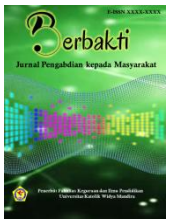

BERBAKTI: Jurnal Pengabdian Kepada Masyarakat
Vol. 4 No. 1, May 2026, pp. 8-19
e-ISSN 2987-033X, https://doi.org/10.30822/berbakti.v4i1.5198
Open Access: https://journal.unwira.ac.id/index.php/BERBAKTI

Strengthening Human Resource Readiness Regarding Automated Container Terminals (ACT) For Port Service Optimization

Encis Indah Suryaningsih[1], Endah Fauziningrum[2], Kundori[3*], Gembong Satria Negara[4], Renny Hermawati[5]
[1,2,3,4,5]AMNI Maritime University, Semarang, Indonesia

e-mail: kundori.jaken@gmail.com[3]

ARTICLE INFO

Article history:
Received: Mar 01, 2026
Revised: Mar 17, 2026
Accepted: Apr 14, 2026

Keywords: Automated Container Terminal; Containers; Terminal Management; Digital Port

ABSTRACT

An introduction to ACT technology is the first step in preparing competent human resources ready to face the era of digital ports. This activity aims to equip students, faculty members, port practitioners, and relevant stakeholders with insights into the components of ACT and integrated terminal management systems. This community service activity was conducted using a participatory method that combined lectures, interactive discussions, technology demonstrations, and case studies. The activity was carried out through several structured and systematic stages, including: the Preparation Stage, the Participant Recruitment Stage, the Activity Implementation Stage, the Evaluation and Reporting Stage, and the Follow-up and Program Sustainability Stage. The event was attended by 127 participants, comprising students from the Mechanical Engineering, Nautical Science, and Port and Waterway Engineering programs, faculty members, as well as port practitioners and representatives from related agencies. The outreach activity enhanced participants' understanding of various aspects of Automated Container Terminals. Participants were highly interested in Automated Guided Vehicle (AGV) technology, which can operate non-stop without an operator; Automated Stacking Cranes (ASC), capable of stacking containers with high precision; and Remote-Controlled Quay Cranes, which can be operated from a control room located far from the pier. This event not only provided theoretical knowledge but also broadened participants' perspectives on career opportunities and the competencies required to navigate the era of digital transformation in the port sector.

INTRODUCTION

Advances in information technology and automation have brought about significant transformations across various industrial sectors, including the port industry. As vital nodes in the global supply chain, ports are required to continuously improve their efficiency, productivity, and competitiveness. One innovation that is now a global trend is the implementation of Automated

Container Terminals (ACT), a container terminal system that integrates automation technology into loading and unloading operations, stacking, and container management (Jobran & Kara, 2022; Pranyoto et al., 2020) . This technology has been proven to increase port throughput, reduce vessel turnaround time, minimize operational errors, and improve workplace safety (Knatz et al., 2024; Majoral et al., 2024) .

As a maritime nation with more than 17,000 islands, Indonesia occupies a strategic position along international trade routes (Kristiyanti et al., 2023) . However, most ports in Indonesia still rely on conventional operational systems that have not yet fully adopted automation technology. This situation results in low national port productivity compared to modern ports in other countries. High dwelling times (Kennedy, 2019) , long ship queues (Khabibah, 2013) , and high logistics costs (Kundori, 2023) , present challenges that must be addressed immediately. Introducing and raising awareness about ACT technology is crucial as a first step in preparing competent human resources ready to face the era of digital ports.

Several previous studies have examined topics related to container terminal automation and digital transformation in the port sector. Previous studies indicate that the integration of AGV, ASC, and Remote-Controlled Quay Crane technologies can significantly improve terminal operational efficiency; however, these studies have focused more on the technical aspects of the systems without addressing the readiness of human resources as on-site operators (Kilinc, 2025) . Furthermore, the main obstacle to implementation lies not solely in technological limitations, but in the low digital literacy of the national port workforce (Carlan et al., 2017). In line with this, ports that have adopted ACT have shown a significant increase in throughput and a reduction in dwelling time; however, this success is highly dependent on the quality of training and preparation of human resources prior to implementation (Othman et al., 2022). Domestically, the high dwelling time at Indonesian ports reflects the weak adoption of technology (Fandi et al., 2026). Meanwhile, the high national logistics costs are a direct result of port operational systems that remain conventional (Aulia, 2025).

AMNI Maritime University, as a partner in this community service initiative, faces a number of concrete challenges that underscore the need for this outreach activity. Based on the results of observations and initial interviews with the study program, it was found that there had never been any formal training or outreach specifically regarding ACT technology organized within the AMNI Maritime University. The existing curriculum does not yet cover material on ACT components such as AGVs, ASCs, or integrated terminal management systems. Additionally, the results of an initial survey conducted among 47 students in the Nautical Science and Commercial Shipping Management programs showed that 78.7% of respondents stated they had never received adequate information about ACT, and only 12.8% could correctly explain the basic concepts of container terminal automation. This situation indicates a low level of understanding and awareness among the academic community regarding the latest developments in port technology, making structured and comprehensive outreach an urgent necessity.

It is hoped that this outreach event will increase awareness and preparedness among the maritime community particularly prospective port workers in facing the digital transformation of the port sector. Additionally, this event is expected to serve as a catalyst for research and collaboration between universities and port industry stakeholders in order to realize modern, efficient, and globally competitive Indonesian ports.

IMPLEMENTATION METHOD

This community service activity was conducted using a participatory method that combined lectures, interactive discussions, technology demonstrations, and case studies. This method was chosen to ensure that participants not only gain a theoretical understanding of Automated Container Terminals but also comprehend the practical and applied aspects of port automation technology. The participatory approach facilitates two-way knowledge transfer between the presenters and participants, ensuring that various questions, doubts, and specific information needs are effectively addressed (Nurhayati et al., 2024).

The program was systematically designed to involve experts in their respective fields, including academics, port industry practitioners, and representatives from companies providing

port automation technology. The training materials were comprehensively developed to cover the basic concepts of port automation, the types of technologies used in Automated Container Terminals, case studies of implementations at modern ports around the world, cost-benefit analyses, and the challenges and opportunities for implementation in Indonesia. To enrich participants' understanding, the event also featured visual aids such as documentary videos of automated port operations, virtual simulations, and interactive presentations using multimedia technology.

The activity was evaluated through pre- and post-tests to measure participants' level of understanding before and after the activity, as well as through a satisfaction survey to assess the effectiveness of the activity's implementation. All participants also received a certificate of participation and a digital module containing a summary of the material, which can be used as a resource for ongoing learning.

This community service activity was carried out through several structured and systematic stages as follows. The preparation phase included internal coordination among the community service team, drafting of the activity proposal, and handling of administrative permits. During this phase, needs were identified and the target participants were determined, namely students from the Engineering, Nautical Science, and Commercial Shipping Management programs, faculty members, as well as invited guests from port practitioners and relevant agencies. The team also communicates with and confirms the availability of invited speakers, as well as prepares comprehensive and easy-to-understand informational materials. Additionally, a survey of facility and infrastructure needs is conducted, and a detailed event schedule is developed.

Participant registration is conducted online via a Google Form to streamline data collection and administration. The target number of participants is at least 100 people, comprising students, faculty members, and port professionals. During this phase, we also follow up with registered participants and prepare the participant kits.

The outreach event will take place over two full days on September 25–26, 2025, at the AMNI Maritime University Auditorium in Semarang. The event will open with remarks from the rector of AMNI Maritime University, followed by a group photo and the administration of a pre-test to participants to assess their initial understanding. The first session featured a presentation on Concepts and Developments of Automated Container Terminals Worldwide, delivered by academic experts and researchers. The presentation covered definitions, the history of development, and global trends in automated ports.

The second session discussed Technologies and Components in Automated Container Terminals, providing a detailed overview of Automated Guided Vehicles (AGVs), Automated Stacking Cranes (ASCs), Remote-Controlled Quay Cranes, Terminal Operating Systems (TOS), the Internet of Things (IoT), and other integration systems. The second day featured a real-world case study on ACT Implementation in Modern Ports: Successes and Challenges, including a documentary video and a comparative analysis of conventional ports versus automated ports in terms of productivity, cost efficiency, workplace safety, and environmental impact.

The next session was an interactive discussion and Q&A session where participants had the opportunity to ask questions, discuss topics, and share their experiences. This session was facilitated by a competent moderator to ensure the discussion remained productive. The event concluded with a post-test, the completion of an evaluation questionnaire, the distribution of certificates, and a group photo. The entire series of activities was thoroughly documented through photos and videos.

At this stage, the results of the pre-test and post-test are analyzed to determine the participants' improved understanding. Data from the satisfaction questionnaire is also analyzed to evaluate the effectiveness of the activity's implementation across various aspects, such as content, speakers, facilities, and organization. The results of this evaluation serve as important input for improving similar activities in the future. The team then compiles a comprehensive report on the community service activity, covering the background, objectives, methods, implementation results, documentation, and recommendations. This report is submitted to the university and may

be published in a community service journal or seminar proceedings to share experiences and knowledge with the broader academic community.

As part of the program's sustainability, the outreach team will establish an online communication group for participants to continue discussing and sharing the latest information on developments in port automation technology. Digital materials, including e-modules, instructional videos, and related articles, will be shared on a regular basis. The team is also exploring potential collaborations with ports or technology companies for follow-up programs such as industrial visits, internships, or advanced training for participants interested in deepening their knowledge and skills in the field of port automation.

RESULTS AND DISCUSSION

A community service event titled Outreach on the Implementation of Automated Container Terminals for Port Service Optimization was held on Wednesday and Thursday, September 25–26, 2025, at the AMNI Maritime University Auditorium in Semarang. The event ran from 8:00 AM to 3:30 PM WIB and was attended by 127 participants, including students from the Engineering, Nautical Science, and KPN programs, faculty members, as well as port practitioners and representatives from relevant agencies. The event was officially opened by the Rector of AMNI Maritime University and attended by representatives from PT Pelindo Regional Central Java, the Tanjung Emas Class I Port Authority and Harbor Master's Office, as well as several shipping companies.

Figure 1. Group photo with the speakers

The outreach program was designed to span two days, featuring three interconnected sessions with a logical progression. This structure is not arbitrary but reflects the principle of scaffolding in constructivist learning theory developed by Vygotsky, in which new understanding is built gradually upon foundational knowledge that has already been established (Nurhasnah et al., 2024). On the first day, the opening session featured an academic speaker presenting a session titled Concepts and Development of Automated Container Terminals Worldwide, covering the definition of ACT as a container terminal system that fully integrates automation into container loading, unloading, and stacking processes; its historical journey from the first semi-automated terminal in Rotterdam in the 1990s, up to the generation of fully automated terminals now operating in various world-class ports. By tracing the chronological development of ACT, participants were encouraged to understand ACT not as an isolated technological entity, but as the product of a long history of innovation responding to the efficiency needs of the global supply chain.

Figure 2. Concepts and Development of Automated Container Terminals

The second session delved deeper into the topic titled Technology and Components in Automated Container Terminals, designed to systematically and structurally build participants' technical understanding. The speaker explained the ACT architecture as an integrated technology ecosystem where each component does not function independently but is interconnected within a cohesive and synergistic system.

The first component discussed is Automated Guided Vehicles (AGVs), which are unmanned vehicles tasked with moving containers horizontally between docks and storage yards. AGVs operate using navigation systems based on lasers, magnets, or a combination of advanced sensors, enabling them to move with precision along predetermined paths, even under dense and dynamic operational conditions. The primary advantage of AGVs lies in their ability to operate non-stop for a full 24 hours without interruption due to human fatigue, as well as their capability to communicate in real-time with a central control system to adaptively optimize movement routes. Participants showed great enthusiasm when the speaker presented a visual simulation of the AGV fleet's movement in the automated terminal, illustrating how hundreds of autonomous vehicles can move in a coordinated manner without a single collision thanks to the intelligence of an algorithm-based traffic management system.

The second component is the Automated Stacking Cranes (ASC), which are automated cranes that operate in container yards to arrange, store, and retrieve containers according to instructions from a central system. ASCs are capable of operating with a level of precision far exceeding that of human operators, with positional deviation tolerances measured in millimeters. This capability enables far more efficient use of yard space, as containers can be stacked higher and more densely without the risk of accidents. Furthermore, modern ASCs are equipped with camera-based sensing systems and three-dimensional laser sensors that allow them to automatically detect container conditions and make operational decisions independently without operator intervention.

The third component, Remote-Controlled Quay Cranes, brings a new dimension to the ACT ecosystem, as it places human operators in an entirely new environment. Unlike conventional crane operators who work at heights in cabins exposed to the elements and physical risks, Remote-Controlled Quay Crane operators work from a comfortable, safe, and well-conditioned control room, using a high-resolution monitor interface and precision joystick to remotely control the cranes on the quay. This paradigm shift not only dramatically improves workplace safety but also allows a single operator to monitor and control more than one crane simultaneously, thereby exponentially increasing labor efficiency.

The Terminal Operating System (TOS) was then introduced as the digital brain that orchestrates the entire ACT ecosystem. TOS is an advanced software platform that integrates data from all terminal components ranging from vessel arrival schedules, the status of each container, the positions of AGVs and ASCs, dock conditions, to truck queues at the entrance gate to generate real-time operational decisions that simultaneously optimize the movement of all assets within the terminal. The TOS's ability to process massive volumes of data and generate optimal decisions in milliseconds makes it the most critical yet most complex component within the ACT architecture. The source emphasized that it is precisely this sophistication of the TOS that truly distinguishes ACT from mere equipment automation, propelling it toward a fundamental operational transformation.

Finally, the Internet of Things (IoT) ecosystem is presented as the connectivity infrastructure that serves as the backbone for the integration of all ACT components. Through a network of sensors embedded in every device, container, and piece of physical terminal infrastructure, IoT enables the continuous and comprehensive collection of operational data, which is then transmitted to a cloud-based analytics platform to be processed into actionable operational insights. IoT integration also allows terminals to seamlessly connect with external logistics ecosystems, including vessel booking systems, customs clearance platforms, land transport networks, and distribution platforms, thereby creating end-to-end and comprehensive supply chain visibility.

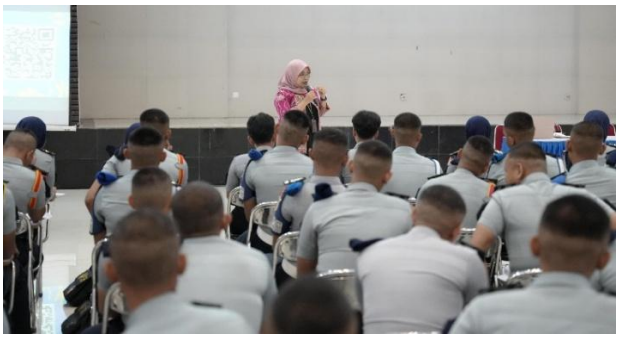

Figure 3. Presentation of ACT components to cadets

On the second day, the third session guided participants from a technical, component-based understanding toward a more contextual and critical perspective through the session titled "ACT Implementation in Modern Ports: Successes and Challenges." This session opened with a screening of a documentary video featuring three world-class automated ports, each representing a different implementation context: the Port of Rotterdam in the Netherlands, a pioneer of European port automation that has been in operation since the 1990s and is now a global benchmark for terminal efficiency standards; the Port of Hamburg in Germany, known for its cutting-edge digital system integration through its smartPORT initiative; and the Yangshan Deep Water Port in Shanghai, China, which represents the latest generation of ACT in the Asian region with unmatched operational scale, encompassing 26 automated cranes and over 130 AGV units operating entirely without human presence on the yard.

The screening of this documentary video had a pedagogical impact that far exceeded what could be achieved through textual presentation alone. Visually witnessing how hundreds of containers were moved with precision by a fleet of autonomous machines moving in a coordinated choreography created an intense cognitive experience for the participants, transforming the concept of ACT from a theoretical abstraction into a concrete reality that could be visualized and evaluated. Participants' reactions evident in expressions of awe, spontaneous discussions among attendees, and a wave of questions that immediately followed the screening confirm that this visual-documentary approach successfully created productive cognitive dissonance: an awareness of the gap between Indonesia's current port conditions and its future potential, which then serves as a driving force for deeper curiosity and motivation to learn.

The session then continued with a structured comparative analysis of conventional terminals and automated terminals across four key dimensions. In terms of productivity, the comparative data presented showed that automated terminals are capable of achieving throughput levels 30–40% higher than conventional terminals with equivalent physical capacity, along with a significant reduction in ship turnaround time, which directly impacts the reduction of shipping fleet operational costs. From the cost-efficiency dimension, participants were guided to understand that while the initial investment for ACT implementation is substantial, the savings generated from reduced direct labor costs and optimized operational energy consumption result in a competitive payback period over the medium term, particularly at ports with high operational volumes. From the occupational safety perspective, the statistical data presented revealed a dramatic decrease in workplace accident rates at terminals that have implemented full automation, as a consequence of minimal human physical interaction in hazardous operational areas such as docks, storage yards, and heavy equipment traffic routes. Finally, regarding environmental impact, participants

gained an understanding that ACT's contribution to ecological sustainability is not merely incidental but a measurable advantage: the use of electric-powered equipment as a replacement for conventional diesel engines, combined with the optimization of vehicle movement routes through intelligent algorithms, collectively results in a significant reduction in carbon emissions per container handled.

The cross-national comparative approach adopted in this session offers methodological strengths that go beyond mere data presentation. By juxtaposing three implementation contexts that differ geographically, historically, and institutionally, participants are enabled to identify universal patterns that apply across contexts such as the importance of mature digital infrastructure and long-term investment commitments while also appreciating the contextual variations that determine how these principles are translated differently in each setting. This ability to distinguish between universal principles and contextual adaptations is the most valuable asset for participants in developing realistic, evidence-based assessments of the opportunities and prerequisites for similar transformations in Indonesia. The entire second day's sessions unfolded with a level of discussion intensity that even surpassed that of the first day, with many participants actively posing critical questions, sharing perspectives drawn from their respective field experiences, and building arguments regarding the concrete opportunities and challenges of implementing ACT in Indonesian ports a dynamic that, in itself, serves as the most persuasive evidence of the success of this outreach activity's learning design.

To measure the effectiveness of the outreach activities, a pre-test was administered before the material was presented and a post-test after the entire series of activities was completed. The test instrument consisted of 20 multiple-choice questions covering understanding of the basic concepts of port automation, types of ACT technologies, implementation benefits, and challenges faced. The evaluation results from 127 participants are presented in Table 1 below.

Table 1. Comparison of Participants' Pre-Test and Post-Test Results

Score Category	Score Range	Pre-Test (Number of Participants)	Pre-Test (%)	Post-Test (Number of Participants)	Post-Test (%)
Excellent	81–100	8	6.3%	89	70.1%
Good	61–80	32	25.2%	35	27.6%
Fair	41–60	54	42.5%	3	2.3%
Less	21–40	28	22.0%	0	0%
Very Low	0–20	5	4.0%	0	0%
Total		**127**	**100%**	**127**	**100%**
Average Score		**52.4**		**84.7**	

Source: Author's data analysis, 2025

Based on Table 1, there was a highly significant increase in understanding following the awareness-raising activity. The participants' average score rose from 52.4 on the pre-test to 84.7 on the post-test, reflecting an increase of 32.3 points, or 61.6%. Before the activity, the majority of participants (42.5%) fell into the "Fair" category, and 26% were in the "Poor" or "Very Poor" categories, indicating that participants' initial understanding of ACT was still relatively limited. This finding aligns with the results of several studies confirming that the concept of port automation remains unfamiliar among Indonesian academics and maritime workers, particularly outside major port cities (Ricardianto et al., 2020).

Following the awareness-raising intervention, the distribution of scores underwent a dramatic transformation: 70.1% of participants achieved the "Very Good" category, 27.6% were in the "Good" category, and no participants remained in the "Poor" or "Very Poor" categories. Only 2.3% of participants remained in the "Fair" category. This achievement exceeded the set success target a minimum 50% increase in understanding with an actual realization of 61.6%. This magnitude of improvement is consistent with findings from various similar outreach activities in the field of .

This 61.6% improvement does not merely reflect the successful transfer of information, but indicates the occurrence of a more fundamental cognitive transformation process. Within the

framework of Bloom's revised taxonomy, the shift from initial understanding which was predominantly at the remembering and understanding levels toward post-activity mastery dominated by the "Excellent" category demonstrates that participants not only absorbed new information but also began to analyze, evaluate, and contextualize that knowledge within the reality of Indonesia's port sector. This is reinforced by the quality of the questions asked during the discussion sessions, which are no longer merely definitive or factual in nature but have evolved toward analytical and solution-oriented questions regarding implementation strategies, policy implications, and national readiness.

This success can be attributed to several methodological factors. First, the use of a blended learning approach that combines conceptual explanations, real-time video footage of world-class port operations, and comparative case studies has proven effective in accommodating participants' diverse learning styles, whether visual, auditory, or analytical. These results align with the principles of multimodal learning proposed by the Institute for , which state that the simultaneous combination of verbal and visual representations can substantially enhance retention and understanding of technical concepts. Second, a session design that builds knowledge hierarchically, from fundamental concepts to implementation case studies, provides effective scaffolding for participants with varying prior knowledge bases. Third, the use of speakers who possess both academic competence and practical relevance in the field of port automation creates credibility that fosters deeper cognitive engagement among participants.

In addition to measuring improvements in understanding, this activity also evaluated participants' satisfaction levels regarding various aspects of the event through a questionnaire distributed at the end of the event. The questionnaire used a 1–5 Likert scale covering eight evaluation aspects. The results of the participant satisfaction evaluation are presented in Table 2 below.

Table 2. Results of Participant Satisfaction Evaluation

No	Evaluation Aspect	Average Score	Category
1	Relevance of materials to the activity's objectives	4.6	Very Satisfied
2	Quality and competence of the speakers	4.7	Very Satisfied
3	Systematic presentation of material	4.5	Very Satisfied
4	Availability of media and presentation materials	4.4	Very Satisfied
5	Opportunities for discussion and Q&A	4.6	Very Satisfied
6	Facilities and room comfort	4.3	Very Satisfied
7	Timeliness of implementation	4.2	Satisfied
8	Organizers' service and catering	4.4	Very Satisfied
	Overall Average	**4.5**	**Very Satisfied**

Source: Author's data analysis, 2025

The results of the participant satisfaction evaluation reflect a very positive level of acceptance of all aspects of the event's organization. The average overall satisfaction score reached 4.5 on a scale of 5.0, exceeding the set target of 4.0 and falling into the "Very Satisfied" category. This achievement indicates that the event's organization not only met but also exceeded the expectations of the majority of participants. From a service *quality* management perspective, a satisfaction score in the 4.5 range indicates that the event successfully created a strong sense of value in the participants' minds a condition that directly contributes to the formation of a positive attitude toward the substance of the material presented.

When analyzed by aspect, the quality and competence of the presenters received the highest score of 4.7. This finding is consistent with the literature on training effectiveness, which consistently identifies the credibility and competence of facilitators as the strongest predictors of participant satisfaction and engagement in technical knowledge dissemination activities (Wahl, 2020). Participants highly appreciated the depth of knowledge and the ability of the speakers to present technical material in a communicative and relevant manner, while also confirming that the selection of speakers with academic-research backgrounds in the field of port automation was the right strategic decision.

The next two aspects that received high scores were the relevance of the material to the activity's objectives and the opportunities for discussion and Q&A, both of which scored 4.6. This outcome is significant: participants not only felt that the content presented was relevant and on-

target, but also felt they had sufficient opportunities for interaction to clarify their understanding and ask critical questions. Given that ACT is a relatively new technology for most participants, the availability of productive discussion space is a key component in the process of knowledge internalization. This aligns with findings from the "regarding transformative learning, which emphasizes that critical reflection through dialogue is an essential mechanism in transforming learners' perspectives.

The only aspect rated in the "Very Satisfied" category was the timeliness of the event, with a score of 4.2. Although this score is still considered good and falls within the "Satisfied" category, this issue warrants serious attention for improvement. Further findings reveal that the delay in the activity schedule was actually caused by the high enthusiasm of participants during the Q&A session, which exceeded the planned time allocation. This paradox is actually a hidden indicator of success: the depth of discussion that went beyond the time limit reflects the participants' high cognitive engagement with the material, a condition that, from an educational perspective, is actually a sign of successful instructional design. Nevertheless, better time management is still needed so that the quality of the discussion does not compromise the regularity of the activity schedule.

The high level of participant enthusiasm throughout the event was not only reflected in quantitative data on increased scores and satisfaction, but also manifested qualitatively through the patterns and quality of questions asked during the discussion sessions. These questions can be grouped into three major interrelated themes: investment and infrastructure, employment and competencies, and national readiness and logistics integration.

Investment and Infrastructure Aspects. Questions regarding the estimated costs of converting conventional terminals into automated terminals have come up repeatedly and have become one of the topics that most frequently spark in-depth discussion. This pattern reflects participants' awareness that the transition to ACT is not merely a technological issue, but also a complex economic and political one. Participants understand that investment in this sector is not limited to the procurement of hardware such as AGVs and ASCs, but also encompasses digital system transformation, the development of communication network infrastructure, and the reconfiguration of the physical layout of existing terminals. Therefore, investment planning must be carried out comprehensively and in phases through innovative financing schemes, including the possibility of public-private partnerships (PPPs), to avoid creating a counterproductive fiscal burden for port operators and the government.

Labor Market and Competency Aspects. The second theme that emerged prominently was the impact of automation on labor market dynamics at ports. Discussions on this issue were intense and complex. On the one hand, participants raised concerns about potential job displacement resulting from the implementation of automated systems. On the other hand, the discussion shifted toward a more constructive direction regarding the new competency profiles required within the automated terminal ecosystem. Speakers offered an important conceptual reframing: automation should not be understood as an eliminative threat to jobs, but rather as a transformative force that reconfigures the profiles and hierarchies of available jobs. This perspective is supported by a growing body of literature on the impact of automation on the labor market, where a study conducted by the found that while automation eliminates certain categories of routine work, it simultaneously creates new job categories requiring higher-level skills, particularly in the fields of system monitoring, advanced maintenance, and operational data analytics. The real challenge for Indonesia, therefore, is not how to prevent automation, but rather how to design human resource development programs capable of preparing the workforce to competitively fill these new roles.

National Readiness and Logistics Integration. The third set of questions reflects a more macro and strategic perspective. Participants raised questions not only about the physical infrastructure readiness of Indonesia's ports but also about the regulatory readiness, institutional governance, and supporting ecosystem necessary for the ACT to function optimally. Questions regarding the duration of the transition from conventional to automated systems indicate that participants view this process as a medium- to long-term transformation journey that cannot be

undertaken impulsively. The issue of integrating the ACT system with the national logistics ecosystem warrants particular attention, given that the effectiveness of automated terminals heavily depends on interoperability with land transport systems, multimodal distribution networks, and existing digital logistics platforms. This view aligns with the perspective of an integrated logistics system (ILS) proposed by the which emphasizes that a logistics node's competitive advantage can only be realized if there is seamless connectivity and synchronization with all components of the supply chain. Thus, the implementation of ACT in Indonesia must be positioned not as a standalone sectoral project, but as an integral component of a comprehensive national logistics development strategy.

Overall, the pattern of questions and the dynamics of the discussion that emerged during this event reflect two important points. First, participants did not merely absorb the material passively but have moved on to a level of critical and reflective thinking regarding the practical implications of ACT technology in the Indonesian context an achievement that surpasses the initial cognitive objectives of this outreach event. Second, this activity successfully revealed knowledge gaps that have not yet been addressed academically within Indonesia's maritime education sector, while simultaneously opening a space for dialogue among academics, practitioners, and industry stakeholders a dialogue that is essential for informing national port transformation policies.

The success of this outreach initiative has far-reaching implications that extend beyond the achievement of established performance indicators. From an academic perspective, this initiative underscores the urgency of revising Indonesia's maritime education curriculum to explicitly incorporate digital competencies and an understanding of automated port systems as part of graduate competency standards. Students currently enrolled in Nautical Science, Marine Engineering, and Commercial Shipping Management programs need to be prepared not only for the current port work environment but also for the professional landscape they will face in the next one to two decades, when the penetration of ACT technology is predicted to become increasingly widespread in the Southeast Asian region.

In terms of practical implications, this event directly contributes to the readiness of the target partners namely, the academic community of AMNI Maritime University and the industry stakeholders in attendance. Students gain conceptual and technical understanding that strengthens their competitiveness in facing job selection processes at port companies that are increasingly technology-oriented. Faculty members gain contextual references that can enrich their course materials with up-to-date industry perspectives. Meanwhile, the port practitioners in attendance gain academic insights that can inform their decision-making when formulating human resource capacity development plans at their respective institutions.

In terms of policy implications, this event sends a relevant signal to policymakers in the port and maritime education sectors. The high level of enthusiasm among participants and the quality of questions raised during the discussion indicate a real and unmet demand for knowledge dissemination programs in the field of port digital transformation. This aligns with the policy direction in the National Port Master Plan (RIPN) and the Indonesian Maritime Transport Blueprint, which identify infrastructure modernization and human resource capacity building as the two main pillars of national logistics competitiveness.

From a scientific perspective, this community service initiative provides empirical evidence that outreach interventions when designed using appropriate methodologies, supported by competent experts, and executed in a format that encourages active participation can yield a significant increase in understanding within a relatively short period of time. These findings complement previous studies on the effectiveness of technology dissemination programs in the maritime sector and provide an implementation model that can be adapted for similar contexts at other maritime educational institutions in Indonesia.

As a strategic follow-up, the community service team plans to organize follow-up activities, including industrial visits to ports that have implemented semi-automated systems, conducting training workshops on Terminal Operating System (TOS) software, and exploring partnerships with industry for student internship programs. AMNI Maritime University is also committed to making port technology outreach activities a regular annual agenda. This commitment is crucial

because, as noted by Ellström (2010), the sustainability of capacity-building programs is a prerequisite for institutional competency transformation not merely individual-level change. Indonesia has a real opportunity to take a proactive stance in the ongoing wave of port transformation, and such outreach, if consistently continued and reinforced with more concrete capacity-building programs, has the potential to become one of the most important catalysts in the journey of national maritime logistics transformation.

CONCLUSION

The community service activity titled Socialization of Automated Container Terminal Implementation for Port Service Optimization, held at AMNI Maritime University in Semarang, went very well and achieved its set objectives. The participants' high level of enthusiasm was evident in the numerous critical questions they asked regarding the technical, economic, and social aspects, as well as the practical implementation of port automation technology in Indonesia. This event not only provided theoretical knowledge but also broadened the participants' perspectives on career opportunities and the competencies required to navigate the era of digital transformation in the port sector.

Based on the results and achievements of this activity, the recommendations that need to be followed up by AMNI Maritime University are the significant 61.6% increase in understanding and the high level of participant enthusiasm, which serve as a strong foundation for promoting the integration of ACT materials into the formal curriculum of the Nautical Science and Commercial Shipping Management programs, for example, by adding elective courses on digital port technology or incorporating topics on terminal automation into existing port management courses. Although this activity has proceeded smoothly and achieved its set objectives, there are several limitations that must be honestly acknowledged as a basis for reflection and future improvement. The lack of simulation facilities or hands-on demonstrations of ACT components, such as AGV miniatures or TOS interface demonstrations, posed a significant challenge, given that this technology is highly visual and kinesthetic; thus, a deeper understanding ideally requires the experience of seeing or touching the actual devices in question.

REFERENCES

Aulia, C. (2025). Penerapan Smart Port System Berbasis Iot Untuk Efisiensi Manajemen Operasional Pelabuhan Di Indonesia. *Riset Sains Dan Teknologi Kelautan*, *8*(2), 79–88.

Carlan, V., Sys, C., Vanelslander, T., & Roumboutsos, A. (2017). Digital innovation in the port sector: Barriers and facilitators. *Competition and Regulation in Network Industries*, *18*(1–2), 71–93. https://doi.org/10.1177/1783591717734793

Evagorou, M., Erduran, S., & Mäntylä, T. (2015). The role of visual representations in scientific practices: From conceptual understanding and knowledge generation to 'seeing' how science works. *International Journal of STEM Education*, *2*(1), 11. https://doi.org/10.1186/s40594-015-0024-x

fandi, ahmad, Satriyo, G., & Suwarso, S. (2026). Critical Factors Affecting Loading And Unloading Performance At Port Terminals. *Santhet (Jurnal Sejarah Pendidikan Dan Humaniora)*, *10*(1), 167–174. https://doi.org/https://doi.org/10.36526/santhet.v10i1.6759

Gunasekaran, A., Lai, K., & Edwincheng, T. (2008). Responsive supply chain: A competitive strategy in a networked economy☆. *Omega*, *36*(4), 549–564. https://doi.org/10.1016/j.omega.2006.12.002

Haleem, A., Javaid, M., Singh, R. P., Rab, S., & Suman, R. (2021). Hyperautomation for the enhancement of automation in industries. *Sensors International*, *2*, 100124. https://doi.org/10.1016/j.sintl.2021.100124

Jobran, Y., & Kara, G. (2022). Examining the Efficiency of Automation in Container Terminals. *Journal of Transportation and Logistics*, *7*(1), 137–155. https://doi.org/10.26650/JTL.2022.1039692

Kennedy, J. (2019). Analisis tingginya biaya logistik di Indonesia ditinjau dari dwelling time. *Jurnal Economic Resource*. https://www.academia.edu/download/85883389/95.pdf

Khabibah, R. (2013). Sistem Antrian Pelayanan Bongkar Muat Kapal di Terminal Berlian Pelabuhan Tanjung Perak Surabaya. *MATHunesa: Jurnal Ilmiah Matematika*, *1*(4). https://ejournal.unesa.ac.id/index.php/mathunesa/article/view/2553/5608

Kilinc, N. U. (2025). *A Strategic Framework for the Remote-Control Center: A Holistic Blueprint for the Autonomous Maritime Ecosystem*.

Knatz, G., Notteboom, T., & Pallis, A. A. (2024). Container terminal automation: Assessment of drivers and benefits. *Maritime Policy & Management*, *51*(6), 1252–1276. https://doi.org/10.1080/03088839.2023.2249460

Kristiyanti, M., Kundori, K., & Hermawati, R. (2023). Membangun Sumber Daya Manusia Dan Teknologi Informasi Sebagai Dasar Kejayaan Maritim Di Indonesia. *Jurnal Sains Dan Teknologi Maritim*, *23*(2), 109–122. https://doi.org/10.33556/jstm.v23i2.337

Kundori, K. (2023). Implementasi kebijakan transportasi laut dalam rangka pengembangan sistem logistik nasional. *Majalah Ilmiah Bahari Jogja*, *21*(1), 52–60.

Majoral, G., Reyes, A., & Saurí, S. (2024). Lessons from Reality on Automated Container Terminals: What Can Be Expected from Future Technological Developments? *Transportation Research Record: Journal of the Transportation Research Board*, *2678*(2), 401–415. https://doi.org/10.1177/03611981231174422

Nurhasnah, N., Sepriyanti, N., & Kustati, M. (2024). Learning Theories According to Constructivism Theory. *Journal International Inspire Education Technology*, *3*(1), 19–30. https://doi.org/10.55849/jiiet.v3i1.577

Nurhayati, N., Apriyanto, A., Ahsan, J., & Hidayah, N. (2024). *Metodologi Penelitian Kualitatif: Teori dan Praktik*. PT. Sonpedia Publishing Indonesia.

Othman, A., El Gazzar, S., & Knez, M. (2022). Investigating the Influences of Smart Port Practices and Technology Employment on Port Sustainable Performance: The Egypt Case. *Sustainability*, *14*(21), 14014. https://doi.org/10.3390/su142114014

Pranyoto, P., Riyanto, Kundori, K., & Muliawan, I. N. G. (2020). Optimalisasi Relokasi Petikemas Di Pelabuhan Tanjung Perak Dalam Menunjang Kegiatan Bongkar Muat Pada PT. ABC: *Jurnal Sains Teknologi Transportasi Maritim*, *2*(2), 33–40. https://doi.org/https://doi.org/10.51578/j.sitektransmar.v2i2.26

Ricardianto, P., Nasution, S., Naiborhu, M. A., & Triantoro, W. (2020). Peluang dan Tantangan Sumber Daya Manusia dalam Penyelenggaraan Pelabuhan Cerdas (Smart Port) Nasional di Masa Revolusi Industri 4.0. *Warta Penelitian Perhubungan*, *32*(1), 59–66. https://doi.org/10.25104/warlit.v32i1.1524

Sislian, L., & Jaegler, A. (2023). The Spread of Social Inclusion in the Maritime Industry: A Social Study. *International Journal of Business Ethics and Governance*, *6*(1), 38–57. https://doi.org/10.51325/ijbeg.v6i1.120

Southworth, J. (2022). Bridging critical thinking and transformative learning: The role of perspective-taking. *Theory and Research in Education*, *20*(1), 44–63. https://doi.org/10.1177/14778785221090853

Wahl, A. M. (2020). Expanding the concept of simulator fidelity: The use of technology and collaborative activities in training maritime officers. *Cognition, Technology & Work*, *22*(1), 209–222. https://doi.org/10.1007/s10111-019-00549-4