

Study on Barcoding Implementation for Improving Materials Tracking at Construction Site

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Abstract: Nowadays, inventory management plays a vital role in every organization because ethical inventory management will help reduce costs and increase productivity. Most of the construction industry still manually maintain their materials and they face a lot of problems in their daily operation. Therefore, this study was conducted to identify the advantages, challenges, and improved ways of barcoding implementation for improving materials tracking at the construction site. The area of research scope is selected in Selangor and the research target respondent is G7 main contractors. Respondents from project managers, site managers, architects, contractors, and site supervisors around the state of Selangor will be selected to get the information. In order to achieve the objectives of this study, the study was conducted using quantitative methods for primary data collection. Secondary data is literature review such as academic books, journal articles, reports, and online data source related to the barcoding implementation for improving materials tracking. Data collection results will be analyzed using descriptive methods to obtain the highest frequency and mean score values using SPSS software. The goal of the outcomes of this analysis is to receive input in response to the objectives set. In addition, it is expected that this thesis would help workers in the construction sector to be armed with a range of options and measures that can be taken to incorporate barcoding to enhance material monitoring at the construction site.

Keywords: Material Tracking, Barcoding, Construction Site

1. Introduction

Nowadays, essential for a country's economic development is the support of the construction industry. Construction development has contributed about 8% to 10% to the promote growth of different countries (Dixit *et al.*, 2019). Major challenges face by the construction industry are project overruns, poor quality of structures, inappropriate procurement systems, and a failure to cope with

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infrastructure requirements (Ogwueleka, 2013). In construction project development, materials are the building blocks important to taken into consideration of the project, it constitute a large amount cost of the project (Lu *et al.*, 2011). Furthermore, inventory in traditional settings could be defined as the company's raw materials, work in process, supplies used in operations and finished goods which were used to ensure the smooth running of the business (Sahari *et al.*, 2012). Material management is the system for planning and controlling to ensure that the right quality and quantity of materials and equipment are specified in a timely manner (Donyavi & Flanagan, 2009). The inventory management during the construction process may be affected by insufficient storage space, repeated orders, over orders, delayed information update and lack of materials (Sardroud, 2012). In addition, inventory management plays a vital role in every organization because ethical inventory management will help reduce costs and increase productivity (Mohamed Shiraj, 2011). Nowadays, almost every type of industry is using barcode technology instead of keyboard data entry because bar code is faster and more accurate than keyboard data entry (Singh & Sharma, 2015). Data capture is three times faster than a skilled data entry operator can enter data with negligible error rates (Islam *et al.*, 2019). Human input errors are more serious than bar codes. A digital copy of a barcode is fast, secure, good, ready, and takes much less time than manually entering a computer (Mandal, 2017). Therefore, the research will be focusing on the barcode implementation for improving materials tracking at the construction site.

Most of the construction industry in Malaysia lacks the technical, fund, managerial capability to conduct the construction project (Gulghane & Khandve, 2015). The overall performance of the construction industry is influenced by project transportation, inefficiently working time, waste of project resources and inefficiency management costs (Gastelum, 2017). Construction projects face many problems include construction waste, excessive resource consumption, adverse impact on the environment, time overruns and cost overruns (Azis *et al.*, 2012). Poor quality of building components, unsafe work areas, human behavior, and misuse of machinery be the cause of construction injuries (Ogwueleka, 2013). Thus, this could lead to a loss of workers' productivity and an increase in the total cost of the project (Sardroud, 2012). In addition, one of the main difficulties in delaying construction projects is improper materials and inventory management (Tedla & Patel, 2018). The main obstacle of materials is the failure of purchase and supply of materials (Ala-Risku & Kärkkäinen, 2006). The material does not match the ordered purchase, change mind to order the material, too much or less material, material, not the arrival at the time and lack of training and proper management will affect the effectiveness of inventory management (Donyavi & Flanagan, 2009). Problems arising from a lack of particular concern in material management such as receiving incorrect material type, increase materials quantity in storage and burglary, theft and vandalism (Tedla & Patel, 2018). The management approach and last-minute improvisation lead to inefficient practices for monitoring material shortages. Poor management will define the material ordered late and always bring uncertain demand to the supplier (Ala-Risku & Kärkkäinen, 2006).

Furthermore, nowadays barcodes are increased automation and reduce human error, which effectiveness of inventory management (Várallyai, 2013). Besides, most of the barcode scanners are using infrared methods to scan a barcode. This may lead to the costing issue where those scanners are expensive to be purchased and unaffordable to the user (Hashim *et al.*, 2013). Deformation and damage to the barcode make it difficult to scan the code correctly. A damaged barcode means that the information is severely lost and cannot be scanned successfully. Delay in construction site operations (Akshatha *et al.*, 2017). If the barcode label cannot be scanned, the worker must manually type the corresponding numeric code, which can cause slow or inaccurate entry of information, further expansion of material management processes (Islam *et al.*, 2019). The poor material management on the labor productivity and the ineffective use of work hours will cause a loss in construction productivity (Song *et al.*, 2006). Therefore, this study seeks to identify the advantages, challenges, and improved ways of the barcode implementation for improving materials tracking at the construction site. The specific objectives of this research include studying the advantages, identifying

the challenges and determining the improved ways of barcoding implementation for improving materials tracking at the construction site.

2. Literature Review

Inventory management is a critical aspect of every construction company as positive inventory management can help to minimize costs and improve profitability. However, as the volume of inventory increases and the rate of content flowing either into or out of supply decreases, it becomes difficult to count the inventories (Woldie, 2018). But, using Barcode can increase the reliability of stock management and efficiently control the inventory by automatically sending an order to the industry when the stock is below the reorder point (Mohamed Shiraj, 2011).

2.1 Advantages of Barcoding Implementation for Improving Materials Tracking

Nowadays, a barcode system is now used as an important complement to automated process support. Barcode has distinct advantages over other approaches such as manual data, magnetic stripes (Pihir *et al.*, 2011). The Barcode is a well-established technology that has reaped the benefits of this invention from all industries. Barcodes are often overlooked as a cost-cutting and time-saving process. In the construction industry, it is a desirable and feasible option to increase productivity and reduce overhead (Rahaman, 2016). The advantages of barcode technology can be list as follow (Phaniteja & Tom, 2010; Garg, 2012; Sudha *et al.*, 2013; Singh & Sharma, 2015).

- (i) *Increase service accuracy*: Increasing the use of barcode technologies to ensure consistency for consumers of information services. Barcodes remove the potential for human error. The frequency of manually inserted data errors is slightly greater than Barcode errors. A barcode scan is simple and accurate and takes much less time than manually entering data.
- (ii) *Fast speed*: The use of barcode technologies speeds up the construction industry's processes and activities and consumers can get their services very easily
- (iii) *Professional productivity and service quality*: Barcode security increases the information professional's performance and consistency of computer services. Operational performance has vastly improved by using bar code technologies, as bar codes require the quicker device and bar code labels processing of information.
- (iv) *Saved space*: Barcodes are very flexible. They can be used for any form of data collection required. It may provide information about materials or inventories.

2.2 Challenges of Barcoding Implementation for Improving Materials Tracking

The application of barcode technology in the circulation system of the construction industry and information technology is most successful due to its speed, accuracy and reliability (Singh & Sharma, 2015). Businesses nowadays are best handled with the use and help of a barcode scanner (Garg, 2012). A Barcode scanner is a device used to extract information optically from the barcode. Barcode scanners are of various types (Singh & Sharma, 2015). However, these are some challenges facing the barcode technology industry (Phaniteja & Tom, 2010; Rahaman, 2016).

- (i) *Line of sight is required*: Since barcodes require line of sight technology, that is, direct visual contact with the reader is needed. All materials must have barcode labels, which are clearly visible to facilitate the scanning.
- (ii) *Disorientation, obstruction by dirt, mist, protrusions, and damage* all because of failed reads or misreads by the scanner.
- (iii) *Simultaneous non-collision scanning of multiple materials* is near impossible.

- (iv) Damage or distortion: Packaging which includes shrink wrapping or other plastic coverings can cause distortion. Wrinkles can create distortions of barcodes that change how the light bounces off it. Which makes it difficult to search the code correctly.

2.3 Improvement Ways of Barcoding Implementation for Improving Materials Tracking

Since barcode scanning is much faster and more reliable than keyboard data entry, almost every form of industry uses barcode technology to replace keyboard input (Singh & Sharma, 2015). Today barcodes are commonly used at supermarkets and convenience stores to keep track of the available inventory and quick product checkout (Akshatha *et al.*, 2017). However, they are some of the improved methods of barcode implementation in the construction industry (Akshatha *et al.*, 2017; Garg, 2012; Sudha *et al.*, 2013).

- (i) Organizing a market incentive program related to barcodes in the construction site.
- (ii) Organizing a campaign related to barcodes in the construction site.
- (iii) Barcode advertising through social media, print media, and electronic media in the construction site.
- (iv) Improve the awareness of barcodes in the construction industry.
- (v) Barcode technology provides professional solution services for the government

3. Research Methodology

3.1 Research Design

The design of the study was conducted to make this study a descriptive research study. The design of the descriptive study was chosen because it was based on the title of the study which was something that respondents were familiar with. In descriptive research, the data collected from a group of respondents will be analyzed before being reported as research findings in the form of frequency and value scores (Akhtar, 2016). The research consists of 5 phases in describing the whole procedure and activities from the start until the end of the research. Phase 1 involves preliminary research that includes the search for information related to the topic to be studied. Besides, phase 2 is about the process of literature review with the research title of study on barcoding implementation for improving materials tracking at a construction site. In addition, phase 3 is about data collection. Data collection can be divided into two categories, which are primary data and secondary data. Furthermore, phase 4 is expressed data analysis and results which explains the data analysis technique and result in the previous data collected through questionnaires. Phase 5 is the final phase for this research which is the conclusion and recommendation. The process of research methodology adopted in this study is shown in Figure 1 below. Most of the researches is intended to collect data and information from a population. Since the population in the study is expected to be large and not the whole community of contractors can give answers to this research question, the survey that corresponds to any aspect of the population is released. Sampling is meant to eliminate population to reduce mistakes in the judgments taken in measurements (Asiamah *et al.*, 2017).

The sample for this study refers to a number of CIDB registered G7 contractors, who have been or have been employed on construction projects across Selangor city. The population size and sample tables for Krejcie and Morgan (Hashim, 2010) can be described in appendix A. A record 2,266 registered G7 grade contractor organizations in the state of Selangor (CIDB, 2019). Consequently, the sample calculation was determined by 2,200 by comparison to table 3.1 above the total population, as the number is the nearest value to the value of 2,266 total G7 contractors associated with CIDB. Hence, a sample of 327 refers to a population of 2,200. This research will be conducted with 327 respondents involved in responding to the form of a questionnaire that will be distributed. The aim of

the preliminary study is to develop the questionnaire so that respondents should have no trouble answering the question and reduce the probability of blanking the question by the respondent. It would discourage critical things from being presented to the respondent (Majid *et al.*, 2017). Researchers may increase the accuracy of such ambiguous and confusing questions by undertaking this study. After a preliminary review of the questionnaire, the data obtained will be evaluated and the accuracy checked to check its efficacy and reliability (Thabane *et al.*, 2010).

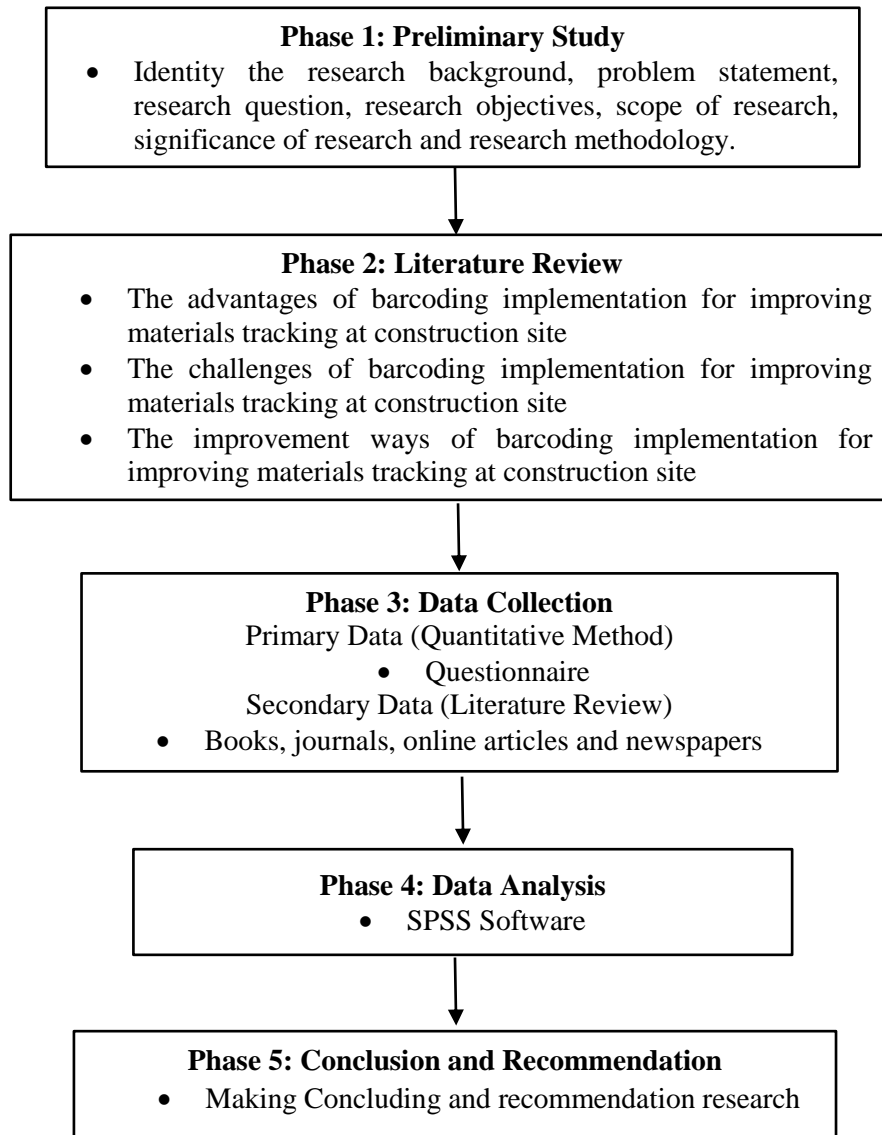


Figure 1: Research methodology flow chart

3.2 Data Collection

The process of data collection is very important because it will prove that the research that is being carried authentic and in fact supported by a variety of references. Primary data were collected through field studies to obtain direct feedback from respondents using questionnaire distribution methods, face-to-face interviews, observations and other methods (Curtis, 2008). Secondary data is information that has already been collected and is usually published or electronically available.

Secondary data have often been collected, analyzed, and organized with a specific purpose in mind, so specific market research may have limited applications (Ajayi, 2017).

Instrumentation of analysis is a resource or method used in the conduct of research. For conducting research, accurate and systematic data collection is crucial. The validity of the data can be assured by appropriate research methods. The instrument includes several research tools (Zohrabi, 2013). Furthermore, pilot training was conducted to ensure that the respondents understood the questions (Trigueros, 2017). The questionnaire's data collection tool was selected through the quantitative method for the primary purpose of collecting the primary data that will be distributed to the survey respondents. Questionnaires are an accessible and well-established way to raise questions about data processing and to be quickly evaluated.

3.3 Data Analysis

Data analysis is a technical process of processing, collecting, and transforming the data obtained (Lutabingwa, 2007). Using the SPSS software, the data collected from the questionnaire delivery process can be analyzed. Before being submitted as a result of the study, data were analyzed to obtain accurate and valid answers SPSS software offers reliable results and is used for quick, easy to upgrade programs. The analysis is carried out to achieve the frequency and mean score values that will be shown in the next chapter in graphs, tables, or diagrams.

4. Results and Discussion

4.1 Respondent's Background

The total questionnaire survey collected from respondents is 103 from the total 327. The percentage of the survey collected was 31.5% from the total 100%. The respondent's background consists of the highest academic qualification, job position, working experience, working experience in handling material management and experience in technology especially barcoding technology in handling material management are shown in Table 1. The below table includes the frequency and percentage of 103 respondents. According to the table shown below, most of the highest academic qualification is a bachelor degree, it is 58.3% because the area of research is a majority bachelor degree. As a result, a Bachelor's degree is strongly participatory. Besides, the highest job position is site manager it is 23.3% because most of the respondent participants are site managers. Next, the working experience of respondents involved is mostly between 4 to 6 years it is 45.6% because the area of research respondent participant is majority 4 to 6 years working experience. The highest working experience in handling material management is also 4 to 6 years it is 54.4%. However, the highest experience in technology especially barcoding technology in handling material management is less than 3 years it is 53.4%. Because most respondents rarely use barcode implementation at the construction site.

Table 1: Summary of respondent's background

Item		Frequency	Percentage (%)
Highest academic qualification	Diploma	26	25.2
	Bachelor Degree	60	58.3
	PhD	13	12.6
	Master	4	3.9
Job Position	Site Supervisor	23	22.3
	Site Manager	24	23.3
	Project Manager	21	20.4

	Architect	20	19.4
	Contractor	15	14.6
Working experience	Less than 3 years	16	15.5
	4 - 6 years	47	45.6
	7 - 9 years	31	30.1
	10 years and above	9	8.7
	Less than 3 years	25	24.3
Working experience in handling material management	4 - 6 years	56	54.4
	7 - 9 years	18	17.5
	10 years and above	4	3.9
	Less than 3 years	55	53.4
Experience in technology especially barcoding technology in handling material management	4 - 6 years	36	35.0
	7 - 9 years	9	8.7
	10 years and above	3	2.9

4.2 Advantages of Barcoding Implementation

The objective of this study is to determine the advantages of barcoding implementation and the result shown in Table 2 with the highest ranking of advantages which measure from the highest to the lowest mean value. The highest-ranking has a mean score value of 4.09 while the lowest ranking is 3.87 with a 0.22 difference in mean score value. The average mean of this question is 3.98 and the ranking is only an indication of the advantages of barcoding implementation.

Table 2: Summary of advantages of barcoding implementation

No	Item	N	Mean	Standard Deviation	Ranking
1.	Barcoding technologies can reduce costs by reducing inventory levels.	103	3.87	0.652	9
2.	Barcoding technology can minimize human error.	103	3.97	0.834	5
3.	Barcoding technology can make the process of entering data easier.	103	4.01	0.834	4
4.	Barcoding technology can quickly provide information on inventory and material data.	103	4.09	0.909	1
5.	Barcoding technology can reduce the time spent looking for missing material.	103	3.93	0.795	7
6.	Barcoding technology can be used effectively monitors materials.	103	3.91	0.841	8
7.	Barcoding technology can increase security with consistent inventory data services.	103	4.04	0.779	2
8.	Barcoding technology can allow the construction site staff to track materials easily.	103	3.95	0.759	6
9.	Barcoding technology help in	103	4.02	0.741	3

improved customer service by using real-time inventory data to provide accurate order status.

Average Mean	3.98
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From the table above, barcoding technology can quickly provide information on inventory and material data to get the highest mean value in the ranking. Therefore, barcoding improves the accuracy of the inventory, and it also significantly reduces the monitoring time spent (Singh & Sharma, 2015).

4.3 Challenges of Barcoding Implementation

The objective of this study is to determine the challenges of barcoding implementation and the result shown in Table 3 with the highest ranking of challenges which measure from the highest to the lowest mean value. The highest-ranking has a mean score value of 4.04 while the lowest ranking is 3.81 with a 0.23 difference in mean score value. The average mean of this question is 3.94 and the ranking is only an indication of the challenges of barcoding implementation.

Table 3: Summary of challenges of barcoding implementation

No	Item	N	Mean	Standard Deviation	Ranking
1.	Barcoding scanners require a direct line of sight to be able to read.	103	3.86	0.813	8
2.	Barcoding technology only can store limited data.	103	3.93	0.783	5
3.	The downtime of barcode technology will require high maintenance costs.	103	3.87	0.788	7
4.	Barcode label damage can cause delays in the material tracking process.	103	3.81	0.755	9
5.	Barcode equipment downtime will result in overtime and lost revenue in the construction site.	103	4.01	0.810	3
6.	Barcoding labels must be affixed to all material in store which can be time-consuming.	103	4.02	0.816	2
7.	Barcoding labels on the material can be easily counterfeited or replicated.	103	3.99	0.747	4
8.	Barcoding is read-only and information cannot be updated or added.	103	3.91	0.818	6
9.	Barcoding equipment is delicate and expensive	103	4.04	0.827	1

Average Mean	3.94
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From Table 3 above, barcoding equipment is delicate and expensive to get the highest mean value in the ranking. However, maintenance is needed for barcoding equipment if a long time ago (Hashim *et al.*, 2013). The barcoding equipment will get wear and tear when long using. Long-term usage can cause harm to the barcode device (Várallyai, 2013). Thus, the cost of using barcodes is getting higher.

4.4 Improvement Ways of Barcoding Implementation

The objective of this study is to determine the improved ways of barcoding implementation and the result shown in Table 4 with the highest ranking of improvement ways which measure from the highest to the lowest mean value. The highest-ranking has a mean score value of 4.10 while the lowest ranking is 3.76 with a 0.34 difference in mean score value. The average mean of this question is 3.97 and the ranking is only an indication of improved ways of barcoding implementation.

Table 4: Summary of improved ways of barcoding implementation

No	Item	N	Mean	Standard Deviation	Ranking
1.	Organizing a market incentive program related to barcodes in the construction site.	103	3.84	0.724	7
2.	Organizing a campaign related to barcodes in the construction site.	103	3.76	0.880	8
3.	Barcode advertising through social media, print media, and electronic media in the construction site.	103	3.98	0.874	5
4.	Improve the awareness of barcodes in the construction industry.	103	4.04	0.713	3
5.	Barcode technology provides professional solution services for the government.	103	4.10	0.774	1
6.	The government applies tax exemption to implement barcodes.	103	4.00	0.767	4
7.	Promote cooperation between government and construction industry by using barcode technical.	103	3.97	0.707	6
8.	Training staff for the development of barcode technical skills.	103	4.08	0.788	2
Average Mean			3.97		

From the table above, barcode technology provides professional solution services for the government to get the highest mean value in the ranking. Furthermore, barcoding deals with different kinds of departments and agencies of the government. The task is to provide government partners with a secure, cost-effective barcoding partner. In the face of tighter budgets, barcoding allows the

department to improve operating efficiency, satisfy directives to increase responsiveness and safety, and reduce costs (Bainbridge & Askew, 2017).

5. Conclusion

In conclusion, the main objective of this research is to investigate the advantages, challenges, and improved ways of barcoding implementation for improving materials tracking at the construction site. The research goals have been accomplished as concluded. During this analysis, there were a few challenges and limitations encountered by the researcher. The limitation is difficult to contact the respondent. Some of the respondents that have been missed and unanswered queries were an issue of data collection. This is because the respondent, who is not able to engage in this study as a result of rushing time to work and does not have any time to complete the questionnaire. Besides, the recommendation for the construction industry is engaged in process tracking for light and heavy equipment, machinery, vehicles, electrical appliances, components and construction parts. Due to the loss and theft of materials, this method can encourage the safety of the construction site. The inventory location can be tracked within 24 hours. However, the recommendations for future studies are offered to support this report. The following suggestion should be viewed and seen as a guide to the continuation of this research on automated equipment identification in the construction industry. This research uses an approach in this analysis, which was a quantitative process, where respondents are asked to fill out the research questionnaire by selecting the answer best to focus on their opinions on each topic.

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