Mastery of Air Conditioning System Installation Skills: A Case Study

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Article History: Received 24 Ogos 2024; Revised 22 September 2024;
Accepted 28 October 2024

Abstract

Mastery of skills in Technical and Vocational Education and Training (TVET) is important to address the demands of the growing labor market and foster human capital development. TVET plays an important role in equipping individuals with the necessary technical knowledge and practical skills to thrive in various industries. This is because assessing the level of competency mastery among students is important to assess the effectiveness of the TVET program and ensure that graduates have the skills required for employment. However, there are challenges, such as skill gaps in the mastery of hands-on skills among students. This study looked at the extent to which Kolej Komuniti Tasek Gelugor (KKTG) students mastered air conditioning system installation skills. A total of 19 respondents from Semester 2 Air Conditioning Technology Certificate students at KKTG were selected for this study. The objective of this study is to identify students' basic knowledge, the cause of students' weaknesses, and the level of students' interest in basic air conditioning system installation skills. The research method used is a quantitative study, which is done through a questionnaire instrument. The results of the study show the average level of respondents, where 91% of respondents have basic knowledge of domestic air conditioning system installation skills. An average of 84.9% of respondents gave a positive response to the indication of weakness in air conditioning system installation skills. In addition, the study also found that an average of 94.7% of respondents had a positive interest in basic air conditioning system installation skills. This study clearly shows that respondents have a high level of mastery of the basics of air conditioning system installation. Therefore, this study is expected to help TVET institutions such as KKTG produce a highly skilled and competent workforce, increase the marketability of students, and further contribute to the overall progress of technical education in the region.

Keywords: Air condition; Knowledge; Level; Mastery; Refrigeration; Skills.

1.0 Introduction

Since independence, our country has achieved various advances in various sectors and industries. Among them is the education sector, where the country is growing in line with the growth of the motherland as a developing country. The number of graduates produced by the Institute of Higher Education (IPT) every year reflects the ability of our young generation to obtain education at the *tertiary* level to seize job opportunities. In Malaysia, Technical

and Vocational Education and Training (TVET) is a major contributor to socio-economic development. However, there are ongoing challenges related to governance and policy implementation that must be addressed to improve public perception and increase enrollment in TVET programs (Aziz and Subramaniam, 2023). Community College, as one of the TVET institutions, offers a variety of programs that go beyond vocational training, where it creates partnerships with industry to address regional needs in producing a highly skilled workforce. It can also increase the marketability of students and further contribute to the overall progress of technical education in the region. Therefore, the level of implementation of theory, practice, and skills in community colleges is the main pulse in ensuring that TVET graduates master technical knowledge and skills.

Vocational Education Transformation has been implemented to mainstream Technical and Vocational Education and Training or its synonym (TVET), in the national education system. This aims to ensure that Malaysia does not fall behind in adapting to the Industrial Revolution (IR 4.0). TVET is an education and training process with the main emphasis on industry practice. According to Aziz and Subramaniam (2023), the increased focus on TVET in recent years is reflected in its prominence in the 11th and 12th Malaysia Plans. Community colleges are one of the TVET institutions that play an important role in providing students with training and expertise in a particular field. This statement is supported by Ali et al., (2018), TVET can produce highly skilled workers to achieve the status of a developed and high-income country. Every course offered at TVET institutions is developed to meet today's job and career needs. Courses such as the Refrigeration and Air Conditioning Technology Certificate Program at Kolej Komuniti Tasek Gelugor (KKTG) have been developed to meet the high demand in this industry. This course provides students with practical as well as theoretical skills in the fields of air conditioning and refrigeration engineering technology. The mastery of students in air conditioning system installation skills is very important for their success in this field. Comprehensive education and training play an important role in ensuring that students acquire the necessary theoretical knowledge and practical skills. Through practical experience and effective supervision, students can develop their ability to perform installations correctly and safely. Technical skills are the ability to apply specific knowledge and expertise in performing tasks.

This clearly shows that knowledge and skills are interrelated and produce students who have high mastery and skills in hands-on activities. Knowledge is specific information required by individuals, and their skills are either in daily activities, tasks, or hands-on activities (Abdul Hamid, 2004). Hands-on activities help in the development of critical skills such as problem solving, critical thinking, and the ability to work in a team. Students learn how to tackle practical challenges and find effective solutions. By integrating more hands-on activities into the TVET program, students will be better prepared to meet the needs of the industry and face the challenges of the real world of work.

As a TVET institute under the Malaysian Ministry of Higher Education, Community College is the post-secondary education institute of choice for Sijil Pelajaran Malaysia (SPM) graduates who are interested in technology and vocational skills-based studies. KKTG offers skilled programs, namely the Refrigeration and Air Conditioning Technology Certificate and the Pastry Certificate. According to Sungkedkit and Thaenkaew (2022), vocational education students can improve their efficiency through self-directed learning, focusing on areas such as air conditioning installation, electrical system installation, and maintenance. This is to ensure that the student is proficient in a certain skill, especially complex problems in the field of engineering. Consequently, the attainment of mastery, encompassing both knowledge and a keen interest in a particular skill, is achieved by students prior to the completion of their studies.

Problem-solving skills require a person's ability to use the mind to explore ideas and overcome shortcomings or obstacles to achieve the set objectives (Ismail F. et al., 2020). This statement is supported by Che Meh N.H. and Aton M.G. (2022). The process of developing critical thinking skills and problem solving needs to be developed and practiced continuously in the curriculum to produce students who are active in learning. This is because employers are not interested in hiring employees who are unable to think of ways to solve problems despite having excellent academic qualifications (Belecina and Ocampo, 2018). In addition, the job market now requires competitive and skilled workers.

Good skills in the field of TVET can help improve the effectiveness of organizational management and a conducive environment, such as the maintenance and installation of effective air conditioning systems. However, studies related to the level of basic knowledge and the practice of continuous supervision of students are limited to specialized TVET programs. This study fills in a big gap by focusing on the Skill Acquisition Theory (SAT), which says that learning a skill has cognitive, associative, and autonomous stages. These stages are necessary for the thorough training needed in fields like installing air conditioning systems (Abdul Hamid, 2004; Belecina and Ocampo, 2018). Besides that, the study important to address the gap in understanding students' mastery of air conditioning system installation with a focus on practical application and hands-on skill development.

This study aims to address this gap by identifying students' foundational knowledge, analyzing the causes of skill weaknesses, and assessing their interest in air conditioning system installation. The findings will underscore the importance of incorporating practical skill-building into the TVET curriculum, which is essential for preparing graduates to meet the demands of a competitive job market. According to Yiga (2022), factors such as skill proficiency, training quality, and alignment with market needs significantly impact employability. Additionally, the insights gained can inform policymakers in refining vocational education strategies to better support Malaysia’s industrial needs, ultimately enhancing the employability and marketability of TVET graduates.

2.0 Methodology

The objective of this study is to ascertain students' fundamental understanding, determine the factors contributing to students' deficiencies, and assess the level of students' enthusiasm towards acquiring skills in air conditioning system installation. The study design entails a survey methodology. Thus, the study was ethically bound in every respect, and participant rights were protected. The informed consent of the respondents was taken before actual data collection. They were provided with information on the purpose of the study, that participation was voluntary, and that they could withdraw from it anytime without penalty. The research was carried out at KKTG located in Penang. The selection of this area was based on its many traits that align with the study's objectives.

2.1 Demographics and Sample Size

The study employed a purposive sampling technique to target a specific group of students enrolled in the Air Conditioning Technology Certificate course at KKTG, during Semester 2, Session II of the 2023/2024 academic year. This sampling method was chosen to ensure that participants possess relevant experience and knowledge regarding air conditioning system installation, aligning closely with the study's objectives. Of the 21 students in the course, 19 participated in the study, yielding a high response rate (90.5%), which contributes to the representativeness and reliability of the findings.

2.2 Research Instrument

The desired information was obtained using a questionnaire instrument. Chua Yan Piaw (2014) asserts that questionnaire instruments are very ideal for survey research due to their ability to generate dependable items. This study employed a modified questionnaire derived from the research conducted by Ariffin et al. (2018). To establish content validity, the modified questionnaire was sent for expert reviewers in TVET education and air conditioning technology. They assessed the relevance and appropriateness of the questionnaire with particular emphasis on items-things that show knowledge, skills gaps, and interest levels relevant to this study. The reliability of the questionnaire was measured by conducting a pilot test on a similar group of TVET students from another semester in KKTG.

The questionnaire consists of seven items in each portion. The feedback for this part utilizes two response options, specifically Yes and No. Chua Yan Piaw (2014) states that the 'Yes' and 'No' scale necessitates a definitive response to the presented option. A response that is affirmative is assigned a score of 1, whilst a response that is negative is assigned a score of 0. This questionnaire is segmented into four distinct sections, specifically:

i. Section A: Demographic Information
ii. Section B: Assess the student's fundamental understanding of skills related to the installation of domestic type air conditioning systems
iii. Section C: Identifying Students' Skill Weaknesses in Air Conditioning System Installation
iv. Section D: Identifying Students' Skill Interests in Air Conditioning System Installation.

3.0 Results and Discussion

The study reveals that students' learning profiles, including age, gender, educational background, and prior experience in air conditioning systems, significantly influence their skill acquisition rates. Most students have basic knowledge of domestic air conditioning system installation. Students show high levels of interest and enthusiasm for basic air conditioning system installation, which can be a catalyst for skill development.

3.1 Demographics of the Study Sample

19 students from the Air Conditioning Technology Certificate course at KKTG Session II 2023/2024 completed the questionnaire administered through google forms. Data from the questionnaire has been collected and analyzed using Microsoft Excel software. Figure 1 shows the number of respondents by gender. Based on Figure 1, the total number of male students is 94.7%, which is 18 people, and female students are 5.30%, equal to one student.

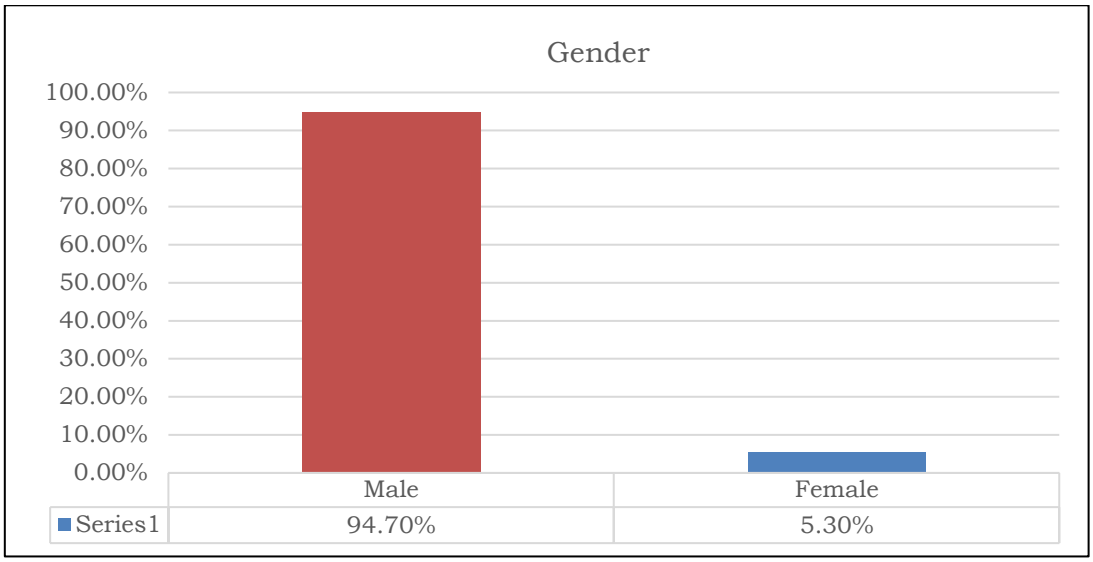

Figure 1: The number of respondents by gender

3.2 Basic Knowledge of Students in Domestic Air Conditioning System Installation Skills

Data analysis from the questionnaire that has been carried out found that students' basic knowledge of domestic air conditioning system installation skills is at a high level. This is because based on the findings from Table 1, seven items agree (B1=100%, B2=94.7%, B3=89.5%, B4=100%, B5=100%, B6=89.5%, B7=63.2%) and seven items disagree (B1=0, B2=5.3%, B3=10.5%, B4=0, B5=0, B6=10.5%, B7=36.8%). The three items that have the highest percentage value of 100% involve "I know the basic skills of air conditioning system installation," I know the basic equipment in air conditioning system installation work," and "I know the flaring process." This finding shows that respondents can develop the skills needed to install domestic air conditioning systems more effectively. The importance of providing students with a solid foundation in the basic principles and working mechanisms of air conditioning systems is highlighted to meet the growing demand for skilled professionals in the field (Lokesh and Vinay, 2024).

These findings closely align with the first objective, which aims to assess students' foundational knowledge of air conditioning system installation. This foundational understanding is crucial, as Skill Acquisition Theory (SAT), emphasizes the transition from declarative knowledge, which entails comprehending laws and facts, to procedural knowledge, which is the capacity to carry out tasks automatically and effectively (DeKeyser 2020). By building a solid theoretical framework, students are better equipped to acquire and refine the hands-on skills essential for proficiency in air conditioning installation." The consistency of high agreement levels among students suggests that instructional methodologies at KKTG may be effective in conveying the core principles and introductory skills necessary for successful installation work.

While the item "I have basic knowledge of air conditioning system installation skills before entering KKTG" contributed 63.2%. This shows that half of the respondents knew the basics related to the installation of air conditioning systems before entering KKTG. According to Muhamad Shafiq and Noraini (2018), the factors that contribute to students' academic achievement are the result of learning methods, the teacher's teaching approach, and the students' own attitudes. At KKTG, the targeted teaching methods employed by lecturers appear to significantly enhance students' practical understanding, as evidenced by high agreement levels across items related to equipment knowledge and procedural skills. This observation aligns with objective two, which focuses on identifying factors contributing to students' knowledge gaps. The literature highlights elements such as a well-structured curriculum and hands-on training as key influences on successful skill acquisition (Lokesh and Vinay, 2024), emphasizing the importance of effective instructional strategies in bridging these gaps.

From the analysis obtained from Table 1, the students' basic knowledge of domestic air conditioning system installation skills is at a high level. Here's an improved continuity version for your statement:

Aligning with objective three, which aims to measure students' interest and enthusiasm, the strong levels of basic knowledge reported may positively correlate with heightened engagement and interest in air conditioning skills. This suggests that a solid foundation in theoretical knowledge can foster a greater enthusiasm for practical skill development. This statement is supported by Sungkedkit and Thaenkae (2022), which is that students who undergo air conditioning training are expected to acquire important skills in air conditioning installation, electrical system installation, and maintenance. Therefore, teaching staff or lecturers help improve students' basic knowledge about air conditioning system installation.

Table 1: Basic Knowledge of Students in System Installation Skills Domestic Type Air Conditioning

No	Item	Yes	No
B1	I know the basic skills of air conditioning system installation	100%	0
B2	I know the process in the air conditioning cycle	94.7%	5.3%
B3	I know the basics of electricity in an air conditioning system	89.5%	10.5%
B4	I know the basic equipment in air conditioning system installation work	100%	0
B5	I know the flaring process	100%	0
B6	I know the brazing process	89.5%	10.5%
B7	I have basic knowledge of air conditioning system installation skills before entering Tasek Gelugor Community College	63.2%	36.8%

3.3 Weaknesses of students in air conditioning system installation skills

Indicators of student weakness in installation skills are important to identify the level of student weakness for domestic-type air conditioning systems. Based on table 2, a total of seven items agree (C1=100%, C2=78.9%, C3=78.9%, C4=94.7%, C5=94.7%, C6=84.2%, C7=63.2%) and seven items do not agree (C1=0, C2=21.1%, C3=21.1%, C4=5.3%, C5=5.3%, C6=15.8%, and C7=36.8%). The item "I understand the basic skills of air conditioning system installation" contributed to a high percentage of 100%. This shows that all students are focused during the teaching and learning session through hands-on activities. According to Hassan et al., (2020), the implementation of hands-on activities during teaching and learning is effective in encouraging students to think critically and creatively and in fostering students' interest in deepening this course. This activity encourages students to think critically and creatively and fosters students' interest in easily understanding the basic skills of air conditioning system installation. This suggests that while students are generally competent in foundational areas, they may struggle with more advanced diagnostic skills, an observation that aligns with objective two that is identifying the causes of students' weaknesses in installation skills.

While the item "I am able to handle the basic/main tools in the process of installing the air conditioning system" has the second highest percentage, which is 94.7%, An understanding of operating machine tools is important for students taking skills courses. This is because, according to Shah (2002), through practical training, an individual acquires physical skills, from the simple to the formation of a very complex attitude. The last item, "I can detect a problematic circuit by using a multimeter," has a percentage value of 63.2% of respondents who understand the use of a multimeter. In addition, the development of training sets and self-learning frameworks can significantly improve students' competence in air conditioning installation, electrical system installation, and maintenance, leading to lifelong learning and skill development (Sungkedkit and Thaenkae, 2022).

While many students demonstrate solid basic skills—reflected by strong consensus on fundamental installation tasks—their challenges with advanced tool-handling and diagnostic abilities underscore the need for a more thorough training approach. Emphasizing complex, scenario-based exercises and incorporating adaptive learning resources can transform students' foundational knowledge into higher-order skills. Research indicates that employability skills are effectively developed using air conditioner simulators, which often outperform traditional work-based training (Jama et al., 2021), by enhancing practical competencies and preparing students for real-world applications. Therefore, instructors can strategically design the curriculum to vary and gradually increase the difficulty of diagnostic tasks, ensuring that students achieve a comprehensive mastery of air conditioning installation skills in line with industry standards.

Table 2: Indicators of Student Weaknesses in System Installation Skills Domestic Type Air Conditioning

No	Item	Yes	No
C1	I understand the basic skills of air conditioning system installation	100%	0
C2	I am able to explain the process in the refrigeration cycle well	78.9%	21.1%
C3	I was able to do the wiring correctly	78.9%	21.1%
C4	I am able to handle the basic/main tools in the process of installing the air conditioning system	94.7%	5.3%
C5	I was able to do the flaring process well	94.7%	5.3%
C6	I am able to do the brazing process well	84.2%	15.8%
C7	I can locate the faulty circuit using a multimeter	63.2%	36.8%

3.4 Student Interest in Basic Air Conditioning System Installation Skills

Based on Table 3, which is the student's interest in basic air conditioning system installation skills, a total of seven items agree (D1=94.7%, D2=94.7%, D3=94.7%, D4=94.7%, D5=84.2%, D6=100%, D7=100%) and seven items disagree (D1=5.3%, D2=5.3%, D3=5.3%, D4=5.3%, D5=15.8%, D6=0%, D7=0%). Through this analysis, it can help the teaching staff determine the level of interest of the students in the basic skills of air conditioning system installation. A high level of interest often serves as a strong motivator in skill development, suggesting that students who find the subject matter engaging and relevant to their career aspirations are more likely to persist and deepen their technical expertise. The study shows that intrinsic interest can enhance both learning outcomes and motivation, supporting objective three, which seeks to assess students' interest levels in these skills. When interest is high, students tend to engage more actively in the learning process, leading to improved competency in both technical skills and theoretical knowledge. Furthermore, effective practicum sessions—led by skilled instructors and conducted in well-equipped laboratories—are critical for hands-on skill development. Structuring these sessions to optimize learning outcomes is essential for maximizing students' skill acquisition (Berman et al., 2020).

This indirectly allows instructors or lecturers to plan appropriate learning programs to help students develop the skills needed in the field and further increase student motivation. The items "I understand the basic concept of installing an air conditioning system" and "The basic skills of installing an air conditioning system are fun" have a high percentage value of 100%. While four items have a percentage value of 94.7%, This shows that students tend to put more effort and focus into learning the skills. A high interest in air conditioning system installation skills can encourage students to achieve better academic achievement in the field (Taha et al., 2022). According to Liang, J. S. (2010), combining advanced technologies such as virtual reality, CAD graphics processing, and 2D animation in a scaffold-based learning environment can offer interactive and effective training for students in the repair and maintenance of automotive air conditioning systems, ultimately improving their knowledge and problem-solving skills. These approaches would provide scaffolded learning experiences for the students to rehearse their performances in simulated settings without exposing them to the risks and costs of hands-on practice. Indeed, in the domain of air conditioning systems, these technologies may not only sustain the level of engagement high but also improve knowledge gaps discussed under objective two.

Table 3 proves that a strong interest in air conditioning system installation skills can give students the impetus to improve their abilities and subsequently make career choices that suit their interests. However, simply relying on interest without structured, progressive challenges may not be sufficient for developing problem-solving skills, a critical component in technical vocations (Liang, 2010). Therefore, high levels of interest should be matched with a curriculum that systematically increases in complexity, guiding students from fundamental concepts to more challenging installation scenarios. Scaffold-based approaches, for example, can sustain engagement while progressively developing students' ability to tackle complex tasks, thereby supporting objective 1 of building a solid foundational knowledge base. This aligns with findings by Omar and Desa (2023), which indicate that students' perceptions of TVET programs significantly influence their engagement and mastery of skills.

Table 3: Indicators of Student Interest in Basic Air Conditioning System Installation Skills

No	Item	Yes	No
D1	I am interested in basic air conditioning system installation skills	94.7%	5.3%
D2	I give full concentration during the learning session	94.7%	5.3%
D3	I love repairing air conditioning systems	94.7%	5.3%
D4	I love studying air conditioning systems	94.7%	5.3%
D5	I like the challenge when the installation process is done	84.2%	15.8%
D6	I understand the basic concept of installing an air conditioning system	100%	0%
D7	Basic air conditioning system installation skills are fun	100%	0%

4.0 Conclusion

Proficiency in tasks such as the installation of air conditioning systems also enhances the outcomes of TVET, which can yield students who are exceptionally competitive. This study highlights the necessity of incorporating both basic and advanced technical skills into TVET curriculums to ensure the development of highly skilled, industry-prepared graduates.

The study demonstrates that students possess a robust comprehension of fundamental installation processes and theoretical knowledge, indicating the efficacy of the college curriculum in addressing the essential aspects of air conditioning systems. According to the data collected, this research demonstrates that KKTG students possess proficient knowledge and skills in the installation of residential air conditioning systems. All students exhibit proficient understanding of fundamental assembly techniques, the utilization of equipment, and assembly procedures, including flaring and brazing. Nevertheless, certain areas that want enhancement have been found, particularly in comprehending the cooling cycle procedure, accurate wiring, and identification of faulty circuits using a multimeter. Furthermore, the research indicates that there is a significant level of enthusiasm among students for acquiring and honing basic assembly skills, since most students demonstrate a profound interest and pleasure in the process of learning and applying these abilities.

Therefore, it is important to acknowledge that certain individuals require more enhancement in advanced proficiencies, particularly in the areas of problem-solving, system optimization, and the incorporation of contemporary technologies. A training program that prioritizes enhancing theoretical and practical knowledge in the refrigeration cycle and electrical wiring guarantees that students will have a comprehensive understanding and the ability to articulate this process effectively. It is crucial to provide students with rigorous training in using tools like multimeters to identify and resolve issues with circuits.

This training will enable them to rapidly detect and address problems in real-life scenarios. Furthermore, engaging in partnerships with the business sector to offer industry-specific training programs and opportunities to experience authentic work scenarios helps enhance students' comprehension and proficiency in a genuine professional setting. According to Thaenkaew and Sungkedkit (2020), a mastery learning self-study package was developed to improve air conditioning system practice skills.

Thus, to maintain the relevance of TVET courses like the Air Conditioning Technology Certificate, it is imperative to subject them to a more constructive reform process. This will ensure the continued sustainability and empowerment of the TVET profession in Malaysia. Implementing this proactive strategy would enhance the employability of students and positively impact the advancement of technical education in the region. Consequently, it will elevate the quality and applicability of vocational education programs in Malaysia. There are several limitations in this study's include its small sample size and concentration on KKTG, which may limit the findings' applicability to other TVET schools or technical courses.

Acknowledgements

The authors would like to extend their sincere gratitude to Kolej Komuniti Tasek Gelugor, Politeknik Tuanku Sultanah Bahiyah and Jabatan Pendidikan Politeknik & Kolej Komuniti that have made significant contributions to various part of this research endeavor.

Author Contributions

M.S. Yusof: Conceptualization, Abstract, Introduction, Discussion, Conclusion; **F. M Isa:** Methodology, Data Collection, Result, Discussion, Writing-Reviewing; **M.Z.Yahaya:** Result, Discussion and Writing-Reviewing

Conflicts of Interest

The manuscript is exclusive and has not been published anywhere, nor is it under consideration by any other journals. All authors have given their consent for the review, agree with the submission, and have declared that they have no conflicts of interest in relation to the work.

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