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Effectiveness of dashboard as a work progress scheduling, monitoring, and decision-making in construction projects

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ABSTRACT

Scheduling, monitoring, and decision-making are important factors in determining the general achievement of sustainable construction. Therefore, this study was conducted to determine the effectiveness of a dashboard as a measuring tool for construction project scheduling, monitoring, and decision-making. A survey with a Likert scale (5 scale) on each viewpoint, including planning, oversight, and independent direction, of 15 respondents from project executors and 7 respondents from supervisors was used as instrumentation. The results showed that the dashboard was evaluated with a value of 92.25 among executors and supervisors linked to product characteristics. Executors also used the scheduling dashboard with a value of 91.73, and the feature of employing the concept for supervision was appropriate as a measuring instrument, scoring 92.15. Furthermore, the final step was the aspect of using the dashboard for decision-making, which was tested and used with a value of 88.14. The use dashboard model is an effective tool for work progress scheduling, monitoring, and decision-making in construction projects.

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1. INTRODUCTION

Incorporating sustainability concepts into project planning, design, construction, and management is an essential social obligation of construction enterprises [1]. The concept has gained attention in recent years since the construction industry has a negative influence on the environment, and green construction [2], [3]. The future of the built environment is heavily reliant on sustainability, which has become a main topic of discussion in the area [4], [5]. Over the years, there has been an increase in demand for new constructions and assets as a result of increasing modernization [6]. Scheduling strategies are one of the most essential aspects of construction sustainability, which can significantly lower project costs by decreasing wastes such as inventory holding fees, penalties for missing deadlines, and other building delays [7].

Scheduling is the most important part of decision-making [8]. One of the primary goals of project supervisors is to complete construction within a certain time frame [9]. Therefore, the development firm requires an accurate booking and control plan to explore work execution. The digital era requires all surveillance platforms to be digitized [10]. Organizing a development project is critical as the first step in starting work [11]. Controlling work delays is conducted to ensure that the planned concept is completed according to the budget, quality, and details [7]. To overcome delays in development execution, several measures were taken, including increasing the number of workers, adding extra time hours, conducting accident programs, adding equipment, and changing the approaches used [12].

To support the decision system database and the integration of all cross-data unit services within a more efficient organization, a project supply chain management system that reduces cost, process, and product development time is required [7]. The strategy for overcoming development work delays necessitates abilities and experience. To complete project management by using computerized proficiency, mechanical education, and human education that prompts advanced use focusing on artificial intelligence (AI) in the modern period [10], [12].

Efficient operation planning and scheduling within the off-site construction supply chain is crucial for project completion [13]. A project management tool is important in sustainable construction [14]. Microsoft Project has been the most popular project management application, and supervisors use Microsoft Project to create timelines and project plans, manage resources, and measure time [14]. Implementing project planning and monitoring tools reduces building costs and allows for shorter development times [15]. This study estimates the apparatus by applying a dashboard model for work progress monitoring, scheduling, and decision-making in project construction. Furthermore, it considers the effectiveness of dashboard estimation tools in project booking, development project management, and independent direction. The implementation of a dashboard model for construction management is expected to speed up the construction process to achieve sustainable development.

2. RESEARCH METHOD

2.1. Study design

In this study, the analyze, design, develop, implement, and evaluate (ADDIE) paradigm was employed [16], which had five stages, namely analysis, design, development, implementation, and evaluation. The dashboard was created by development administration firms in Medan who were members of the Association of Indonesian Project Scheduling Experts (PAPPI). The following exercises were completed during the execution stage: i) leading project control official preparation on the dashboard from five hired workers, ii) providing support for member preparation, and iii) information gathering through meetings and surveys, identified with dashboard items, using the dashboard for planning exercises, observing exercises, and independent direction.

The validity was determined by the correctness of the content and assistance from project booking professionals. The assessment stage was intended to offer input to the development entertainers to implement corrections for forgotten criteria. Based on the survey and meeting information analysis, the end purpose of this evaluation phase is to assess the usefulness of dashboard estimation tools for scheduling, monitoring, and dynamic activities on development projects.

2.2. Instruments

The survey was taken in a construction project located in Medan City, Indonesia. The instrument used is a survey with a Likert scale (5 scale) on each viewpoint, including planning, oversight, and independent direction, of 15 respondents from project executors and 7 respondents from supervisors. The survey data were examined objectively, while the meeting data were evaluated subjectively, and the questionnaire is presented in Table 1.

Table 1. Research questionnaire

	Product aspect	Scheduling	Monitoring	Decision-making
A	Design view	Suitable for scheduling	Suitable for monitoring	Precise and smooth
B	Accessibility	Suitable for the creation of a summary	Monitor the weekly evaluation	Presents information data
C	Usage understanding	Can find out the evaluation schedule	Displays actual job evaluation information	Data estimation for project completion
D	Information presentation	Displays plan data and schedule realization data	Easy to read	Present data on the actual cost of work
E	Quick display of results	Displays the project cost budget planning	Timely data comparison	Displays the progress deviation
F	Availability of features	Describe the work schedule in detail	Displays the deviation of the plan	Displays schedule status for decision-making
G	Indicator display	Links dependencies between activities clearly	Displays milestones as a target control	Displays the actual cost deviation for decision-making
H	Serving proportional features	Inform the resources involved	Displays completion time information during review	Displays the deviation of the completion time
I	Integration of features with scheduling	Sufficient for one project schedule	Displays the progress deviation	Displays resource information for decision-making
J	Update features on the results of the schedule evaluation	Describe the duration of the work in detail	Displays the actual weight of work clearly	Display job information clearly for decision-making

3. RESULTS AND DISCUSSION

3.1. Dashboard interface

Figure 1 depicts the dashboard interfaces for project scheduling, monitoring, and decision-making. The project data are displayed at the top of the interface to help workers understand the type of work being performed. The contract value and progress value are, and progress percentage listed in the center of the table. Also, next to the middle table, there are two graphs shown in the interface. The graph on the left depicts the overall project progress curve. The right graph depicts the curve's position at the time of week 15 evaluation. For the decision-making process, with the number of days of delay displayed on the dashboard, management can search for appropriate acceleration activities or strategies to catch up with the delay. For example, if the time is only 3-7 days, it may be sufficient to do overtime; but, if the time exceeds 7-14 days, it may be possible to add a work team (group); however, if the time surpasses 14 days, it may be possible to change the work sequence or carry out a new strategy by adding tools. For the monitoring process, at the bottom of the interface, there are numbers that show the project's status: time deviation and delay time. Due to their inherent dynamic and unique nature, construction projects are frequently exposed to high degrees of uncertainty, which can create schedule delays and budget overruns [17]. A well-designed visualized dashboard could provide intuitive information to construction project managers for improved decision-making [18].

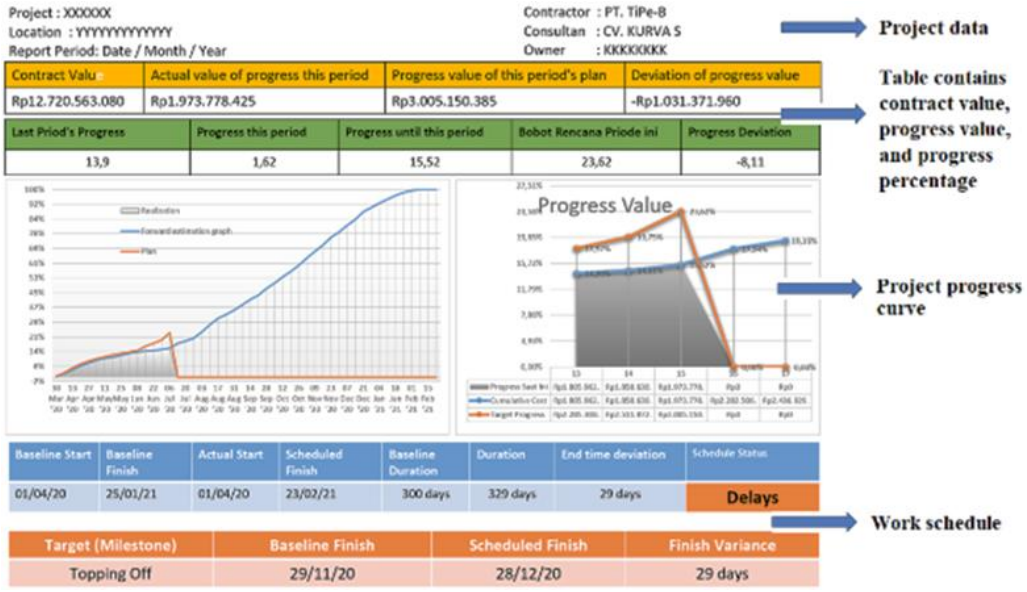

Figure 1. Dashboard interface

3.2. Dashboard product aspect

Figure 2 shows that the score of each viewpoint on the dashboard product aspect and project executors has a value of more than 75, as shown in Figure 2(a). The viewpoint of (displays result quickly: 1-G) has the highest final score of 93.33 with a Likert score of 70. Meanwhile, the viewpoint of 1-B and 1-H has the lowest final score of 88.00, and the components of the assessment can be approved. Similar to executors, the dashboard aspect is also approved by supervisors, as shown in Figure 2(b), with a total score higher than 35. The viewpoint of 1-A, 1-D, 1-I, and 1-J has a similar score to other viewpoints described, where the dashboard product has a good design and accessibility, is integrated with the schedule, and is up to date on the schedule evaluation process. Construction management software easy to use could help businesses increase output while also giving value to customers [19].

3.3. Dashboard for scheduling

Figure 3 shows the score of each viewpoint on the use of a dashboard for project scheduling. The value of each viewpoint is higher than 75, as shown in Figure 3(a), indicating that the components of the assessment can be approved. The viewpoint of 2-A (suitable for scheduling activity) has the highest score of 92.00. The score is higher than the criterion of 75, but the viewpoint of 2-E and 2-L has the lowest final score of 86.66. Similar to executors, the dashboard aspect is also approved by supervisors, as shown in Figure 3(b), with a total score higher than 35. The viewpoint of 2-B and 2-G has similar highest score (97.14) compared

to others, indicating that the dashboard product is suitable for the creation of a project schedule summary and links dependencies between activities.

Project control and the accuracy of progress reporting are crucial aspects of a project, allowing planners to notice any variation between planned and actual progress to measure and ensure that the project is still within time, quality constraints, and cost [20], [21]. Based on the result, the dashboard design model falls between analytical and operational types. The design characteristics depend on the needs and roles of the dashboard [22]. In the construction industry, the dashboard can be used to monitor many types of data, functionality, and information, as well as to achieve project objectives. It helps supervisors identify trends and patterns of progress [7]. Monitoring the work progress to enable adherence to project schedules and budgets is the most highly valued performance metric [23].

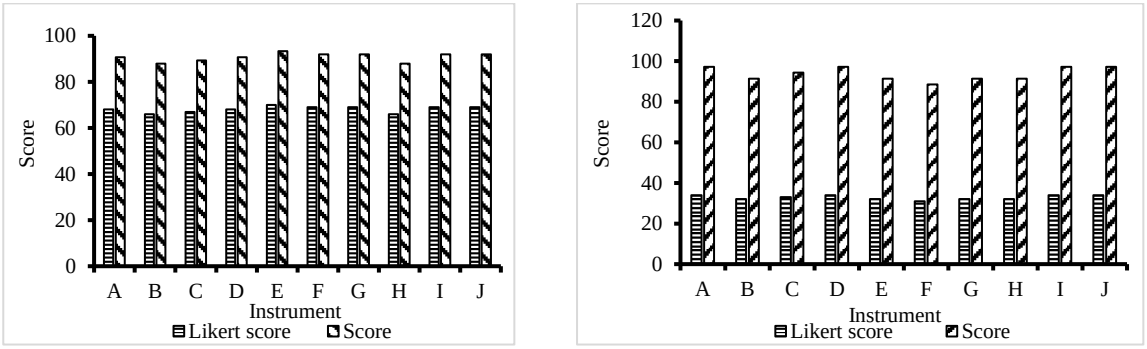

Figure 2. Score of each viewpoint on product aspect of (a) project executor and (b) project supervisor

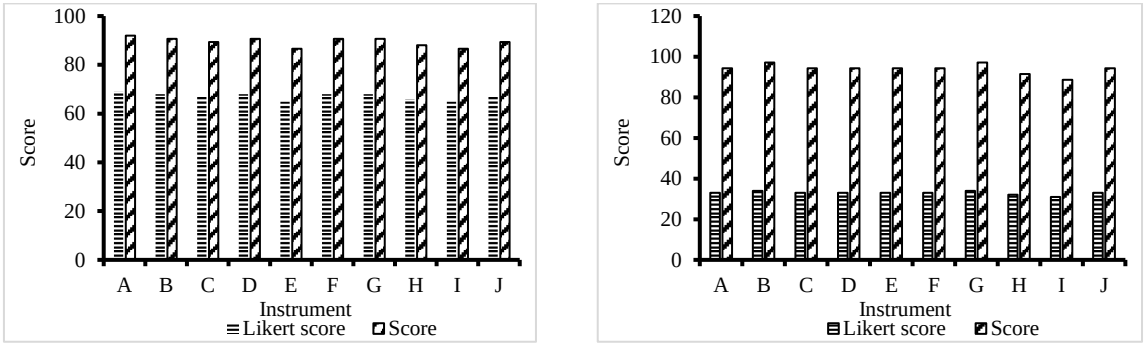

Figure 3. Score of each viewpoint on project scheduling of (a) project executor and (b) project supervisor

3.4. Dashboard for monitoring

Figure 4 shows the score of each viewpoint on the use of a dashboard for project monitoring. Similar to the aspect and project scheduling, the value of each viewpoint from interviews was higher than 75, as shown in Figure 4(a), representing all components of the assessment. The viewpoint of 3-B has a higher score (93.33), indicating the dashboard can monitor the weekly evaluation of the project schedule. The score is higher than the criterion of 75, but the viewpoint of 3-J has the lowest final score of 85.33. Similar to executors, the aspect is also approved by supervisors, as shown in Figure 4(b), with a total score higher than 35. The viewpoint of 3-C, 3-D, 3-H, and 3-I has the highest score of 97.14, indicating dashboard product can display actual job evaluation information data, is easy to read, and displays completion time information during the review.

Project monitoring plays a crucial role in the successful completion of projects and is a symbol of excellence in the field of construction [21], [24]. The temporal demands and susceptibility to human fallibility inherent in manual and conventional monitoring processes can be mitigated through the use of an integrated dashboard [24]. The monitoring of project advancement on-site assumes significance, engendering a precise and punctual evaluation of the progress of work [25]. This practice empowers senior management to effectuate timely adjustments in instances where project advancement veers from the preordained timetable [26], [27]. Dashboard, functioning as an electronic tool for project management, expedites the dissemination of

information to both construction teams and stakeholders. The manual monitoring practices entrenched in progress measurement methods necessitate physical human presence and a protracted temporal investment.

Dashboard provides a reliable monitoring system to enable a transparent, clear, and precise view of the tasks by collecting and exposing a user-centric set of information [28]. Therefore, the design model layout should be friendly, concise, and simple to use, and allow decision-makers 130 to focus on relevant and important information. A good dashboard can display all relevant information on a single screen without the need for scrolling or switching between multiple screens.

A previous study [27] on construction performance monitoring through still images, time-lapse photos, close-range, aerial site images, and laser scanners, timely and accurate on-site construction operations can bring immediate awareness of project status and issues to be resolved immediately. Since traditional construction progress monitoring is time-consuming, costly, and prone to error, manual data collection lacks accuracy. Monitoring is carried out to determine when projects are running on schedule, behind schedule, and critically delayed.

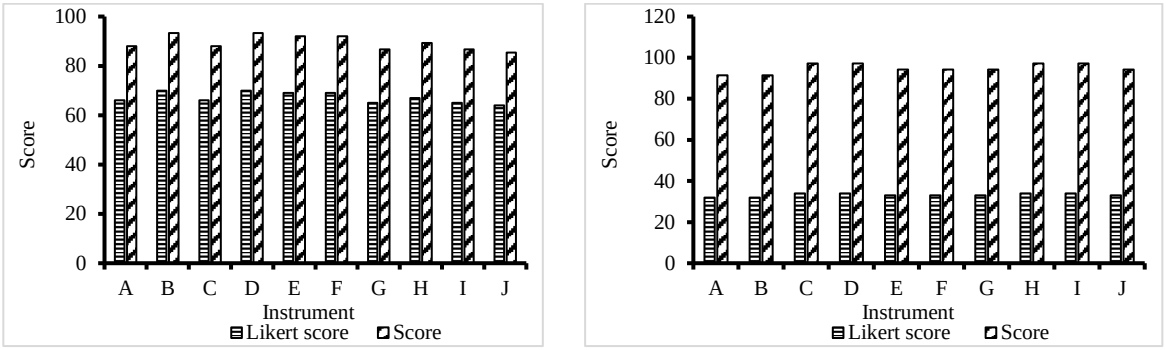

Figure 4. Score of each viewpoint on project monitoring of (a) project executor and (b) project supervisor

3.5. Dashboard for decision-making

In Figure 5, the depicted data shows the assigned scores for each viewpoint concerning the use of a dashboard in the context of project decision-making. In alignment with project scheduling and monitoring, the significance attributed to each viewpoint substantially exceeded the threshold of 75, as shown in Figure 5(a). This observation underscores the comprehensive coverage of all assessment components. Meanwhile, the viewpoint labeled 4-C garnered the highest score of 93.33, indicative of the effectiveness in facilitating a weekly appraisal of the project schedule.

Despite surpassing the minimum criterion score of 75, the viewpoint designated as 4-I attained the lowest cumulative score of 76.00. Mirroring the perspective of executors, the aspect of the dashboard also garnered endorsement from supervisors, as indicated in Figure 5(b), obtaining an aggregate score above 35. The viewpoints denoted as 4-D and 3-F secured the most elevated scores of 97.14, underscoring the proficiency in precise data on actual work costs and effectively presenting schedule statuses, facilitating informed decision-making processes.

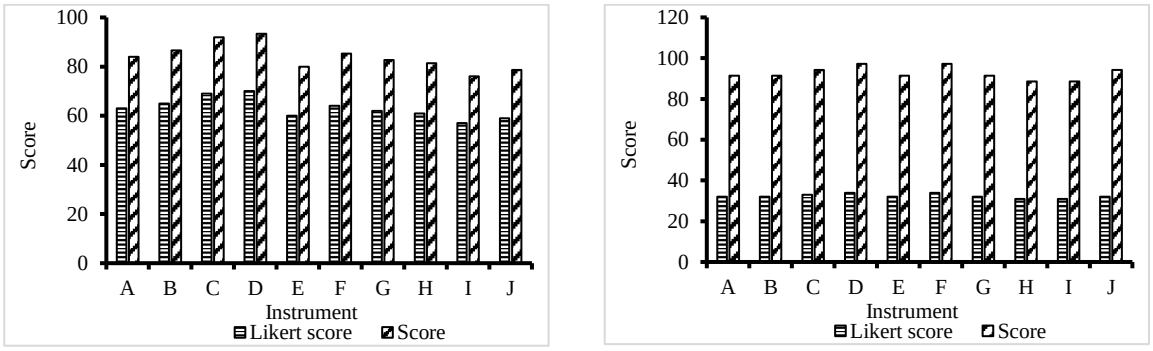

Figure 5. Score of each viewpoint on decision making of (a) project executor and (b) project supervisor

The design should address how information is captured, modeled, and displayed on the screen. Dashboard is a paperless project monitoring tool that enables the management team to know its status and make rapid decisions. The design should be user-friendly, easy to understand, and provide effective progress monitoring with consistent measurements [29]. The dashboard model is an important element in development and is considered part of the communication tools between data and knowledge. In the geospatial dashboard, technologies such as user-oriented, visualization perception, and visual media are important elements to be considered [23]. The selection and organization of display media, such as graphs, charts, tables, and drawings, contribute to the practices in the design model [30]. A dashboard is a visual display of the most important information inherent to achieving objectives, data consolidation into one concept, and arranged on a single screen to provide quick information and monitor project status [31].

3.6. Studies in dashboard tools

Much research has been conducted to evaluate the dashboard tools in project planning, monitoring, and decision-making, as shown in Table 2. The majority of the present literature on dashboards for construction projects has focused on the development and optimization of dashboards for construction management to improve their accuracy in practice [32]–[34]. Other studies [35], [36] showed the actual application of dashboards, such as performance assessment on building projects, using these digitally visible tools. Also, a study investigates the impact of dashboard information load and user cognitive style on cognitive load for construction-related activities [18]. This study concludes that a dashboard that has a good design, quick display, and proportional features improves activity for scheduling, monitoring, and decision-making.

Table 2. Studies on the use of dashboards in construction projects

Theme	Finding	Reference
Project status dashboard for construction project progress reporting	Accurate and regular progress reporting of construction projects enables the project management team to know the status of their project and to make informed decisions.	[34]
A zoomable location-based dashboard for construction management	Specific visualization can improve the dashboard's accuracy.	[32]
Performance analysis of an entity from the construction sector using the dashboard	Performance analysis of economic entities in a building project using a dashboard to demonstrate the long-term advantages of its decisions	[36]
Early warning dashboard for advanced construction planning metrics	The dashboard demonstrated the potential to measure project performance areas beyond the capacity of previously available planning metrics when applied to data from two building projects.	[33]
Using data analytics and visualization dashboards for engineering, procurement, and construction project performance assessment	The dashboard assists managers in planning their workload to guarantee that projects are completed on time and that client demands are met as planned.	[35]
Graphical features of interactive dashboards have little influence on engineering students performing a design task.	Dashboards should be constructed with minimal features to convey the necessary information, and interactive dashboards highlight the gap between objective performance and user-assessed performance.	[37]
Effect of information load and cognitive style on the cognitive load of visualized dashboards for construction-related activities	A well-designed visualized dashboard could provide intuitive information to construction project managers for effective decision-making.	[18]
Effectiveness of dashboard model development for work progress scheduling, monitoring, and decision-making in construction projects	Well-designed dashboard improves activity for scheduling and monitoring activities, as well as the employment for decision-making.	This study

4. CONCLUSION

The inclusion of the product for scheduling and monitoring activities, as well as the employment for decision-making, was collectively indicative of the integration of the accessible dashboard within the application. The use of a dashboard was accessible in the application for oversight of the development project work. Subjectively, executors and supervisors tried the item with quantitative test results averaging 91.06.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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Nathanael Sitanggang	✓	✓		✓			✓			✓	✓	✓	✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors state no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [PLAL], upon reasonable request.

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