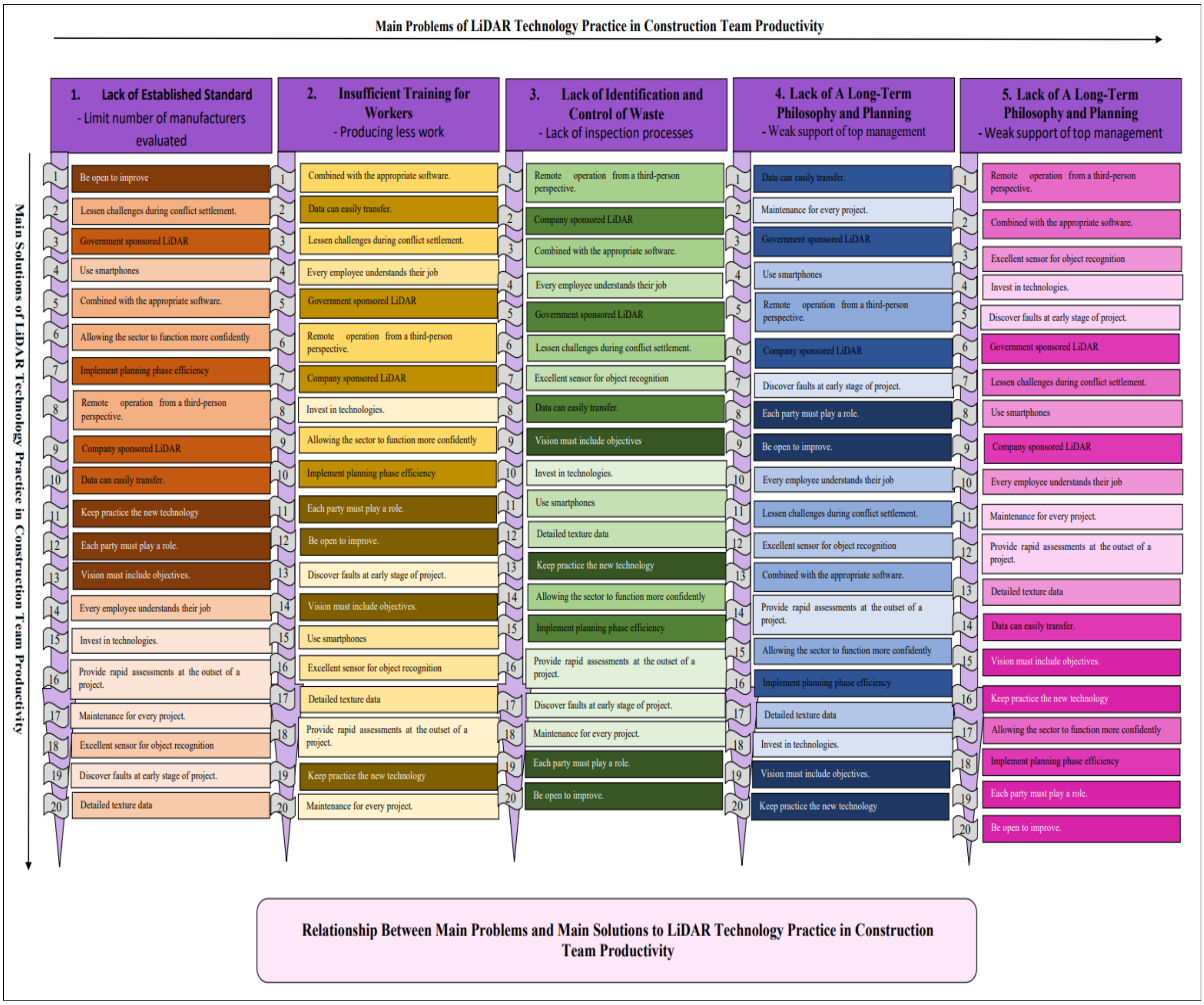

Fig. 2 Relationship framework between main problems with main solutions for LiDAR technology practice in construction team productivity

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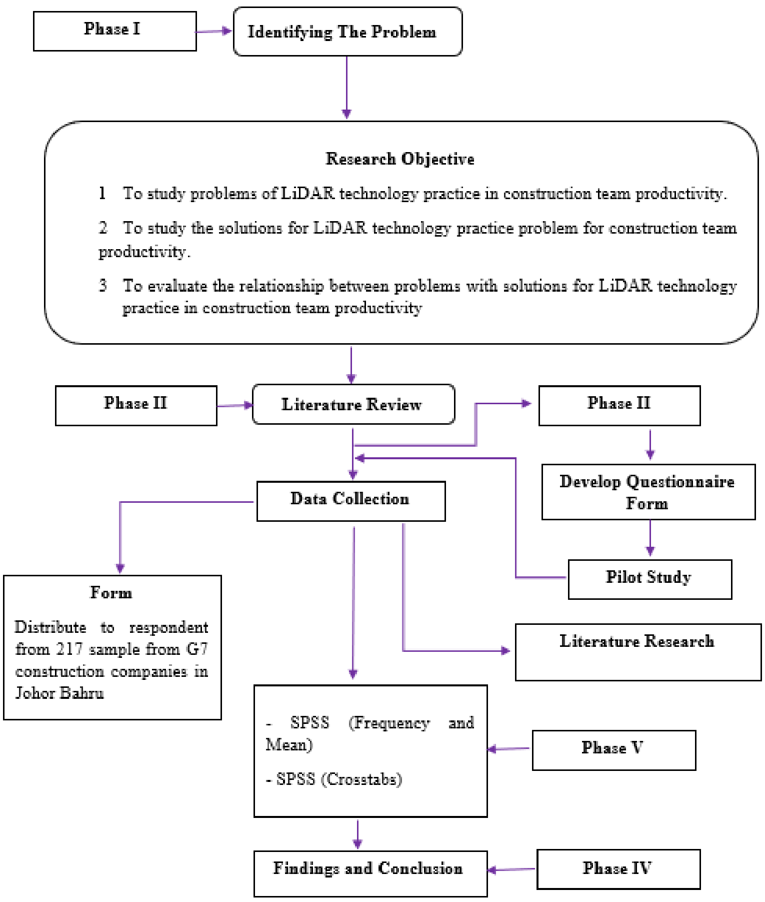
Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Norelya Ardyla Mohmad Fauzi @ Mohamad Fauzi, Rozlin Zainal;* ***data collection:*** *Norelya Ardyla Mohmad Fauzi @ Mohamad Fauzi;* ***analysis and interpretation of results:*** *Norelya Ardyla Mohmad Fauzi @ Mohamad Fauzi;* ***draft manuscript preparation:*** *Norelya Ardyla Mohmad Fauzi @ Mohamad Fauzi, Rozlin Zainal, Narimah Kasim, Hamidun Mohd Noh. All authors reviewed the results and approved the final version of the manuscript.*

Appendix A: Procedure of Research



Procedure of Research

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