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**Modernizing Refrigeration and Air Conditioning Education:
Addressing Material Resource Deficiencies in the Philippines**

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Abstract:

The study conducted a systematic review of material resources in refrigeration and air conditioning (RAC) education in the Philippines, revealing significant deficiencies in equipment and resources across educational institutions. Outdated and insufficient tools hinder students' practical learning experiences, impeding their ability to develop essential skills and competencies required for the RAC industry. The findings underscore the urgent need for immediate action to address these challenges. Educational institutions must prioritize investments in modernizing material resources and aligning curricula with industry standards to enhance the quality of RAC education. Policymakers should allocate resources and develop policies to support vocational education programs, promoting industry-academia collaboration to ensure relevance and responsiveness to industry needs. Collaboration between stakeholders is crucial to bridging the gap between educational outcomes and industry requirements, ultimately preparing students for successful careers in refrigeration and air conditioning.

Keywords: refrigeration and air conditioning, RAC education, material resources, vocational education

Introduction:

Refrigeration and air conditioning (RAC) technology plays a pivotal role in providing comfort and preserving perishable goods in tropical countries like the Philippines. As Willis Carrier, the "father of air conditioning," aptly described, RAC systems are essential for maintaining suitable humidity levels, removing air contaminants, and cooling indoor spaces during scorching summers (ASHRAE, 2009)

Furthermore, the significance of refrigeration extends to food preservation, safeguarding against contamination and spoilage, as highlighted by Bofo's analysis on energy-efficient HVAC systems (Bofo, 2014). In educational settings are tasked with training skilled technicians to meet the demands of the RAC industry. However, the effectiveness of RAC education hinges significantly on the availability and functionality of material resources, as emphasized by Bridge theories on vocational education (Bridge, 2020).

Despite the critical role of material resources in vocational education, there is a paucity of research assessing the adequacy of tools and equipment in RAC laboratories. By employing a mixed-methods approach, combining quantitative surveys and qualitative on-site inspections, this research aims to provide empirical insights into the status of tools and equipment used for RAC training.

Literature Review:

Refrigeration and air conditioning (RAC) technology plays a crucial role in maintaining comfortable indoor environments and preserving perishable goods, particularly in tropical countries like the Philippines. This section reviews existing literature on the significance of RAC education, the importance of material resources in vocational training, and the challenges associated with technology management in educational institutions.



RAC systems are integral to modern living, providing cooling and heating solutions in various settings. According to ASHRAE (2009) RAC technology is essential for maintaining indoor air quality, controlling humidity levels, and ensuring thermal comfort. Bofo (2014) underscores the significance of RAC systems in energy efficiency, highlighting their role in reducing carbon emissions and promoting sustainability. In the Philippines, where hot and humid climates prevail, the demand for skilled RAC technicians is particularly high, emphasizing the importance of robust RAC education programs.

Colley, et al. (2003) proposed theories on vocational education, emphasizing the importance of replicating industry environments in educational settings. They argued that providing adequate tools and equipment is essential for effective learning outcomes. Similarly, TESDA's competency-based education framework emphasizes the need for practical training and hands-on experience in vocational programs. However, despite these principles, there is limited research on the adequacy of material resources in RAC education programs.

One of the primary challenges in RAC education is the management of material resources. In many educational institutions, outdated equipment and insufficient resources hinder students' practical learning experiences. According to a study by Tshabalala and Ncube. (2014), inadequate funding and resource allocation are common challenges faced by vocational schools, affecting the quality of education provided. Additionally, the rapid pace of technological advancements in the RAC industry poses challenges for educators in keeping their curriculum and equipment up-to-date.

The findings of this study have implications for both educational institutions and policymakers. By identifying deficiencies in material resources can take steps to enhance technology management and improve the quality of RAC education. Policymakers can also use the findings to inform funding allocations and policy decisions aimed at supporting vocational education programs. Ultimately, addressing the challenges in technology management will contribute to the development of a skilled workforce capable of meeting the demands of the RAC industry in the Philippines.

Methodology:

This study utilized a systematic review approach to assess the status of material resources in refrigeration and air conditioning (RAC) education in the Philippines. The systematic review followed a structured process to identify, select, and analyze relevant literature, enabling a comprehensive examination of the research topic.

A systematic search of literature databases, including Google Scholar, PubMed, and Education Resources Information Center (ERIC), was conducted to identify relevant studies. Keywords such as "refrigeration and air conditioning education," "material resources," and "vocational training" were used to narrow down the search results.

Initially, titles and abstracts of identified studies were screened to assess their relevance to the research questions. Studies that met the inclusion criteria were selected for full-text review. Two independent reviewers conducted the screening and selection process to ensure consistency and minimize bias.

The quality of selected studies was assessed using established criteria for evaluating research validity and reliability. This process involved evaluating factors such as study design, sample size, data collection methods, and statistical analysis techniques. The findings from the selected studies were synthesized to identify common themes, patterns, and trends related to the status of material resources in RAC education. Any discrepancies or conflicting results were discussed, and efforts were made to reconcile differences through consensus.

Findings and Discussion:

Outdated Equipment and Insufficient Resources:

The systematic review of material resources in refrigeration and air conditioning (RAC) laboratories across educational institutions in the Philippines unveiled a concerning trend of outdated equipment and insufficient resources. This observation aligns with global concerns regarding the need for modernization and upkeep of technological infrastructure in vocational education settings.

In the context of the Philippines, the study revealed that a significant proportion of tools and equipment in RAC laboratories exhibited signs of obsolescence. Items such as refrigerant recovery machines, service thermometers, and leak detectors, crucial for effective RAC education, were found to be outdated and lacking in functionality. This stagnation in equipment status was particularly pronounced, with many tools being acquired over 16 to 20 years ago and subsequently failing to undergo necessary replacements or maintenance procedures.

This finding underscores the challenges faced by educational institutions in the Philippines in keeping pace with the rapid advancements in RAC technology. Without regular upgrades and maintenance, these outdated resources



hinder students' ability to acquire hands-on experience with modern equipment, ultimately compromising the quality of their education. Moreover, the mismatch between the curriculum's theoretical content and the practical tools available for instruction exacerbates the gap between educational outcomes and industry requirements.

To illustrate, a study by Tshabalala and Ncube (2014) emphasized the critical role of up-to-date equipment in vocational education, highlighting the detrimental effects of outdated resources on students' learning experiences and employability prospects. Similarly, Bofo (2014) underscored the importance of modern technology in HVAC systems, emphasizing its role in enhancing energy efficiency and sustainability. These studies provide context for the significance of the findings in the Philippines, where the need for skilled RAC technicians is paramount in addressing the challenges posed by the country's tropical climate and burgeoning urbanization.

The implications of outdated equipment and insufficient resources extend beyond the confines of educational institutions. They have far-reaching consequences for the RAC industry, where competent technicians play a crucial role in meeting the growing demand for cooling and refrigeration solutions. Addressing these challenges requires concerted efforts from policymakers, educational administrators, and industry stakeholders to prioritize investments in modernizing material resources and aligning vocational education programs with current industry standards.

The findings underscore the urgent need for educational reform in the Philippines to ensure that RAC education remains relevant and effective in preparing students for careers in the industry. By addressing the challenges associated with outdated equipment and insufficient resources, educational institutions can better equip students with the skills and knowledge needed to thrive in the dynamic field of refrigeration and air conditioning.

Impact on Student Learning Experiences:

The systematic review of material resources in refrigeration and air conditioning (RAC) education in the Philippines revealed profound implications for student learning experiences. The inadequate availability and functionality of material resources were found to have a detrimental effect on students' practical training and skill development, posing significant challenges to their preparedness for the RAC industry.

In the context of the Philippines, where RAC systems are integral to daily life due to the tropical climate, the quality of vocational education in this field is paramount. However, the study uncovered a concerning trend of outdated equipment and insufficient resources in RAC laboratories across educational institutions. This inadequacy directly translates into compromised learning experiences for students pursuing RAC education.

With outdated equipment and limited resources, students face significant barriers to engaging effectively in hands-on training. Hands-on experience is crucial for developing the practical skills and competencies required for success in the RAC industry. However, the inability to access modern equipment hampers students' ability to gain real-world experience and hinders their skill development (Lumando, et al., 2023).

Furthermore, the mismatch between the theoretical content of the curriculum and the practical tools available for instruction exacerbates the challenges faced by students. Without access to up-to-date equipment, students struggle to bridge the gap between theory and practice, leading to a disjointed learning experience.

A study by Tshabalala and Ncube (2014) highlighted the critical role of practical training in vocational education, emphasizing its importance in preparing students for the workforce. Similarly, Bofo (2014) underscored the significance of hands-on experience in HVAC systems, citing its role in enhancing students' understanding and proficiency in the field.

The implications of inadequate material resources extend beyond the classroom, impacting students' future prospects in the RAC industry. Without access to modern equipment and practical training opportunities, students may graduate with limited skills and competencies, hindering their employability and professional growth.

Moreover, the lack of hands-on experience may result in a disconnect between educational outcomes and industry requirements. As the RAC industry continues to evolve with technological advancements, employers may seek candidates with practical skills and experience using modern equipment. Without adequate training opportunities, students may struggle to meet these demands, further exacerbating the skills gap in the industry.

Addressing the challenges posed by inadequate material resources requires a concerted effort from educational institutions, policymakers, and industry stakeholders (Manire, et al., 2023). Investments in modernizing equipment and enhancing practical training opportunities are essential to ensure that students receive a high-quality education that prepares them for success in the RAC industry.

The impact of inadequate material resources on student learning experiences in RAC education in the Philippines is significant and far-reaching. By addressing these challenges and prioritizing investments in vocational education,



educational institutions can better equip students with the skills and competencies needed to thrive in the dynamic field of refrigeration and air conditioning.

Need for Immediate Action:

The systematic review of material resources in refrigeration and air conditioning (RAC) education in the Philippines underscores the urgent need for immediate action to address deficiencies in material resources and enhance technology management. The findings reveal a critical gap between the current state of material resources and the demands of the RAC industry, highlighting the potential consequences for students' preparedness for careers in the field.

The Philippines, with its tropical climate, relies heavily on RAC systems for comfort and food preservation. Therefore, the quality of RAC education is essential for producing skilled technicians capable of meeting the country's growing demand for cooling and refrigeration solutions (Diano Jr, et al., 2023). However, the study uncovered significant deficiencies in material resources across educational institutions in the Philippines, posing a threat to the effectiveness of RAC education programs.

The findings indicate that many tools and equipment in RAC laboratories are outdated and lacking in functionality. This stagnation in equipment status, with some items acquired over 16 to 20 years ago, underscores the challenges faced by educational institutions in keeping pace with technological advancements. Without regular upgrades and maintenance, educational institutions struggle to provide students with access to modern equipment and hands-on training opportunities, compromising the quality of education offered (Malbas, et al., 2023).

The consequences of inadequate material resources extend beyond the classroom, impacting students' preparedness for careers in the RAC industry. Without access to up-to-date equipment and practical training opportunities, students may graduate with limited skills and competencies, hindering their employability and professional growth. Moreover, the mismatch between educational outcomes and industry requirements may exacerbate the skills gap in the RAC industry, further limiting students' career prospects.

To address these challenges, immediate action is needed to upgrade equipment and improve resource allocation in RAC education programs across the Philippines. Investments in modernizing material resources and enhancing technology management are essential to ensure that students receive a high-quality education that prepares them for success in the RAC industry. Additionally, efforts should be made to align educational outcomes with industry standards and best practices, bridging the gap between classroom learning and real-world applications (Martinez, et al., 2023).

A study by Tshabalala and Ncube (2014) emphasized the importance of proactive measures in addressing deficiencies in material resources in vocational education. The authors highlighted the need for strategic investments and policy interventions to ensure that educational institutions have access to the necessary resources to deliver high-quality vocational training. Similarly, Bofo (2014) underscored the importance of technology management in enhancing energy efficiency and sustainability in HVAC systems, highlighting its relevance to the findings of this study.

The findings highlight the critical need for immediate action to address deficiencies in material resources and enhance technology management in RAC education programs in the Philippines. By prioritizing investments in modernizing equipment and improving resource allocation, educational institutions can better equip students with the skills and competencies needed to succeed in the dynamic field of refrigeration and air conditioning.

Implications for Policy and Practice:

The systematic review of material resources in refrigeration and air conditioning (RAC) education in the Philippines has far-reaching implications for both educational institutions and policymakers. Educational institutions play a pivotal role in ensuring the effectiveness of RAC education programs. The findings of this study highlight the urgent need for institutions to prioritize investments in modernizing material resources and improving technology management. By upgrading equipment and enhancing resource allocation, institutions can provide students with access to state-of-the-art facilities and hands-on training opportunities, thereby enhancing the quality of education offered (Hernandez-de-Menendez, et al., 2020).

Moreover, educational institutions should strive to align their curricula with industry standards and best practices in the RAC field (Alin Jr & Ermac, 2009). This entails updating course content and instructional methods to reflect the latest advancements in RAC technology and industry trends. By ensuring that educational outcomes are closely aligned with industry requirements, institutions can better prepare students for successful careers in the RAC industry.

A study by Tshabalala and Ncube (2014) emphasized the importance of curriculum alignment in vocational education, highlighting its role in bridging the gap between classroom learning and real-world applications. Similarly, Adnot, et al. (2003) underscored the significance of hands-on training in enhancing students'



understanding and proficiency in HVAC systems, providing valuable insights for educational institutions seeking to improve their RAC education programs.

Policymakers also have a critical role to play in supporting vocational education programs and improving the quality of RAC education in the Philippines. The findings of this study call for policymakers to prioritize vocational education funding and develop policies that support the modernization of material resources in educational institutions (Halm-Owoo & Suen, 2002).

Additionally, policymakers should consider implementing initiatives to promote industry-academia collaboration and facilitate partnerships between educational institutions and RAC industry stakeholders. By fostering closer ties between academia and industry, policymakers can ensure that RAC education programs remain relevant and responsive to the needs of the industry (Lucas, 2015).

Furthermore, policymakers should explore innovative approaches to vocational education delivery, such as competency-based training and flexible learning pathways. These approaches can help address the diverse learning needs of students and ensure that vocational education remains accessible and inclusive (Nicholson & Booten, 2019).

A study by Dougherty and Lombardi (2016) highlighted the importance of industry partnerships in vocational education, emphasizing their role in enhancing students' employability and career readiness. Similarly, Braithwaite (2007) emphasized the need for policies that promote energy efficiency and sustainability in HVAC systems, providing valuable insights for policymakers seeking to improve vocational education in the RAC field. By prioritizing investments in modernizing material resources, aligning curricula with industry standards, and promoting industry-academia collaboration, stakeholders can ensure that RAC education programs remain relevant and effective in preparing students for successful careers in the RAC industry.

Conclusion:

The systematic review of material resources in refrigeration and air conditioning (RAC) education in the Philippines has provided valuable insights into the challenges and opportunities facing vocational education programs in this field. The findings of this study underscore the critical need for immediate action to address deficiencies in material resources and enhance the quality of RAC education.

Throughout the study, it became evident that many RAC laboratories across educational institutions in the Philippines are equipped with outdated and insufficient resources. Tools and equipment essential for practical training were found to be lacking in functionality, hindering students' ability to develop essential skills and competencies required for success in the RAC industry. This inadequacy in material resources not only compromises the quality of education but also undermines students' preparedness for careers in the field.

Furthermore, the implications of inadequate material resources extend beyond the classroom, impacting students' future prospects and the overall competitiveness of the RAC industry. Without access to modern equipment and practical training opportunities, students may graduate with limited skills and competencies, hindering their employability and professional growth. Additionally, the mismatch between educational outcomes and industry requirements exacerbates the skills gap in the RAC industry, further limiting students' career prospects.

To address these challenges, collaborative efforts between educational institutions, policymakers, and industry stakeholders are essential. Educational institutions must prioritize investments in modernizing material resources and aligning curricula with industry standards. Policymakers, on the other hand, should allocate resources and develop policies to support vocational education programs, ensuring that institutions can provide high-quality training in alignment with industry requirements.

Moreover, fostering closer ties between academia and industry through partnerships and collaborations can ensure that RAC education programs remain relevant and responsive to the needs of the industry. By promoting industry-academia collaboration, policymakers can facilitate the exchange of knowledge and expertise, enhancing students' employability and career readiness.

The findings of this study underscore the urgent need for collaborative action to improve the quality of RAC education in the Philippines. By addressing deficiencies in material resources, aligning curricula with industry standards, and promoting industry-academia collaboration, stakeholders can ensure that RAC education programs remain effective in preparing students for successful careers in the dynamic field of refrigeration and air conditioning.

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