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# Readiness Assessment in Adopting Digital Inventory Technology: Basis for an Implementation Plan of Modular Casework Delivery in High-Rise Condominium Projects in Metro Manila

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## Abstract

Efficient material management is critical in high-rise condominium projects, particularly in modular casework delivery where bulk shipments, limited staging areas, and manual inventory practices often result in inaccuracies, delays, and wasted resources. Casanuova Inc., a Metro Manila–based construction firm, faces these challenges and requires a practical digital solution. This study employed a descriptive–correlational design to assess material management challenges and employee readiness to adopt QR code–based digital inventory systems. A near-census approach was used, with 40 respondents representing site engineers, warehouse staff, installers, and project managers. Data were gathered through a structured survey grounded in the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT), measuring constructs such as perceived usefulness, ease of use, social influence, and facilitating conditions. Findings revealed systemic material management issues, particularly in inventory accuracy, traceability, and manpower utilization. Employees demonstrated high readiness and acceptance of QR technology, with perceived usefulness and ease of use emerging as the strongest predictors of adoption. However, moderate scores for social influence and lower ratings for facilitating conditions highlighted organizational gaps requiring managerial reinforcement and structured training. A statistically significant relationship was found between readiness levels and perceived improvements in material management outcomes. The study confirms that QR code–based systems provide a cost-effective, mobile, and context-sensitive solution for modular casework delivery. The proposed phased implementation plan, which was validated by experts, emphasizes preparatory training, pilot testing, and continuous monitoring to ensure successful adoption. By integrating TAM and UTAUT insights with supply chain frameworks, the study offers Casanuova Inc. a practical pathway to enhance accuracy, accountability, and efficiency in high-rise construction projects.

**Keywords:** construction material management, QR codes, modular casework, Technology Acceptance Model, UTAUT, supply chain performance, digital inventory systems

## INTRODUCTION

The success of construction projects depends heavily on how well materials are managed, as these account for a large portion of overall project expenses. In the Philippines, where high-rise condominium developments are rapidly increasing due to urbanization and population growth, companies face the pressing challenge of ensuring that material handling and inventory systems are efficient, accurate, and sustainable. In high-density urban construction, particularly vertical residential developments, material management is further constrained by limited space, restricted movement, and tight installation schedules. Material management practices significantly influence site productivity, and effective handling and storage of materials directly improve overall project efficiency (Yıldız, 2024).

Inefficient material management results in project delays, cost overruns, and wastage. These are factors that negatively affect both company performance and client satisfaction. Materials may represent more than 50 percent of a project's total cost, and poor management can lead to execution delays, excess waste,

reduced productivity, and inflated costs. These risks are amplified in projects nearing completion, where errors in material delivery and allocation can immediately disrupt installation activities and extend project timelines. This cascade of issues ultimately undermines project outcomes and stakeholder satisfaction (Rodríguez, 2022).

Casanuova Inc. is a construction firm specializing in modular casework systems for high-rise condominium developments in Metro Manila. Established in 2016, the company focuses primarily on interior finishing works for vertical residential projects, often entering construction sites during the final phases of development. The company supplies and installs prefabricated interior components designed for large-scale residential projects. The rising popularity of prefabricated casework, commonly referred to as modular cabinets, is widely attributed to its reduced onsite works, minimal wastage, and rapid installation. While modular casework offers efficiency in terms of mass production and streamlined installation, it also presents challenges in material handling and inventory. Components are often delivered in bulk packages, making precise tracking essential to ensure that correct materials are delivered to the proper place at the needed time. A slight delay due to logistical errors will greatly impact its advantage. In practice, Casanuova Inc. operates under strict time and space constraints, as many project sites have no permanent on-site warehouse and only allow a small temporary staging area for unloading. Relying on manual methods of inventory management has made it difficult to maintain accuracy, often resulting in misplaced items, reporting inconsistencies, and delays that affect overall project performance.

It is important to note that modular construction in Casanuova Inc. refers to modular cabinets for interior systems, not large structural modules such as precast walls. While the components are relatively smaller in size, they are delivered in bulk quantities, in the range of thousands, and divided into numerous pieces per unit, creating complexity in inventory tracking and

management. In high-rise condominium projects where some floors or units may already be operational, unloading activities are often rushed and highly regulated, increasing the risk of misplacement and incorrect allocation of materials. Due to the absence of sufficient staging areas, materials are ideally delivered directly from container trucks to their designated units or floors, leaving little room for error in tracking and documentation. Here is where the digital solution comes into play.

Globally, firms in the construction industry have started adopting digital technologies to address such challenges. Recent studies highlight that Quick Response (QR) code–based systems offer a low-cost and accessible method for material tracking, since they can be scanned directly with smartphones and quickly integrated into site workflows (Byers, Cheriyamulla, Ewason, Hall, & De Wolf, 2022). Compared with more complex systems such as RFID, GIS, or fixed scanning infrastructure, QR technology supports mobility, rapid deployment, and minimal training—features particularly suitable for temporary, fast-moving construction environments. For firms like Casanuova Inc., which rely on construction workers with varying levels of technological exposure, QR scanning offers a practical digital solution that leverages readily available mobile devices without requiring significant capital investment. In addition, QR-based inventory systems promote paperless documentation, supporting the company's commitment to sustainability and environmentally responsible construction practices.

Integrating similar digital solutions into construction inventory systems presents an opportunity for companies like Casanuova Inc. to address recurring inefficiencies without the immediate need to develop costly custom software. Rather than functioning as a long-term asset management platform, technology-based tracking supports accuracy and speed in short-duration, high-volume material movements typical of modular interior works. This study therefore seeks to assess material management challenges and employee

readiness for digital inventory adoption and to propose an implementation plan digital solution for improving accountability, transparency, and project control in Casanuova Inc.'s modular casework delivery operations.

Theoretical Framework. This study is grounded in established theories of technology adoption that explain how individuals and organizations accept, use, and derive value from digital systems in operational contexts. The primary foundation is the Unified Theory of Acceptance and Use of Technology (UTAUT), which synthesizes constructs from earlier models to explain behavioral intention and usage behavior. UTAUT identifies performance expectancy, effort expectancy, social influence, and facilitating conditions as determinants of adoption, making it particularly relevant in construction environments where perceptions, peer influence, and organizational support shape technology use (Nnaji et al., 2023a). Complementing this, the Extended Technology Acceptance Model (Extended TAM) emphasizes perceived usefulness and ease of use, with Sorce and Issa (2021) showing that construction personnel adopt digital tools when they improve efficiency and integrate seamlessly into workflows. This perspective supports the study's focus on digital inventory technology in modular casework operations, where speed, accuracy, and minimal disruption are critical. Beyond behavioral acceptance, digital construction supply chain frameworks highlight that adoption should enhance coordination, traceability, and accountability, with recent literature noting that digital identification and tracking tools improve visibility and control in fragmented, time-sensitive supply chains. Collectively, UTAUT, Extended TAM, and supply chain perspectives provide an integrated framework linking employee readiness with operational improvement, ensuring theoretical rigor and practical applicability.

Conceptual Framework. The conceptual framework of this study is anchored on the integration of digital asset and inventory technologies to enhance material management in construction, guided by the Unified Theory of Acceptance and Use of Technology (UTAUT), the Extended Technology Acceptance Model (TAM), and supply chain management perspectives. Using an Input–Process–Output (IPO) model, the framework illustrates how data on material management challenges and employee readiness serve as inputs, which are processed through surveys, statistical analysis, and technology preference assessments, ultimately producing a proposed implementation plan. UTAUT emphasizes performance expectancy, effort expectancy, social influence, and facilitating conditions as determinants of adoption (Nnaji et al., 2023a), while Extended TAM highlights perceived usefulness and ease of use, particularly in workflow-driven construction contexts (Sorce & Issa, 2021). These theories ensure that employee perceptions and organizational realities are central to the analysis. The output, a digital technology-enabled implementation plan for Casanuova Inc., aims to improve inventory accuracy, manpower efficiency, and coordination among procurement, logistics, and on-site operations. It also enhances data visibility for managerial decision-making through systematic reporting and monitoring. By combining behavioral acceptance theories with supply chain perspectives, the framework ensures theoretical rigor and practical applicability in high-rise condominium project management.
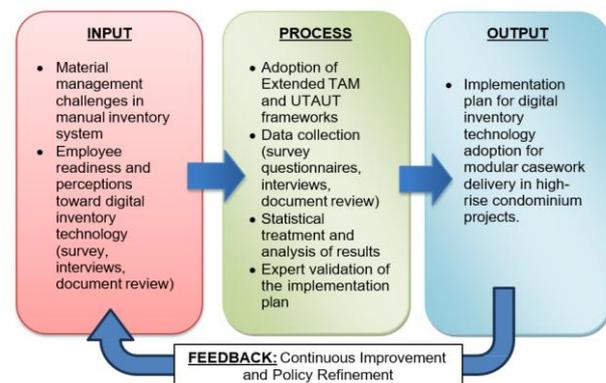


Figure 1
*Research Paradigm of the Study*

**Statement of the Problem.** Despite the operational advantages of modular casework, Casanuova Inc. continues to encounter

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persistent material management challenges in its high-rise condominium projects in Metro Manila. These challenges are intensified by the nature of modular casework delivery, which involves bulk shipments of fragmented components, limited on-site space, restricted movement during interior finishing stages, and the absence of permanent warehouse facilities. The continued reliance on predominantly manual inventory and tracking practices has raised concerns regarding accuracy, efficiency, accountability, and overall project control.

In response to these concerns, this study seeks to assess the current condition of material and inventory management practices at Casanuova Inc., evaluate employee readiness for adopting digital inventory solutions, and develop a practical implementation plan that leverages digital technology to improve material tracking and accountability. Specifically, the study aims to answer the following questions:

1. What are the current challenges of manual inventory method for modular casework delivery in high-rise condominium projects in Metro Manila, in terms of:
   1.1 Inventory Accuracy;
   1.2 Material traceability and visibility;
   1.3 Site coordination and reporting;
   1.4 Delivery timelines;
   1.5 Phased delivery for prefabricated components;
   1.6 Vertical logistics and tracking oversight; and,
   1.7 Manpower utilization?

2. What is the level of employee readiness and acceptance toward adopting digital inventory technology as measured through the following constructs:
   2.1 Perceived usefulness;
   2.2 Perceived ease of use;
   2.3 Social influence; and,
   2.4 Facilitating conditions?

3. What digital asset and inventory technology is preferred by Casanuova Inc. employees in terms of:
   3.1 Inventory control;
   3.2 Material tracking; and,
   3.3 Logistics management?

4. Is there a significant relationship between employee readiness to adopt digital inventory technology and the perceived improvement of material management system?

5. What digital technology-enabled implementation plan can be proposed to support accurate, efficient, and accountable material and inventory management in modular casework delivery for high-rise condominium projects?

**Null Hypothesis.** There is no significant relationship between employee readiness to adopt digital inventory technology and the improvement of the company's material management system.

**Scope and Limitations of the Study.** This study focused on Casanuova Inc. personnel directly engaged in material inventory management for modular casework delivery in high-rise condominium projects in Metro Manila, including project managers, engineers, consultants, QA/QC staff, safety officers, site leadmen, installers, and warehouse staff, as they represent critical control points in material flow such as receiving, storage, transfer, and installation. To avoid bias, the Operations Head, who also served as the researcher, was excluded from the respondent pool. The scope emphasized challenges of manual inventory methods, specifically inventory accuracy, material traceability and visibility, site coordination and reporting, delivery timelines, phased delivery of prefabricated components, vertical logistics oversight, and manpower utilization. It also examined employee readiness and acceptance of digital inventory solutions, framed by constructs of perceived usefulness, ease of use, social influence, and facilitating conditions from TAM and UTAUT. The study did not involve developing or testing actual software systems nor evaluating long-term financial returns, but was limited to assessing current practices, readiness, and formulating a

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proposed digital technology-enabled implementation plan based on surveys, interviews, and document reviews. This plan aims to guide managerial decision-making and process improvement rather than serve as a fully engineered solution. While findings are context-specific to Casanuova Inc., insights may apply to other firms facing similar constraints, though generalization beyond comparable settings requires caution.

**Significance of the Study.** Efficient material management is vital to the success of construction projects, especially in high-rise condominium developments where modular components must be delivered and tracked under strict time and space constraints. This study is significant because it addresses recurring issues of accountability, accuracy, and coordination in modular casework delivery by proposing a digital technology-based material management system. Recognizing that most target users are ordinary site workers with limited exposure to advanced technology, the study emphasizes practicality, scalability, and affordability rather than complex solutions. By aligning with operational realities of interior finishing works, the proposed system offers a low-cost yet effective approach to improving inventory tracking and coordination, ensuring that construction processes remain efficient and manageable within the demanding environment of high-rise projects.

For Casanuova Inc., the study provides a structured plan to address weaknesses in manual inventory practices, including accuracy, traceability, visibility, coordination, and labor-intensive processes. The implementation plan aims to reduce material losses, minimize rework and delays, optimize manpower utilization, and improve decision-making through reliable inventory data, thereby enhancing project control, cost efficiency, and client satisfaction. For the construction industry, the findings serve as a reference for firms facing similar challenges, encouraging wider adoption of digital inventory solutions that improve transparency and accountability. For the academe, the study contributes to

literature by linking TAM and UTAUT theories to real-world challenges, while future researchers may validate or expand the plan through pilot testing or comparative studies. Ultimately, the research highlights measurable improvements in KPIs such as accuracy, delivery coordination, and manpower efficiency, bridging theoretical models with practical digitalization strategies in construction management.

## LITERATURE REVIEW

Effective material management is a critical determinant of construction project success, directly influencing cost efficiency, schedule reliability, and quality performance. Empirical studies confirm that practices in material supply, handling, stock control, and waste management significantly affect outcomes, with Yıldız, Güneş, and Kıvrak (2024) showing that coordinated systems enhance time efficiency, cost control, and quality delivery, positioning material flow as a core operational function. Challenges often emerge during execution, where weaknesses in inventory discipline and information flow manifest as stock discrepancies, inaccurate records, delivery delays, waste, and misplacement—issues linked to manual or fragmented tracking. With materials accounting for 50–60% of project costs, inefficiencies can cascade into major overruns and delays (Yıldız et al., 2024; Rathinakumar et al., 2025). Sila (2021) further emphasized that poor inventory practices lead to damaged materials, weak procurement planning, and untimely deliveries, jeopardizing completion and quality. While literature often focuses on large modular components, fewer studies address fragmented modular casework systems. In contexts like Casanuova Inc., where numerous interior parts must be tracked across multiple floors, complexity intensifies, highlighting a gap in research and the need for digital tracking solutions tailored to modular casework environments.

**Material Management as a Core Component of Construction Project Control.** Material management is increasingly recognized in

construction literature as a core component of project control rather than a peripheral logistical task, particularly in complex and fast-paced environments. Within frameworks such as the Project Management Body of Knowledge (PMBOK), it integrates closely with cost, procurement, and resource management, ensuring oversight of material flows, expenditures, and schedules (Wayrah et al., 2021; Nnaji et al., 2024). This integration supports proactive decision-making and minimizes risks of shortages, delays, and waste. Lean Construction principles further emphasize waste reduction and flow reliability, showing that aligning inventory practices with Lean methodologies improves productivity and efficiency (Wang et al., 2011). Similarly, Integrated Project Delivery (IPD) fosters collaboration and real-time adjustments to material decisions (Alaloul & Qureshi, 2021). Digital technologies such as RFID, IoT monitoring, and inventory platforms enhance transparency and accountability, enabling real-time tracking and coordination across procurement, logistics, and site operations (Chubin, 2024; Zhelezniak, 2025).

Material management is also tied to risk management, as material-related risks directly affect cost and schedule performance. Cost–benefit analyses weigh bulk purchasing against risks of storage costs, damage, and waste (Wolf et al., 2024; Wang et al., 2011). Just-in-Time (JIT) delivery reduces holding costs and congestion but requires accurate tracking and reliable logistics (Alaloul & Qureshi, 2021). Effective supply chain coordination, supported by digital tracking, ensures workflow continuity and visibility, especially in modular and multi-floor projects (Morganti et al., 2023). Emerging technologies like AI and machine learning extend capabilities by enabling predictive planning and optimized resource allocation (Sardroud & Limbachiya, 2010; Khomenko et al., 2025). For Casanuova Inc., where modular casework involves fragmented materials and strict schedules, digital inventory management is a strategic tool for oversight, risk reduction, and coordination. Thus, literature confirms material management as a managerial control

mechanism, justifying its central role in the proposed implementation plan aligned with established construction management principles.

**Inventory Control Systems in Modular and Prefabricated Construction.** Inventory control in modular and prefabricated construction is a critical challenge due to the complexity of logistics, fragmented deliveries, and limited buffer capacities, issues that closely mirror Casanuova Inc.'s experiences. Zohourian, Pamidimukkala, and Kermanshachi (2025) highlighted transportation complexity, limited design flexibility, and high initial costs as common hurdles, which resonate with Casanuova's struggle to manage prefabricated components across high-rise structures. Capuyan (2024) emphasized the importance of Integrated Project Delivery (IPD) in Philippine modular construction, showing that collaboration among stakeholders improves supply chain management and reduces discrepancies. International frameworks also provide valuable insights: Liu et al. (2023) proposed a digital twin platform integrating BIM, IoT, and GIS to simulate logistics flows and detect deviations in real time, while Xiong (2025) confirmed that prefabricated systems reduce costs and time but require efficient tracking to realize these benefits. Zohourian (2025) further quantified modular advantages—50% shorter construction time, 20% cost reduction, and up to 83% less waste—yet reinforced that success depends on precise logistics and inventory control.

Transportation and logistical coordination remain central concerns, as Salari et al. (2022) noted that bulky components prevent contractors from maintaining large buffer stocks, increasing risks of misplacement and delays. Digital strategies offer solutions: Liu et al. (2023) demonstrated BIM–IoT–GIS integration for accurate module arrival tracking, while Fieldwire (2024) showcased agile tracking of millions of parts, reducing reporting time and confusion. The AIA's practice guide (2019) also stressed BIM's role in coordinating off-site and on-site operations,

yielding efficiency gains in schedules and costs. For Casanuova, where modular casework involves fragmented deliveries across multiple floors, QR-based inventory tracking emerges as a pragmatic first step toward digitalization, offering real-time visibility without requiring advanced infrastructure. Collectively, these studies confirm that while modular construction promises efficiency, its success hinges on robust inventory systems. By adopting QR-based tracking, Casanuova can strengthen oversight, reduce risks, and align with global best practices, positioning digital inventory control as a strategic enabler of project efficiency and accountability.

**Digital Technology in Construction Material Management.** Digital technologies are reshaping construction material management by addressing inefficiencies in manual inventory systems and supporting the demands of complex, time-sensitive projects such as high-rise and modular construction. Tools like RFID, QR codes, and IoT-enabled tracking systems enhance identification, monitoring, and control of materials, reducing waste and logistical errors while improving schedule adherence (Xu et al., 2021; Lee & Lee, 2021).

Table 1
*Comparison of Digital Inventory Technologies Used in Construction Material Management*

| Technology | Key Features | Advantages | Limitations | Suitability for Modular Casework |
|---|---|---|---|---|
| QR Codes | Mobile scanning, low-cost | Easy to use, flexible, no infrastructure | Requires manual scanning | High |
| RFID | Automated scanning | Fast, no line-of-sight | Expensive, fixed readers | Moderate |
| IoT | Real-time sensing | Continuous monitoring | High cost, infrastructure-heavy | Low–Moderate |
| BIM-linked systems | Visual integration | Planning & coordination | Not real-time on site | Supportive only |

Table 1 illustrates the comparative features of these technologies, showing QR codes as the most practical option due to their low cost, ease of use, and reliance on smartphones, which makes them highly adaptable to temporary and mobile construction environments. RFID and IoT systems, while offering automated scanning and continuous monitoring, require costly infrastructure and specialized hardware,

limiting their suitability for fast-moving projects. BIM-linked systems, particularly when integrated with Digital Twin technology, provide dynamic, real-time asset representations that support proactive decision-making and logistics planning (Sepasgozar et al., 2023; Saad et al., 2023). However, their dependence on complementary tools for on-site visibility reinforces the practicality of QR-based systems for modular casework delivery, aligning functionality with operational constraints.

Beyond technical capabilities, organizational and behavioral factors significantly influence technology adoption. Employee readiness, management support, and training availability determine acceptance, with technologies perceived as useful, easy to use, and backed by leadership being more readily integrated into workflows (Ammar & Nassereddine, 2022; Hatoum & Nassereddine, 2024). Lessons from retail and logistics sectors highlight the effectiveness of combining mobile scanning, real-time tracking, and Just-In-Time (JIT) delivery models, which reduce site congestion and storage costs—critical in high-rise projects with limited staging areas (You & Feng, 2020; Lee & Lee, 2021). In the Philippine context, adoption remains gradual due to barriers such as limited training and organizational resistance, yet momentum is building through policy initiatives and industry efforts (Hatoum & Nassereddine, 2024). Table 1 underscores that QR codes, with their high suitability for modular casework, offer a cost-effective, flexible, and scalable solution that aligns with Casanuova Inc.'s operational realities. By supporting accuracy, speed, and mobility without requiring complex infrastructure, QR technology provides a feasible pathway for digital transformation in construction material management, directly supporting the study's focus on employee readiness and the development of a balanced, context-appropriate implementation plan.

**Technology Adoption Models in Construction.** Technology adoption models such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) provide strong explanatory

frameworks for understanding employee readiness in construction contexts. TAM emphasizes perceived usefulness (PU) and perceived ease of use (PEOU) as central determinants of adoption (Davis, 1989), while UTAUT expands this to include social influence and facilitating conditions (Venkatesh et al., 2003). Empirical studies confirm that usefulness and ease remain the strongest predictors of acceptance in construction ICT, mobile applications, and BIM platforms (Abbas et al., 2020; Alaloul et al., 2021). For Casanuova Inc., where QR technology is being introduced, these constructs are crucial: if employees perceive QR scanning as helpful and simple, adoption is more likely. Studies in Malaysia and Saudi Arabia highlight the importance of social influence, management support, and infrastructure in shaping behavioral intention (Alaloul et al., 2021; Abbas et al., 2020), while local research in the Philippines reinforces that organizational support and training are decisive factors (Mata, 2024; Dimaculangan, 2023a). Thus, embedding QR adoption within a supportive organizational framework is essential to overcoming resistance and ensuring readiness.

Further extensions of TAM and UTAUT highlight additional behavioral dimensions relevant to construction. Hewavitharana et al. (2021) emphasized "Perceived Personal Benefits" as a key determinant of digital transformation adoption, underscoring the need to communicate tangible advantages such as labor savings, accuracy, and reduced stress. A systematic review by Nnaji et al. (2023b) identified constructs including ease of use, usefulness, social norms, attitude, perceived behavioral control, and facilitating conditions, concluding that UTAUT offers stronger predictive power than TAM or TPB in construction contexts. For Casanuova Inc., this validates the inclusion of these constructs in survey design to assess readiness for QR adoption. Moreover, De Witte (2024) demonstrated the importance of culturally sensitive adaptations of UTAUT2 in the Philippines, reinforcing the need to tailor constructs to local socio-technical

environments. By grounding methodology in validated behavioral models while adapting them to Casanuova's specific workflows and cultural context, the study ensures a robust framework for evaluating employee readiness and linking adoption to performance outcomes.

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## METHODS

**Research Design.** This study employed a descriptive–correlational research design to examine material management challenges and assess employee readiness for adopting digital inventory technology in modular casework operations for high-rise condominium projects. The descriptive component measured the extent of material management issues and readiness levels using a Likert-scale survey grounded in Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) constructs, while the correlational component analyzed the relationship between employee readiness to adopt QR scanning technology and perceived improvements in material management. This design was appropriate as it did not involve experimental manipulation or system implementation but instead described existing conditions and natural relationships within Casanuova Inc.'s organizational setting. Findings from both descriptive and correlational analyses provided the empirical basis for developing a proposed implementation plan for digital technology adoption, intended to guide managerial decision-making and process improvement. This generated evidence-based insights that support technology adoption

planning while recognizing the operational constraints and readiness of the organization. **Population, Sample Size, and Sampling Technique.** The study population consisted of Casanuova Inc.'s project team members directly engaged in material handling for modular casework in selected high-rise condominium projects in Metro Manila, including site engineers, warehouse staff, foremen, installers, and project managers overseeing procurement and tracking. A total of 40 employees participated, representing about 90% of the workforce directly involved in material management, thus adopting a near-census (total enumeration) approach rather than probability-based sampling to ensure comprehensive coverage and minimize bias. Respondents were profiled according to their roles in receiving, storage, issuance, installation, and supervision, as well as their years of experience in construction and modular projects, prior exposure to digital tools such as spreadsheets, BIM, QR systems, and RFID, and their training in inventory practices. This profiling was essential to confirm their direct involvement and familiarity with material workflows, while also recognizing differences in roles, experience, and technological exposure as critical factors influencing adoption constructs like perceived usefulness, ease of use, and organizational support. Consequently, the respondent profile strengthens the validity of findings by ensuring that perceptions of material management challenges and readiness for QR technology were drawn from individuals most relevant to the study's objectives.

**Research Instrument**. The primary instrument of this study was a structured survey questionnaire developed by the researcher and grounded in the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT), both widely applied in assessing employee readiness and technology acceptance in construction contexts. The questionnaire had two parts: the first collected respondents' profile information such as job role, length of service, and prior exposure to digital tools, while the second measured

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readiness to adopt digital inventory technology using TAM and UTAUT constructs. Readiness was assessed through Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Social Influence (SI), and Facilitating Conditions (FC), which collectively informed Behavioral Intention (BI) to adopt QR scanning technology. PU evaluated perceived improvements in accuracy and efficiency, PEOU assessed simplicity of use, SI measured encouragement from peers and management, and FC examined resources and training support. All items were rated on a five-point Likert scale, enabling quantitative analysis for descriptive and correlational purposes.

Table 2 presents the five-point Likert scale used to interpret respondents' level of agreement on statements related to material management challenges experienced by Casanuova Inc.

Table 2

*Likert Scale and Verbal Interpretation for Material Management Challenges*

| Scale | Range | Verbal Interpretation |
|---|---|---|
| 5 | 4.21 – 5.00 | Strongly Agree |
| 4 | 3.41 – 4.20 | Agree |
| 3 | 2.61 – 3.40 | Neutral |
| 2 | 1.81 – 2.60 | Disagree |
| 1 | 1.00 – 1.80 | Strongly Disagree |

Table 3 shows the five-point Likert scale used to interpret respondents' level of readiness and acceptance toward adopting QR scanning technology in terms of perceived usefulness, ease of use, social influence, and facilitating conditions.

Table 3

*Likert Scale and Verbal Interpretation for Readiness and Acceptance toward QR Scanning Technology*

| Scale | Range | Verbal Interpretation |
|---|---|---|
| 5 | 4.21 – 5.00 | Very High |
| 4 | 3.41 – 4.20 | High |
| 3 | 2.61 – 3.40 | Moderate |
| 2 | 1.81 – 2.60 | Low |
| 1 | 1.00 – 1.80 | Very Low |

**Data Gathering Procedure.** The data gathering procedures of this study involved the administration of a structured survey questionnaire to Casanuova Inc.'s project team members directly engaged in material management for modular casework in high-rise condominium projects. Prior to distribution, the researcher secured approval from company management to ensure organizational support and respondent participation. The survey was conducted in person at project sites and warehouses, allowing respondents to complete the questionnaire during scheduled work breaks to minimize disruption to operations. Clear instructions were provided, and confidentiality of responses was emphasized to encourage honest feedback. The questionnaire, grounded in TAM and UTAUT constructs, was designed to capture both demographic profiles and readiness indicators, with items measured on a five-point Likert scale. Completed surveys were collected immediately to ensure high response rates and data integrity. This systematic approach ensured that the gathered data accurately reflected employee perceptions and readiness, forming the empirical basis for subsequent descriptive and correlational analyses.

**Statistical Treatment of Data.** To interpret the data gathered, the following statistical tools were used:

*Weighted Mean.* This was used to determine the overall level of readiness of employees in terms of the different factors of the study: perceived usefulness, perceived ease of use, social influence, facilitating conditions, and willingness to adopt QR scanning.

*Frequency and Percentage.* These were used to describe the profile of the respondents (such as job role and years of service) and the distribution of their responses in each category.

*Analysis of Variance (ANOVA).* ANOVA was used to determine whether employee readiness toward adopting QR scanning technology has a statistically significant relationship with the improvement of Casanuova Inc.'s material management system. This statistical technique tested whether variations in employee

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readiness significantly explain differences in perceived improvement in material management performance. A 0.05 level of significance was used as the criterion for determining statistical significance.

**Ethical and Safety Considerations.** The researcher ensured adherence to ethical and safety standards throughout the conduct of the study. Participation in surveys and interviews was strictly voluntary, and respondents were informed of the study's purpose, data confidentiality, and their right to withdraw at any time. All collected information was treated with anonymity and used solely for academic purposes. Furthermore, the study acknowledges that digital transformation in construction must also consider data security, worker safety, and responsible technology use, particularly when introducing new systems on-site. These principles reflect the managerial responsibilities of the construction management profession under the MSCM framework.

## RESULTS

Following the presentation of the proposed implementation plan, quantitative data from 40 respondents are analyzed to address the study's research questions: (1) the current inventory management challenges experienced by the company, (2) the level of employee readiness and acceptance toward adopting digital asset and inventory technologies, particularly QR scanning, and (3) the relationship between employee readiness and the perceived improvement of the material management system. The findings are subsequently discussed in relation to the theoretical foundations of the study, including the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), to establish theoretical support for the proposed implementation plan.

**Material Management Challenges in Manual Inventory Method.** This section presents the level of material management challenges encountered by Casanuova Inc. in its manual inventory method. The challenges were grouped into seven domains: inventory accuracy, material traceability and visibility, site coordination and reporting, delivery timelines, phased delivery of prefabricated components, vertical logistics and tracking oversight, and manpower utilization.

The composite mean distribution in Table 4 (3.94, "Agree") confirms that Casanuova Inc.'s manual inventory method faces systemic challenges across all seven domains of material management. Inventory accuracy (3.92) and material traceability (3.95) highlight recurring discrepancies between recorded and actual stock, as well as frequent misplacement of materials during transfers, which directly disrupt workflow efficiency. Site coordination and reporting (4.00) emerge as one of the most critical issues, with manual recording and delayed updates leading to reporting errors that hinder decision-making. Delivery timelines (3.87) and phased delivery of prefabricated components (3.88) further compound these inefficiencies, as delayed or fragmented deliveries cause stock-outs, installation delays, and repeated follow-ups. These findings collectively emphasize that manual systems lack the responsiveness and precision required for modular casework delivery in high-rise projects, where timing and coordination are crucial.

Table 4
*Composite Mean Distribution of Current Challenges in the Manual Inventory Method of Modular Casework Delivery in High-Rise Condominium Projects*

| Variables | Mean | Verbal Interpretation |
|---|---|---|
| Inventory accuracy | 3.92 | Agree |
| Material traceability and visibility | 3.95 | Agree |
| Site coordination and reporting | 4.00 | Agree |
| Delivery timelines | 3.87 | Agree |
| Phased delivery for prefabricated components | 3.88 | Agree |
| Vertical logistics and tracking oversight | 3.94 | Agree |
| Manpower utilization | 4.01 | Agree |
| **Composite Mean:** | **3.94** | **Agree** |

Equally significant are the challenges in vertical logistics (3.94) and manpower utilization (4.01),

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which underscore the operational strain of manual tracking in multi-floor environments and the excessive labor demands of repetitive inventory tasks. Respondents strongly agreed that manual counting slows down site operations and diverts manpower from core construction activities, reflecting inefficiencies that reduce productivity and increase fatigue. The difficulty of tracking modular components across floors without clear tagging systems further illustrates the limitations of manual oversight in complex project layouts. Taken together, these results demonstrate that the manual inventory method is not only error-prone but also labor-intensive, creating systemic bottlenecks in material visibility, coordination, and workforce efficiency. The consistent "Agree" responses across all domains point to the urgent need for digital inventory technologies that can provide real-time reporting, structured tracking, and optimized labor utilization to strengthen material management reliability.

**Readiness and Acceptance of QR Scanning Technology.** This section presents the level of readiness and acceptance of Casanuova Inc. employees toward adopting QR scanning technology. Readiness was measured in four constructs: perceived usefulness, perceived ease of use, social influence, and facilitating conditions.

The composite mean of 4.07 ("High") in Table 5 demonstrates that Casanuova Inc. employees exhibit strong readiness and acceptance toward adopting QR scanning technology, with particularly high confidence in its usefulness (4.22, "Very High") and the influence of organizational support (4.22, "Very High"). These results highlight that employees perceive QR scanning as a practical solution to existing inefficiencies in manual inventory, especially in improving accuracy, efficiency, and productivity. The strong social influence scores further emphasize the role of management and workplace culture in shaping positive attitudes toward adoption, suggesting that leadership endorsement and organizational encouragement are critical drivers of

readiness. Together, these findings indicate that employees not only recognize the operational benefits of QR scanning but also feel supported by their organizational environment, creating favorable conditions for implementation.

Table 5
*Composite Mean Distribution of Employee Readiness and Acceptance toward Digital Inventory Technology*

| Variables | Mean | Verbal Interpretation |
|---|---|---|
| Perceived usefulness | 4.22 | Very High |
| Perceived ease of use | 3.93 | High |
| Social influence | 4.22 | Very High |
| Facilitating conditions | 3.90 | High |
| **Composite Mean:** | **4.07** | **High** |

Meanwhile, perceived ease of use (3.93, "High") and facilitating conditions (3.90, "High") reflect confidence that QR scanning can be integrated into daily operations without excessive difficulty, though these domains scored slightly lower than usefulness and social influence. Employees believe the system will be easy to learn and supported by adequate infrastructure and technical assistance, but resource sufficiency and clarity of interaction were noted as relatively weaker points. This suggests that while employees are generally optimistic, successful adoption will require careful attention to training, resource allocation, and system usability to sustain momentum. Overall, the consistently high ratings across all constructs confirm that QR scanning technology is both desirable and feasible, with employee readiness anchored in its perceived usefulness and reinforced by strong organizational support.

**Preferred Digital Asset and Inventory Technology.** Table 6 shows that QR code scanning using mobile phones emerged as the most preferred digital technology for inventory control, selected by the majority of respondents (65.0%). This preference indicates that employees favor a solution that supports quick identification, minimal equipment requirements, and mobility within site conditions. Other options such as barcode systems and RFID received lower preference, suggesting concerns related to additional

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hardware requirements, cost, or operational complexity. The results imply that QR-based inventory control is perceived as the most practical and suitable option for managing modular casework components in high-rise projects.

Table 6
*Preferred Digital Technology for Inventory Control*

| Digital Technology Option | Frequency | Percentage (%) |
|---|---|---|
| QR code scanning using mobile phones | 26 | 65 |
| Barcode-based inventory system | 7 | 17.5 |
| RFID-based tracking system | 4 | 10 |
| Spreadsheet-based digital inventory logs | 3 | 7.5 |
| **Total:** | **40** | **100** |

As presented in Table 7, QR code scanning was identified as the most preferred technology for material tracking, with 70.0% of respondents selecting this option. This finding suggests that employees value the ability to track materials accurately from delivery to designated floors or units using readily available mobile devices. Technologies such as GPS/GIS and RFID were less preferred, likely due to their limited applicability to unit-level tracking or their higher technical and infrastructural requirements. The results reinforce the suitability of QR scanning for material movement monitoring in space- constrained and vertically distributed construction environments.

Table 7
*Preferred Digital Technology for Material Tracking*

| Digital Technology Option | Frequency | Percentage (%) |
|---|---|---|
| QR code scanning | 28 | 70 |
| Barcode system | 6 | 15 |
| RFID tracking | 4 | 10 |
| GPS/GIS-based tracking system | 2 | 5 |
| **Total:** | **40** | **100** |

Table 8 indicates that QR code scanning using mobile devices is the most preferred technology for logistics management, chosen by 62.5% of respondents. This preference reflects the practicality of QR-based solutions for coordinating unloading, transfer sequencing, and delivery monitoring without requiring fixed infrastructure. The lower preference for warehouse-based logistics systems further supports the finding that respondents favor mobile and flexible solutions that align with temporary project conditions and limited staging areas typical of high-rise condominium developments.

Table 8
*Preferred Digital Technology for Logistics Management*

| Digital Technology Option | Frequency | Percentage (%) |
|---|---|---|
| QR code scanning using mobile devices | 25 | 62.5 |
| RFID-based logistics management system | 6 | 15 |
| Dedicated warehouse / logistics management system | 5 | 12.5 |
| Manual tracking supported by digital logs | 4 | 10 |
| **Total:** | **40** | **100** |

Across inventory control, material tracking, and logistics management functions, QR code scanning consistently emerged as the most preferred digital asset and inventory technology among Casanuova Inc. employees. The dominance of QR-based options across all three functional areas indicates a strong inclination toward solutions that are mobile, easy to use, and compatible with existing devices such as smartphones. Importantly, the findings demonstrate that QR scanning was not assumed as the solution at the outset of the study but instead emerged organically based on employee preferences and perceived suitability to project conditions.

These results provide empirical support for the development of the proposed QR-enabled implementation plan, as the selected technology aligns with both employee preference and operational constraints identified earlier in the study. By grounding the proposed solution in actual user preference, the study strengthens the practical relevance and adoptability of the recommended and endorsed digital inventory approach for modular

casework delivery in high-rise condominium projects.

**Relationship between Employee Readiness and Improvement of the Material Management System.** To address the third research question, the study examined whether employee readiness to adopt QR scanning technology is associated with the perceived improvement of Casanuova Inc.'s material management system. The null hypothesis states that there is no significant relationship between employee readiness and perceived improvement. In contrast, the alternative hypothesis posits that a significant positive relationship exists, suggesting that higher levels of employee readiness correspond to greater improvements in material management processes.

Table 9

*Significant Relationship between Employee Readiness and Improvement of Casanuova Inc.'s Material Management System*

| Source of Variation | Sum of Squares (SS) | df | Mean Square (MS) | F-value | p-value | Interpretation |
|---|---|---|---|---|---|---|
| Regression (Between) | 5.62 | 1 | 5.62 | | | |
| Residual (Within) | 3.99 | 39 | 0.10 | 54.87 | 0.000 | Significant |
| Total | 9.61 | 40 | | | | |

Table 9 presents the results of the ANOVA examining the relationship between employee readiness to adopt QR scanning technology and the improvement of Casanuova Inc.'s material management system. The analysis yielded an F-value of 54.87 with a p-value of 0.000, which is below the 0.05 level of significance, indicating a statistically significant relationship between the variables.

This result shows that differences in employee readiness are associated with meaningful differences in perceived material management improvement. Higher levels of readiness correspond to greater improvements in inventory accuracy, tracking efficiency, and overall system performance, confirming that readiness is a key factor in successful implementation rather than a secondary support element.

The findings highlight the importance of strengthening readiness factors, such as

perceived usefulness, ease of use, social influence, and facilitating conditions, to maximize the benefits of QR-based inventory systems. Overall, the ANOVA results provide empirical support for the proposed QR-based material management implementation plan, emphasizing that technological improvements must be accompanied by strong employee readiness to achieve sustainable operational gains.

**Discussion of Findings in Relation to the Technology Acceptance Model (TAM) and UTAUT.** The findings of the study affirm the relevance of the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) in explaining employee readiness and acceptance of QR Code-based inventory technology. High mean ratings for perceived usefulness indicate that employees believe QR scanning enhances job performance by improving inventory accuracy and reducing time spent locating modular components, consistent with TAM's assertion that usefulness drives acceptance. Similarly, high perceived ease of use scores highlights the simplicity of QR scanning, supported by its compatibility with mobile phones already familiar to workers. These results reinforce TAM's emphasis on ease of use as a determinant of adoption, validating QR technology as a low-complexity solution suitable for construction environments with limited digital exposure. Together, these findings justify QR integration in high-rise condominium projects where efficiency and accuracy are critical.

UTAUT constructs further strengthen the analysis, with performance expectancy results showing that employees anticipate improvements in unloading accuracy, reduced delays, and streamlined material movement. Effort expectancy findings confirm that QR scanning is easy to learn, requiring minimal training, which supports phased rollout strategies without disrupting operations. However, moderate to low scores for social influence suggest that peer or supervisory pressure is not a strong driver of adoption, highlighting the need for managerial

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reinforcement through leadership endorsement and monitoring. Lower ratings for facilitating conditions also reveal gaps in organizational support, such as training resources and clear procedures, which could hinder sustained use despite positive perceptions of usefulness and ease. These insights directly inform the inclusion of preparatory activities in the implementation plan, such as training briefs and standardized guidelines, to strengthen enabling conditions.

Overall, the study demonstrates that while employees exhibit high readiness and acceptance of QR scanning technology, successful adoption depends on addressing gaps in social influence and facilitating conditions. The analysis confirms a statistically significant relationship between readiness and perceived improvements in material management, underscoring that higher readiness levels correlate with better system outcomes. By grounding the implementation plan in TAM and UTAUT constructs, the study translates theoretical insights into practical strategies tailored to Casanuova Inc.'s operational realities. This ensures that QR code adoption not only improves efficiency and accuracy but also aligns with employee perceptions and site-specific constraints, thereby enhancing the likelihood of successful integration in modular casework delivery.

**Proposed Implementation Plan for Digital Inventory Management System.** The proposed implementation plan is designed to address the persistent material management challenges identified at Casanuova Inc., particularly those related to inventory accuracy, material traceability and visibility, site coordination and reporting, delivery timelines, and manpower utilization of manual inventory practices in modular casework projects. Rather than presenting QR scanning as a stand-alone technological tool, the implementation plan positions it as a managerial control mechanism that supports accountability, transparency, and informed decision- making in construction project management.

**Expert Validation of the Implementation Plan.** The proposed implementation plan was validated by experts to ensure its relevance, feasibility, and applicability to high-rise condominium construction projects. Validators were purposively selected based on their professional roles and experience in construction operations, material management, and project coordination, including a project manager, site engineer, operations supervisor, and IT practitioner with direct exposure to modular workflows. Using a structured checklist, they evaluated the plan against criteria such as alignment with site constraints, clarity of QR scanning processes, ease of use, feasibility with existing resources, accuracy of inventory data, and scalability to future projects, rating each on a four-point scale and providing qualitative feedback. Suggested revisions included clarifying scanning responsibilities, improving label placement for durability, and strengthening monitoring mechanisms, which were integrated into refined procedures and control phases. Overall, expert validation yielded favorable ratings, confirming the plan's high acceptability, practicality, and suitability for addressing material management challenges in modular casework delivery.

Figure 2 presents the proposed implementation plan for integrating QR technology into digital inventory management for modular casework delivery in high-rise condominium projects, structured into four phases: Pre-Implementation Planning, System Setup, Pilot Implementation and Training, and Refinement with Continuous Improvement. This phased approach complements the Input–Process–Output model in Figure 1, ensuring that empirical findings and readiness assessments are systematically translated into operational strategies. Designed to address constraints such as restricted unloading windows, absence of on-site warehousing, reliance on manual records, and risks of misplacement, the plan emphasizes mobility and simplicity by utilizing QR codes scanned through mobile devices, avoiding costly infrastructure and minimizing disruption. Its phased rollout aligns with employee readiness levels, allowing gradual

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adaptation through preparatory activities and pilot testing, thereby reducing resistance and operational risks. Continuous monitoring and performance measurement further support informed decision-making before scaling to future projects. Overall, the plan serves as a context-sensitive output that integrates TAM and UTAUT insights with supply chain perspectives, supporting accuracy, speed, and accountability in modular casework delivery.
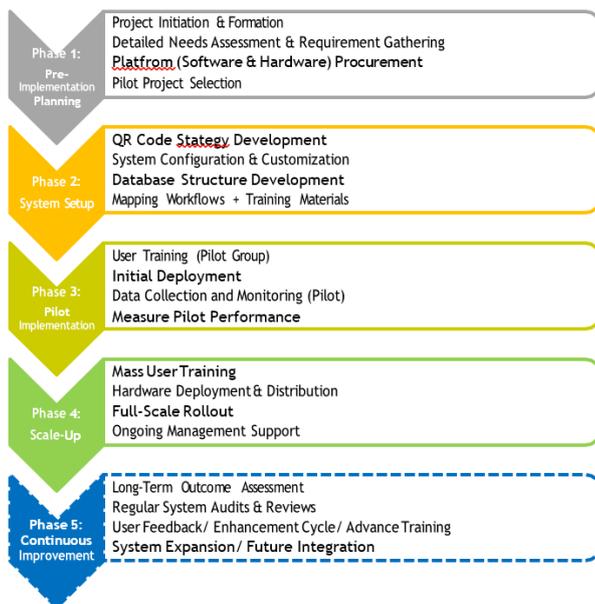


Figure 2
*Proposed Implementation Plan for Digital Technology-Enabled Modular Casework Delivery in High-Rise Condominium Projects*

*Guiding Principles.* These guiding principles were derived from high employee readiness and the identified challenges:

1. **Prioritize Usefulness.** The system must clearly demonstrate improvements in inventory accuracy and tracking efficiency.

2. **Ensure Ease of Use.** Implementation must be supported by structured training and adequate tools, leveraging the high perceived ease of use among employees.

3. **Phased Rollout.** Start with a pilot project to refine workflows before full-scale deployment.

Overall, the proposed implementation plan serves as a researcher-developed innovation that integrates digital inventory technology with established construction management principles. By embedding monitoring, feedback, and intervention mechanisms into routine material workflows, the implementation plan enables a shift from reactive problem-solving to proactive project control. In doing so, it operationalizes accountability and transparency in material management and provides a scalable, low- cost pathway for digital transformation in modular construction projects.

## DISCUSSION

The findings of this study confirm that material management challenges in modular casework delivery for high-rise condominium projects are systemic, particularly in inventory accuracy, traceability, manpower utilization, and vertical logistics oversight. These results are consistent with prior literature emphasizing that poor inventory practices lead to delays, wastage, and inflated costs (Yıldız et al., 2024; Rodríguez, 2022). Casanuova Inc.'s reliance on manual systems mirrors broader industry concerns where fragmented workflows and limited staging areas exacerbate inefficiencies (Sila, 2021). The study demonstrates that QR code–based inventory systems offer a feasible solution, consistent with research highlighting their low cost, flexibility, and adaptability to fast-moving construction environments (Xu et al., 2021; Lee & Lee, 2021). Compared with RFID and IoT systems, QR technology requires minimal infrastructure and training, making it particularly suitable for temporary, space-constrained projects. This supports the argument that technology adoption must align with operational realities rather than technological sophistication alone (Wang et al., 2025).

Employee readiness and acceptance further validate the applicability of TAM and UTAUT in construction contexts. High ratings for perceived usefulness and ease of use confirm that workers believe QR scanning improves

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accuracy and efficiency while being simple to learn, consistent with TAM's core constructs (Davis, 1989; Abbas et al., 2020). Similarly, UTAUT's performance and effort expectancy dimensions were strongly reflected, with employees expecting QR scanning to reduce delays and streamline material movement while requiring minimal training (Venkatesh et al., 2003; Alaloul et al., 2021). However, moderate scores for social influence and lower ratings for facilitating conditions highlight organizational gaps, echoing findings that managerial support and infrastructure are decisive in adoption success (Dimaculangan, 2023b; Hatoum & Nassereddine, 2024). These results emphasize that while employees are ready to adopt QR technology, sustained implementation requires leadership endorsement, clear procedures, and adequate training resources. The statistically significant relationship between readiness and perceived improvement of material management confirms that higher readiness levels directly translate into better system outcomes, reinforcing the predictive power of TAM and UTAUT in construction technology adoption (Nnaji et al., 2023b ).

In conclusion, the study establishes that QR code–based inventory systems provide a practical pathway for Casanuova Inc. to address persistent material management challenges in modular casework delivery. The results highlight that successful adoption depends not only on technological design but also on employee readiness, organizational support, and alignment with site-specific constraints. Recommendations include strengthening managerial reinforcement to enhance social influence, providing structured training and clear procedures to improve facilitating conditions, and gradually integrating QR systems into broader supply chain frameworks such as SCOR, Lean Construction, and Supply Chain 4.0 (Sholeh et al., 2021; Banks & McDaniel, 2022; Akinsulire et al., 2024). Expert validation confirmed the plan's feasibility, with refinements ensuring accountability and clarity of responsibilities. Overall, the study

contributes both theoretically and practically by bridging TAM and UTAUT constructs with supply chain perspectives, offering Casanuova Inc. a structured, evidence-based implementation plan that enhances material visibility, coordination, and efficiency in high-rise modular casework projects.

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