Assessing OUM Students' Employability in Smart Manufacturing through Focus Groups, Observations, and Competency Assessments

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ABSTRACT

This study examines the readiness of Malaysian Open University (OUM) students for roles in sustainable smart manufacturing. Data collection involved focus groups, on-site observations, and competency-based tasks with OUM students employed in the manufacturing sector and selected company staff. The primary aim was to assess the competencies of OUM students for employability in sustainable smart manufacturing and gather insights from company personnel. Findings indicate that while students possess foundational knowledge, there are gaps in advanced technical skills and practical application. Recommendations include curriculum enhancements and targeted training to bridge these gaps.

Keywords: Employability, Smart Manufacturing, Competency Assessment, Focus Groups, On-Site Observations

INTRODUCTION

The manufacturing industry is undergoing a transformation with the integration of advanced technologies, leading to the emergence of sustainable smart manufacturing. This shift demands a workforce equipped with specific competencies to navigate and excel in this evolving landscape. Universities play a crucial role in preparing students to meet these industry requirements. This study focuses on evaluating the competencies of Malaysian Open University (OUM) students employed in the manufacturing sector, aiming to assess their readiness for sustainable smart manufacturing roles.

Research Objectives

1. Assess the current competencies of OUM students working in the manufacturing industry concerning sustainable smart manufacturing.
2. Identify gaps between the students' competencies and industry expectations.
3. Gather insights from company staff on the employability of OUM students.
4. Provide recommendations to enhance the curriculum and training programs to better prepare students for the industry.

LITERATURE REVIEW

The transition to sustainable smart manufacturing necessitates a workforce proficient in advanced technologies and sustainable practices. Studies have highlighted the importance of competency development in areas such as additive manufacturing and the integration of digital tools to enhance production efficiency. Additionally, the World Economic Forum emphasizes the need for purposeful leadership and dynamic collaboration to nurture a sustainable workforce in advanced manufacturing. Competency-based learning and assessment have been shown to effectively bridge the gap between academic experiences and employer expectations, ensuring that graduates possess the necessary skills for industry success.

The Need for Workforce Competency in Sustainable Smart Manufacturing

The transition to sustainable smart manufacturing demands a highly skilled workforce capable of adapting to

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rapid technological advancements while incorporating sustainable practices. This paradigm shift requires the integration of Industry 4.0 technologies such as artificial intelligence (AI), the Internet of Things (IoT), and cyber-physical systems into production processes (Nasreen et al., 2022). As manufacturers move towards data-driven decision-making and automation, professionals must possess technical proficiency in advanced digital tools and sustainable production strategies to remain relevant in the industry (Smith & Jones, 2020).

Industry Requirements for Competency Development

Employers increasingly seek candidates who are proficient in smart manufacturing technologies, particularly in areas such as additive manufacturing, machine learning, and industrial robotics (Tan et al., 2020). Studies indicate that hands-on experience with these technologies significantly enhances students' readiness for employment (Jollands et al., 2012). In Malaysia, the Fourth Industrial Revolution (IR 4.0) has placed a strong emphasis on competency-based learning to ensure that university graduates align with industry expectations (Lim et al., 2008).

The World Economic Forum (2024) has underscored the importance of purposeful leadership and dynamic collaboration in building a sustainable workforce. Industry leaders emphasize that future employees must not only possess technical skills but also demonstrate critical thinking, adaptability, and problem-solving abilities to keep pace with the evolving demands of smart manufacturing environments (World Economic Forum, 2024).

Competency-Based Learning as a Bridge Between Academia and Industry

Competency-based learning has been widely recognized as an effective strategy for bridging the gap between academic experiences and workplace expectations (Baughman, 2012). This learning approach shifts away from traditional lecture-based education and focuses on practical, hands-on training, where students gain real-world experience in smart manufacturing processes (Azmi et al., 2018). In competency-based education, assessments focus on students' ability to apply knowledge and skills in actual work scenarios, ensuring that graduates meet the evolving needs of modern manufacturing industries (Quinn et al., 2008).

A study on Malaysian technical and vocational education and training (TVET) institutions highlights that graduates who undergo competency-based assessments demonstrate higher employability and adaptability in smart manufacturing settings compared to those who rely solely on theoretical learning (Ismail & Mohammed, 2015). Employers particularly value graduates who have engaged in practical projects, industrial attachments, and digital simulations, as these experiences develop critical manufacturing competencies (Rahmat & Hassan, 2011).

METHODOLOGY

To ensure a thorough evaluation of Malaysian Open University (OUM) students' employability competencies in the sustainable smart manufacturing industry, a multi-method approach was employed. This included focus groups, on-site observations, and competency-based tasks. These methods were chosen to provide a well-rounded understanding of the students' capabilities, practical applications of their skills, and areas requiring improvement.

Focus Groups

Focus groups were conducted to gather qualitative insights from OUM students currently employed in the manufacturing sector and company staff who directly supervise or collaborate with them. These discussions aimed to assess:

1. The alignment between students' academic learning and industry expectations.
2. The perceived strengths and weaknesses of OUM students in handling smart manufacturing processes.
3. Industry expectations regarding skills such as automation, data analytics, and sustainability-focused manufacturing.

4. Suggestions from employers on how academic programs could be improved to better prepare students for industry needs.

Each focus group consisted of six to ten participants to ensure an interactive yet manageable discussion. Sessions were recorded and transcribed for thematic analysis, allowing researchers to identify recurring concerns, trends, and suggestions.

On-Site Observations

To supplement the focus group discussions, direct on-site observations were carried out at selected manufacturing facilities. These observations aimed to capture real-time applications of knowledge and skills in the workplace. Key aspects assessed included:

1. Students' ability to operate and interact with smart manufacturing systems such as automated production lines, Internet of Things (IoT) devices, and data analytics tools.
2. Their problem-solving capabilities when dealing with real-world production challenges.
3. Their adaptability to emerging manufacturing technologies and sustainability initiatives.
4. Communication and teamwork skills within a high-tech manufacturing environment.

Researchers followed a structured observation checklist to ensure consistency across multiple sites. They also engaged with supervisors to clarify specific job roles and responsibilities.

Competency-Based Tasks

To further assess students' technical competencies, structured competency-based tasks were designed and implemented. These practical assessments were aligned with the core requirements of smart manufacturing and included:

1. Automation & Robotics Task: Evaluating students' ability to program and troubleshoot automated manufacturing systems.
2. Data Analytics for Manufacturing Task: Assessing students' capacity to interpret production data, detect inefficiencies, and propose optimisations.
3. Sustainability and Lean Manufacturing Task: Measuring students' understanding of sustainable manufacturing practices, waste reduction strategies, and energy efficiency improvements.
4. Team-Based Problem-Solving Task: Evaluating students' abilities in communication, leadership, and collaboration through group-based simulations that require joint decision-making, role delegation, and effective conflict resolution in a manufacturing context.

Students were required to complete these tasks under supervised conditions, with assessments conducted by both industry professionals and academic evaluators. Their performance was scored based on accuracy, efficiency, and problem-solving approaches.

To ensure the reliability and objectivity of the competency-based assessments, statistical validation methods were applied throughout the evaluation process. Rubrics were first developed and refined in collaboration with industry experts to establish clear criteria for each task, ensuring alignment with current manufacturing standards. A pilot run of the assessments was conducted with a smaller cohort to test the consistency of the instruments. Inter-rater reliability was measured using Cohen's Kappa to determine agreement levels between assessors, which indicated a high degree of scoring consistency across evaluators.

Construct validity was established by mapping the assessment criteria against established competency frameworks in smart manufacturing, such as those provided by the Malaysian Qualifications Framework (MQF) and relevant technical skills standards from SIRIM and MIDA. Factor analysis was then performed on the assessment scores to confirm that each task accurately measured distinct competency dimensions—technical, analytical, sustainable, and interpersonal. Internal consistency reliability was assessed using Cronbach's alpha, with results above the acceptable threshold of 0.7, indicating dependable performance measurement across items

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within each competency domain.

Student scores were further analysed using descriptive statistics and item difficulty analysis to identify the clarity and fairness of tasks. This helped in calibrating the assessment levels for future cohorts. Feedback from both assessors and students was also collected through structured surveys and analysed using thematic coding to refine the assessment structure. These validation efforts collectively confirmed that the competency-based tasks provided a statistically sound and industry-relevant measure of students' readiness for roles in smart manufacturing.

Comprehensive Evaluation from Multiple Sources

By combining focus group discussions, on-site observations, and competency-based tasks, this research provided a holistic view of the students' competencies. The data collected allowed for:

1. A comparison between self-reported skills (from focus groups) and observed performance in real work settings.
2. Identification of specific skill gaps that could be addressed through curriculum improvements.
3. Recommendations to strengthen the employability of OUM students in the rapidly evolving smart manufacturing industry.

This comprehensive data collection strategy ensured that the findings were grounded in real-world industry requirements, providing actionable insights for academia and industry stakeholders alike

RESULTS & OUTCOMES

1. Assessment of OUM Students' Employability Competencies

The assessment revealed that OUM students possess a solid foundation in theoretical knowledge, particularly in manufacturing principles, industrial processes, and sustainability concepts. Their understanding of fundamental topics such as automation, lean manufacturing, and digital production systems aligns with the academic curriculum offered by the university. However, despite this strong theoretical grounding, notable gaps were identified in advanced technical skills, particularly in the application of smart manufacturing technologies, real-time problem-solving, and practical engagement with Industry 4.0 systems.

Feedback from company staff and industry professionals indicated that while students exhibit adaptability and a willingness to learn, they often lack hands-on experience with the latest industry tools, software, and machinery used in modern manufacturing environments. This limitation can hinder their efficiency and confidence in workplace settings that require familiarity with automation systems, data-driven manufacturing analytics, and digital twin technologies. Industry supervisors emphasized that graduates who enter the workforce without direct exposure to these tools often require extensive on-the-job training, delaying their full integration into the company's operations.

2. Analysis of the Identified Gaps and Industry Expectations

The findings suggest a disconnect between the current curriculum and the practical demands of the industry. While students are well-versed in theoretical concepts, they struggle with applying these concepts to real-world manufacturing scenarios. The gaps are particularly evident in key areas such as automation, data analytics, sustainability, and lean manufacturing.

Advanced Automation and Robotics

Many OUM students lack proficiency in robotic programming, human-machine interface (HMI) operations, and sensor-based manufacturing controls. These technical skills are essential for Industry 4.0-driven production systems, where automation plays a critical role in enhancing efficiency and reducing human error. However, students have minimal hands-on experience with collaborative robots (cobots) and automated production lines, limiting their ability to work effectively in smart manufacturing environments.

Industrial Data Analytics and Smart Manufacturing Integration

Smart manufacturing relies heavily on real-time data analysis, predictive maintenance, and digital connectivity. Many students struggle with interpreting manufacturing data, using predictive analytics for process optimization, and working with cloud-based industrial platforms. The ability to integrate big data applications, IoT technologies, and AI-driven decision-making is still developing among graduates, which poses a challenge for employers seeking data-literate professionals.

Sustainability and Circular Manufacturing Practices

While students understand the principles of sustainable manufacturing, they lack practical exposure to implementing energy-efficient production strategies, waste reduction methodologies, and lifecycle assessment tools. Industry professionals have noted that graduates often lack hands-on experience in executing green manufacturing initiatives and carbon footprint reduction strategies, which are increasingly important in global supply chains.

Lean Manufacturing and Process Optimization

Lean manufacturing techniques are widely adopted in high-volume production settings to reduce waste and improve efficiency. Although students are familiar with lean methodologies, they require more hands-on experience with process flow simulations, Six Sigma applications, and real-time production adjustments. Industry professionals highlighted a gap in students' ability to apply lean principles in fast-paced environments, affecting their readiness for roles in continuous improvement and operational excellence.

3. Addressing the Industry-Academia Gap Through Competency-Based Learning

These gaps align with previous research highlighting the need for continuous technical training to bridge critical skill deficiencies in the manufacturing sector (Nasreen et al., 2022; Tan et al., 2020). Competency-based learning approaches have been widely recognized as a solution to this disconnect, ensuring that graduates gain industry-relevant skills alongside their academic knowledge.

RECOMMENDATIONS FOR BRIDGING THE SKILL GAPS

Enhancing Hands-On Technical Training in the Curriculum

To bridge the gap between theory and practice, universities should increase lab-based learning, project-based tasks, and real-world case studies that focus on smart manufacturing tools and software. Virtual reality (VR) and augmented reality (AR) training simulations can also allow students to engage with realistic manufacturing scenarios in a controlled learning environment, improving their technical proficiency before entering the workforce.

Strengthening Industry Collaboration and Apprenticeship Programs

Developing long-term partnerships with manufacturing firms will provide students with structured internship programs, industry-sponsored workshops, and job shadowing opportunities. Engaging industry experts as guest lecturers, course co-instructors, and project mentors will help students gain valuable insights into current industry practices and the latest technological advancements.

Implementing Competency-Based Assessments

Traditional exams often fail to measure practical skill proficiency. Universities should integrate competency -based assessments that require students to demonstrate their ability to operate automation systems, analyze production data, and optimize manufacturing processes. Additionally, outcome-based evaluations—where students are tested on real manufacturing problems rather than just theoretical knowledge—will better align with industry needs.

Expanding Digital Learning and Smart Manufacturing Simulations

The integration of cloud-based learning tools, digital twin technologies, and AI-powered manufacturing simulators will allow students to simulate real-time decision-making in industrial environments. Encouraging students to use industrial software such as Siemens NX, AutoCAD, SolidWorks, and SAP for digital manufacturing planning can also improve their technical competencies and industry readiness.

Fostering Lifelong Learning and Certification Programs

Given the rapid evolution of smart manufacturing technologies, students must embrace lifelong learning to stay competitive in the job market. Encouraging them to pursue micro-credentials, specialized certifications, and online training programs in automation, industrial AI, and sustainability will increase their employability and industry adaptability. Universities should collaborate with industry associations and technology providers to offer students certifications in industrial robotics, AI-powered maintenance, and sustainability auditing, further enhancing their career prospects in the smart manufacturing sector.

Incorporating Blended Learning through Virtual Labs, Industry Modules, and Simulations

Integrating blended learning strategies into the curriculum will improve students' practical exposure and technical readiness. Virtual labs allow learners to experiment with manufacturing processes, automation systems, and digital controls in a risk-free environment, supporting remote access and self-paced learning. Embedding industry-led modules developed in collaboration with manufacturing partners will ensure that course content remains aligned with evolving practices and tools. These modules can cover areas such as predictive maintenance, robotics integration, or digital twin applications. In addition, real-time simulations offer opportunities for students to engage with realistic manufacturing scenarios that test their analytical thinking, decision-making, and adaptability. These blended learning approaches not only accommodate diverse learning preferences but also mirror the dynamic environments found in smart factories, preparing students more effectively for workforce demands.

Establishing Partnerships with Smart Manufacturing Firms for Internships and Live Projects

Collaborating with smart manufacturing firms will give students meaningful exposure to real-world industrial environments. These partnerships can provide structured internship placements where students apply their technical knowledge to actual production systems, automation tools, and data-driven processes. Involvement in live industry projects will also enable students to work alongside engineers and technicians on challenges such as system optimisation, process redesign, or lean implementation. Through such experiences, students can develop practical skills that go beyond classroom learning, including time management, cross-functional communication, and on-site problem-solving. Engaging with firms using advanced technologies such as IoT, AI-driven analytics, and smart sensors also helps students understand current trends and expectations in the manufacturing sector. These collaborations not only benefit students but can also strengthen institutional ties with the industry, supporting curriculum relevance and graduate employability.

Supporting Faculty Development in AI, IoT, and Automation

To keep up with the pace of technological change in manufacturing, targeted professional development for faculty is essential. Institutions should organise regular training workshops and certification programmes in areas such as artificial intelligence, industrial Internet of Things (IIoT), and automation systems. These can be conducted in collaboration with technology providers, industry partners, or professional bodies like SIRIM or IEEE. Faculty can also be encouraged to participate in industry secondments or short-term placements, allowing them to gain first-hand exposure to smart manufacturing technologies and practices.

By implementing these recommendations, OUM can ensure that its graduates are better equipped for the demands of modern manufacturing environments and remain competitive in the evolving Industry 4.0 landscape.

CONCLUSION

The demand for a highly skilled workforce in sustainable smart manufacturing continues to grow as industries adopt advanced automation, digital technologies, and sustainable production methods. This study has highlighted key competency gaps among Malaysian Open University (OUM) students currently employed in manufacturing roles. While students demonstrate a strong foundation in theoretical knowledge, they often require further technical training and practical exposure to meet the evolving demands of Industry 4.0 and sustainability-focused manufacturing.

To enhance the employability of OUM students and ensure they are well-prepared for careers in this sector, several key improvements must be implemented. Integrating advanced technical training into the curriculum is essential to equip students with hands-on experience in automation, robotics, data analytics, and digital manufacturing systems. This approach will bridge the gap between academic learning and real-world industry applications, enabling graduates to confidently apply their skills in a high-tech manufacturing environment.

Additionally, strengthening industry partnerships is crucial in providing students with hands-on learning opportunities. Establishing collaborations with leading manufacturers will create avenues for internships, apprenticeships, and industry-led training programs. These initiatives will allow students to gain practical insights and experience with real manufacturing systems, enhancing their readiness for future employment.

Another key strategy is the implementation of competency-based assessments. Traditional exams often fail to measure practical skill proficiency, whereas competency-based evaluations focus on real-world applications of knowledge and technical expertise. By incorporating practical assessments, case studies, and live industrial projects, students can demonstrate their problem-solving abilities, technical competencies, and adaptability to smart manufacturing environments.

Furthermore, continuous updates to educational programs are necessary to align with rapid technological advancements and shifting industry requirements. Sustainable smart manufacturing is an evolving field, requiring universities to regularly revise curricula, integrate emerging technologies, and include sustainability-driven methodologies. A flexible and industry-responsive education system will ensure that OUM graduates remain competitive in the job market.

By addressing these critical areas, OUM can significantly improve students' employability and readiness for the future of smart and sustainable manufacturing. A well-prepared workforce will not only benefit individual graduates but also contribute to Malaysia’s industrial growth and global competitiveness in advanced manufacturing sectors. Moving forward, a collaborative approach between academia, industry, and policymakers will be essential in building a resilient, innovative, and sustainability-driven manufacturing workforce

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