

PAPER

Enhancing Student Achievement through a Digital Learning Module: The TEFA-T Model in a Teaching Factory of Automotive Vocational Education

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ABSTRACT

This study is based on preliminary studies that identified the problem of suboptimal learning quality. The objective of the study is to develop a digital e-module within the teaching factory (TEFA) (TEFA)-T learning model as an effort to improve the academic achievements of automotive vocational students, ensuring the module is valid, practical, and effective. The study method is research and development (R&D) using the Instructional Development Institute (IDI) model development procedure, which consists of three stages: define, develop, and evaluate. The results of this study generally produce a comprehensive digital learning e-module design consisting of a cover, preface, table of contents, learning structure, learning patterns, e-module position map in learning, glossary, learning introduction, learning activities, evaluation, and closing. The TEFA-T learning e-module is statistically validated and practical. The average Aiken's V value obtained is 0.967, indicating that the digital e-module content is in the valid category. The TEFA-T learning e-module is considered very practical, as shown by the average practicality assessment scores of 92.20% from lecturers and 90.60% from students, both in the "Very Practical" category. In conclusion, after implementing the TEFA-T learning e-module, students can build knowledge inductively and deductively, as well as gain learning experiences through one-way interaction, personal interaction, and effective learning interaction, significantly improving student academic achievement (Sig. 2-tailed value is less than 0.05).

KEYWORDS

TEFA-T learning e-module, validity, practicality, effectiveness and academic performance of students

1 INTRODUCTION

The Fourth Industrial Revolution, often referred to as Industry 4.0, is a phenomenon that has been observed to transform various facets of human life. This includes

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changes in how people live, the dynamics of human-machine interaction, and the interactions among machines [1]. This transformation comprised technologies such as information technology, mobile communication, e-commerce, automotive technology, social media, internet-based communication, collaboration systems, cloud computing, and intelligent robots [2]. Based on these observations, higher education institutions need to incorporate the capability to anticipate rapid developments in technology. In this regard, their curricula and learning models should be in line with the demands of highly competitive industries and keep pace with the rapid advancements in information and technology. This is primarily important because it has been observed that the advent of each industrial revolution led to the reshaping of traditional work processes [3]. In particular, vocational education is the answer to producing a workforce capable of thriving in this digital age. Accordingly, the challenges and responsibilities of Technical and Vocational Education and Training (TVET) have become exceedingly important as they can produce technicians with skills that are relevant to industry demands [4, 5].

As established in previous research, in the 21st-century job market, the challenge of becoming a competitive automotive expert lies in the requirement for multifaceted skills and the capacity to proactively identify future career opportunities [6, 7]. It is also essential for experts to excel in communication as well as problem-solving skills, innovation, creativity, and critical thinking skills [8] in order to adequately develop the potential to manage systems. However, there is currently a gap between expectations and reality. Among automotive engineering students, certain competencies have seen a decline. Graduates in this field still often lack well-developed communication skills, problem-solving capabilities, creative thinking, and critical thinking skills [9, 7]. Based on these observations, it becomes essential for educational programs to incorporate more opportunities for students to develop soft skills [10]. Previous research has also emphasized the importance of developing innovative approaches to the educational system to continuously improve the learning process, thereby enhancing the skills and achievements of the students. In accordance with this understanding, the teaching factory (TEFA)-T model was developed as one of the student-centered models capable of making students actively engage in the learning process [11, 9]. Furthermore, the model was introduced with the primary goal of improving how knowledge, problem-solving skills, critical thinking, and intellectual abilities are being implemented [15].

Although the TEFA model is not a new learning approach, its integration with the troubleshooting concept can be regarded as an innovation within the field of automotive vocational education. This model effectively amalgamates and incorporates principles from multiple educational theories, which are being utilized in a logically structured sequence of activities. Furthermore, the TEFA-T possesses the capability to actively engage students by grounding the learning process in real-world motor vehicle-related tasks. This approach fosters collaborative problem-solving and encourages learners to share responsibility for resolving these challenges [12, 7]. Based on this comprehensive understanding, further development is essential to harness the full potential of the TEFA model when implemented. This model optimization was introduced to tackle the challenge of sub-optimal quality. Accordingly, after completing the development phase, it became imperative to create a “Learning E-module” that supports the effective and efficient execution of the TEFA-T model within the Department of Automotive Engineering.

As rightly stated in previous research, the development of interactive and innovative TEFA-T e-modules is very important due to the profound shifts in the education landscape and the influence of technological advancements on the learning

methods being adopted by students. In the past, education tended to be passive, where students received information from instructors via traditional teaching approaches. However, the present digital age is characterized by readily accessible information on the internet as well as the availability of and the express access exhibited by students to explore various technological tools. In this regard, the creation of interactive and innovative e-modules becomes an important stride in adapting to the evolving demands of education and equipping the younger generation to confront future challenges [13]. It is crucial to comprehend that when executed with the appropriate strategy, these e-modules can emerge as potent instruments for enriching the quality of learning and enhancing the academic performance of students. Accordingly, considering the crucial role played by technology in contemporary education, the development of interactive and innovative e-modules becomes increasingly pertinent in advancing educational effectiveness and achieving superior outcomes.

2 THEORETICAL REVIEW

2.1 Learning e-module of TEFT-T model

Learning e-modules, a concept widely embraced in education [14], serve as versatile tools used by individuals and institutions to create diverse materials, resources, and guidelines. As rightly observed by previous research, these materials help to foster the development of specific competencies and objectives, both realized and forthcoming. According to [15], a module constitutes a self-contained package of activities crafted to achieve a set of defined competencies and student objectives.

In this regard, [14] delineated modules as teaching materials designed for specific courses. Furthermore, innovative learning e-modules, as elucidated by [13] and [16], are instrumental tools within the field of education. These tools have been found to function either as replacements for or enhancements to conventional instructional models. It is also important to clarify that innovative e-modules are thoughtfully designed with a modern and creative approach to bolster instructional effectiveness [17]. Innovative e-modules come in diverse formats, comprising text, video, interactive software, or combinations of various media [1]. Additionally, the primary strength of these e-modules lies in their capacity to seamlessly integrate technology, visualization, and interactivity into the learning process. This integration aids students in comprehending and assimilating educational content more effectively [1]. Based on this understanding, it can be concluded that the approach cultivates greater engagement, relevance, and responsiveness to individual learning needs while concurrently nurturing their critical thinking, creativity, and problem-solving capabilities.

As rightly established by previous research, learning e-modules play a vital role in enhancing the effectiveness and efficiency of teaching materials, thereby aiding students in comprehending and applying relevant content [18]. Furthermore, these e-modules serve as valuable tools in helping students overcome challenges and elevating their academic performance [19]. It is also crucial to comprehend that these tools represent the support systems stemming from the development of the TEFA-T model in the field of automotive vocational education. In accordance with the results of previous investigations, the success of implementing the TEFA-T model largely hinges on the active participation of the students, making it imperative to engage with this innovative e-module [20].

A well-constructed e-module serves as a comprehensive resource for educators to teach specific topics through carefully planned activities that are all in line with designated learning outcomes (LO). Accordingly, the utilization of such e-modules has the potential to enhance the motivation level exhibited by students, pique their interest, and foster greater participation in the learning process. It also encourages the students to build confidence, showcase their talents, and improve collaborative skills, which significantly contribute to improved academic performance [15].

Before embarking on e-module development, it was deemed imperative to analyze the disparities that existed between the abilities possessed by each student, as emphasized by [14]. This analysis was vital, as it helps in ensuring that learning objectives can be attainable for all. Accordingly, [21] underscored that as the potential of students varies, so does their capacity to complete tasks and exercises. In this regard, proficient students should be presented with tasks that challenge their intelligence and imagination, hence enhancing their skills and talents [22]. On the other hand, weaker students should be assigned tasks that are suitable to their intelligence, capabilities, and talents, as advocated by [23].

According to previous research, the development of a learning e-module must adhere to established rules, standards, and procedures, ensuring that the resulting e-module is genuinely suitable and offers maximal benefits for enhancing the quality of the learning process [22]. Moreover, as stated by [24], a well-crafted e-module should prioritize practicality, making it accessible for students to study, understand, and absorb independently. This promotes individual learning, thereby granting students the opportunity and encouragement to learn autonomously, which, in turn, reduces the need for constant supervision by teaching staff or lecturers.

2.2 TEFA-T learning model

The proposed learning model, known as TEFA-T, represents a fusion of the TEFA concept with the troubleshooting approach. Furthermore, it operates on the fundamental principle of initiating new knowledge acquisition by utilizing the link-and-match methodology, with an emphasis on product quality as the starting point [6] and [25]. The development of this model was considered essential to harness the strengths and benefits of both the TEFA model and the troubleshooting approach within the field of automotive vocational education. In this regard, its foundational development concepts were drawn from the works of [26] and [27]. Simultaneously, the development of the troubleshooting methods was influenced by the methodologies put forth by [28], [29].

The development process yielded seven distinct learning syntaxes, comprising (1) troubleshooting the problem, (2) organizing the order, (3) collaborative problem-solving, (4) executing the order, (5) quality control, (6) presentation and discussion, and (7) assessment. The implementation of the proposed learning model brought about significant enhancements in the soft skills, task proficiency, academic performance, self-confidence, sense of responsibility, problem-solving prowess, and teamwork abilities exhibited by the students. It is also important to establish that the developed model syntaxes were ensured to meet stringent criteria for validity, practicality, and effectiveness, which rendered the parameters highly suitable for practical implementation. Moreover, in terms of comprehensive support, the TEFA-T model necessitated supplementation with another component, such as a learning e-module. This component was also ensured to adhere to the standards of validity, practicality, and effectiveness to confirm its compatibility with the objectives and success of the TRFA-T model.

3 RESEARCH METHOD

The research conducted follows a mixed-method approach, specifically combining Research and Development (R&D) with a quantitative perspective. This mixed-method approach was implemented in line with the framework proposed by [30] and [31], which integrated both quantitative and qualitative research approaches. Accordingly, as rightly established by previous observations, the incorporation of multiple research methods enhances confidence, produces more valid results, and helps mitigate potential methodological biases [31]. In this context, the qualitative method complemented the quantitative research results, as recommended by [32]. Furthermore, the process adopted for the development of the TEFA-T learning e-module using the Instructional Development Institute (IDI) model adhered to three key stages, namely define, develop, and evaluate [33]. The initial stage, “define,” consists of problem identification and an analysis of the curriculum, student characteristics, and learning material concepts. The subsequent “develop” stage comprised creating the initial prototype and validating the product. Finally, the “evaluate” stage includes testing and analyzing the outcomes of the developed e-module shown in Figure 1.

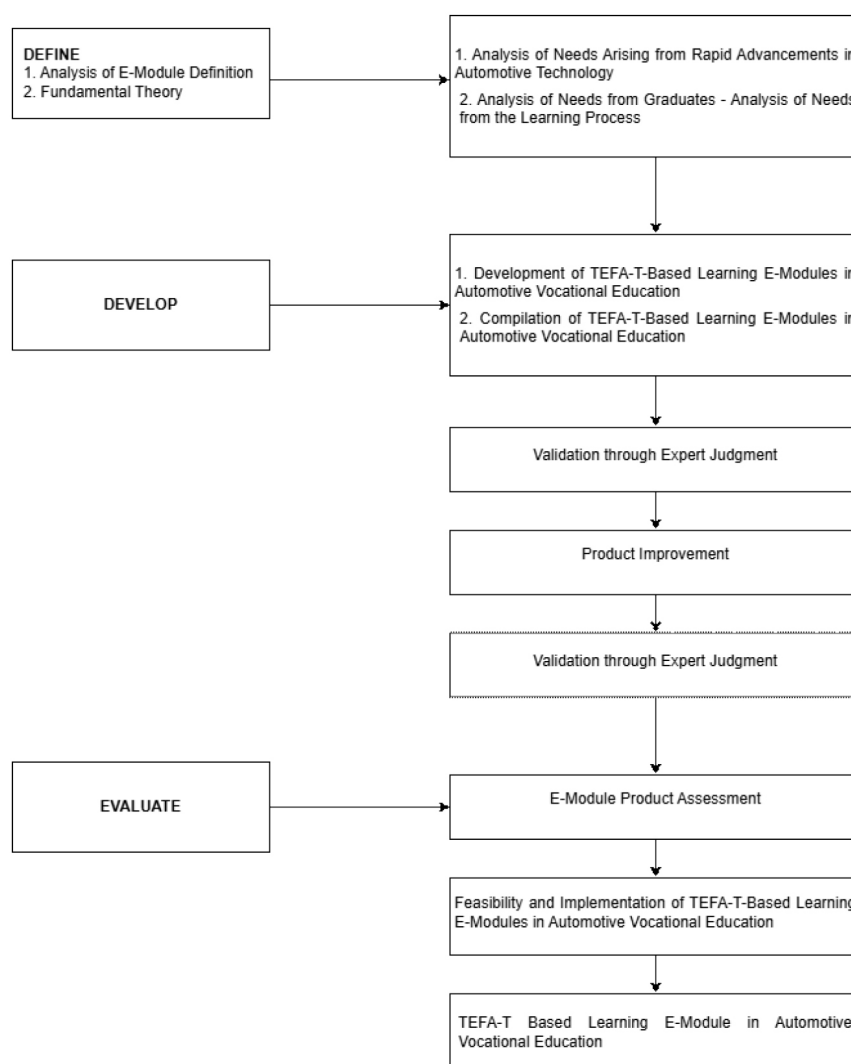


Fig. 1. Steps and stages of learning e-module

4 RESULTS AND DISCUSSIONS

4.1 TEFA-T module development

The development process of the module focuses on the LO related to steering, brakes, and suspension, along with those of the DIII Automotive Engineering study program. During this model development phase, the existing module is being evaluated. It has been identified that the module’s weaknesses lie in the description and organization of the material, which are neither comprehensive nor detailed [34, 18]. Moreover, there is a lack of exercises and in-depth analysis material suitable for online learning. Consequently, this student module is designed to be more visually appealing to enhance students’ cognitive skills [35, 17]. It also includes complete material and case studies for online learning to boost the affective domain. Additionally, the module provides detailed project examples to develop students’ psychomotor skills [19]. To further aid students’ understanding, the material includes descriptions and images that stimulate their imagination [36, 37]. The case study elements are thoroughly itemized and detailed in this module [20]. A recent review of steering, brakes, and suspension is also included, supplemented by color graphics. Each component’s working system is explained and accompanied by diagrams to facilitate learning. The layout is designed to be visually appealing to prevent student boredom. The module structure is depicted in Figure 2. The formatting of a paper reflects its structure, which in turn reflects your thoughts. A manuscript without a clear structure cannot be formatted by our typesetting team (nor will it be understood or cited by readers). Use heading levels with care and don’t mix them up (e.g., a heading level 1 should not be followed by a heading level 3).

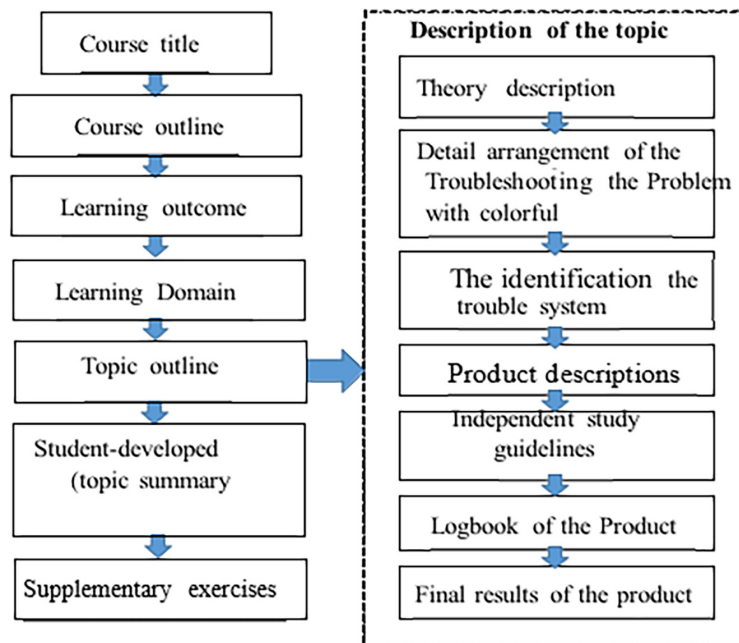


Fig. 2. The structure of the developed module

4.2 Validity of learning digital learning module

Module validation is carried out by a team of validators who assess 14 different aspects of the learning module. These aspects include: the alignment of the material

with both main and supplementary competencies, the accuracy of the content, the quality of supporting materials, the relevance and updating of the content, the effectiveness of presentation techniques, the support for presentations, the methods of presenting the learning material, the completeness of the presentation, engagement strategies, creative elements, communicative and interactive features, alignment with the students' intellectual levels, the coherence and consistency of the content, and the appropriate use of terms and symbols.

The learning e-module of the TEFA-T model was comprehensively assessed for validity. This assessment covered six distinct aspects, namely the front page, objectives, language, and writing style, instruction clarity, syntax arrangement, and materials of the e-module. Table 1 presents the results of the assessment, which was evaluated by the expert panel for this e-module.

Table 1. Validator team assessment of the learning e-module

No	Validation Components	V1	V2	V3	V4	V5	Aikens'V	Category
1	Front page component of the learning E-Module	5.0	5.0	4.0	5.0	5.0	0.95	Excellent
2	Learning Objectives	5.0	4.0	5.0	5.0	4.0	0.90	Excellent
3	Language and Writing Style	5.0	5.0	5.0	5.0	5.0	1.00	Excellent
4	Indicator Instructions	4.0	5.0	5.0	5.0	5.0	0.95	Excellent
5	Arrangement of learning syntax	4.0	5.0	5.0	5.0	5.0	0.95	Excellent
6	Learning Materials	5.0	4.0	5.0	5.0	4.0	0.90	Excellent
	AVERAGE						0.941	

The validity assessment of the learning e-module was carried out to examine its suitability for use in the learning process of the Department of Automotive Engineering. Accordingly, a team of five experts in the relevant field conducted this assessment using valid and reliable assessment instruments. The results of the data analysis showed an average Aiken V value of 0.985, with ratings ranging from 0 to 1. According to [16], a score above 0.60 is considered quite high (valid). In this case, the obtained validation results yielded a value of $V = 0.941$, which is ≥ 0.600 , confirming its validity. It is also important to acknowledge that based on the improvement suggestions provided by the expert team, refinements were made to further enhance the e-module for suitable usage.

4.3 Discussion

The validity of the learning e-module refers to a measure of how well the TEFA-T model is in line with the educational objectives set for it [37]. In this regard, validity tests were conducted throughout the development stages, comprising needs analysis, objective identification, and alignment with curriculum standards. Additionally, the experts who participated in the development process provided input and validation, confirming that the content of the model remained in sync with the most recent advancements in technology, experiments, physics, and practical applications. Based on this understanding, it was concluded that the learning e-module exhibited sufficient validity in its capacity to facilitate the attainment of learning objectives.

The results of the validity assessment showed that the TEFA-T Learning E-module adhered to the criteria for developing a scientifically sound product. This includes

ensuring logical consistency between the expected and actual e-module content, as outlined by [38] and [37]. Additionally, the assessment was carried out using a product evaluation technique inspired by Schwartz (1986), which incorporated expert reviews and a focus group discussion (FGD). Drawing from Schwartz's theory (1986), the e-module was thoroughly assessed for validation by experts and thorough discussions during the FGD activities. Based on the outcomes of these validity assessments and FGDs, it became clear that the developed learning e-module met the scientific criteria and was suitable for use.

It is also important to specify that the TEFA-T learning e-module was crafted with practicality as a central consideration [39]. Practicality, in this context, refers to the capacity of the proposed model to be efficiently and easily applied in real-life scenarios. It features straightforward and comprehensible language specifically designed for students. Moreover, the e-module seamlessly incorporated modern technology, granting convenient access through online platforms and digital resources. This flexibility empowered students to learn at their convenience, regardless of location, thereby augmenting its practicality in higher education.

The effectiveness of the TEFA-T learning e-module was also evaluated, and significant effectiveness was observed, which was evidenced by the improvement in outcomes and the enhancement of the task-related skills exhibited by students [37]. Accordingly, the utilization of this e-module yielded favorable educational outcomes, including a heightened grasp of physics concepts, proficiency in contemporary technology, and the aptitude to apply theory in real-world scenarios. The e-module also fostered the cultivation of task-related skills such as analysis, experimentation, and problem-solving, which hold significant value in both academic and professional settings. In line with these observations, the research data and user feedback affirmed that the e-module also effectively enhanced both academic achievement and student skills.

The results of the validity and effectiveness test indicated that the TEFA-T learning e-module exhibited a positive impact on the academic performance of the observed students. This was evidenced by the significant difference observed between the academic performance of the students who used the e-module and those who did not, as shown in Table 1. Furthermore, the e-module was also found to influence various aspects of the affective domain, including discipline, commitment, responsibility, communication, teamwork, self-confidence, and interest of the students. It is also important to specify that in the psychomotor domain, the e-module exhibited a greater impact on task and psychomotor skills compared to process skills. In light of these results, it was recommended that the TRFA-T model should be incorporated with the learning e-module, along with the concurrently developed Student Manual, to enhance the learning process. These outcomes are in line with those of [40] and [41], where it was stated that the implementation of interactive and innovative e-modules effectively enhanced the academic performance and task-related skills of students.

The application of the TEFA-T E-module has demonstrated its capacity to offer constructive alternatives and innovations in learning, rendering it more engaging. The act of engaging in learning activities through this innovative e-module-based approach was found to enhance student engagement, thereby enabling a deeper comprehension of research materials and an improvement in the quality of their process skills. This observation is in line with the results of [36], who asserted that the proper implementation of PjBL e-modules positively impacted the cognitive, psychomotor, and academic achievement competencies of students. Additionally, it emphasized that students gain direct experience by applying work-based models like TEFA during their learning process, thus facilitating the absorption of acquired knowledge. The e-module contributed to the overall quality of LO by comprising a

comprehensive content structure and addressing the competencies that students are expected to achieve [12].

In accordance with these observations, the utilization of the TEFA-T E-module in the learning process was found to exhibit a positive impact on the process skills of the students, subsequently enhancing their cognitive, affective, and psychomotor abilities. This result is in line with the Cognitive and Information Processing Theory, which states that knowledge acquired through direct experience tends to be retained longer in the memory of students due to their active involvement in the learning process. Moreover, hands-on learning, particularly in the context of automotive education, has the potential to ignite curiosity, and this renders the students more proactive and creative.

Throughout the implementation process of the TEFA-T e-module, students tended to become more self-reliant in the learning process, which was largely driven by their heightened curiosity about the contents of the e-module. This corresponded with the result of [20], who suggested that the implementation of electronically-based e-modules encouraged students to assume a more independent and active role. In turn, this fostered positive interactions during the learning journey through the inclusion of activities such as direct observation, hands-on work, job shadowing, classification, prediction, measurement, drawing conclusions, material communication, and problem-solving.

According to the utilization of innovative learning e-modules can effectively address the individual challenges faced by less active students, thereby reinvigorating their engagement in the learning process. This perspective is in line with the result of who stated that well-structured e-modules play a crucial role in addressing individual learning difficulties and facilitating rapid mastery of subject matter among students. Accordingly defined an e-module as a comprehensive and structured learning package, precisely designed to achieve specific LO. As rightly stated by one of the key factors that contributed to the enhancement of skills possessed by students lies in the improvement of learning quality through the implementation of innovative e-modules.

A good e-module in the context of education can have a significant positive impact on a conducive academic atmosphere. Well-designed e-modules not only provide relevant and well-structured course material but also motivate students to learn. By presenting information in an engaging and easily understandable manner, these e-modules can enhance students' interest in learning. Moreover, good e-modules can facilitate independent and collaborative learning, enabling students to develop a deeper understanding of the subject matter. Thus, a good e-module can be a key element in creating an academic atmosphere that supports the optimal development and achievement of students.

In summary, the TEFA-T E-module developed in this study underwent a rigorous validation process to ensure the attainment of learning objectives, practicality in application, and effectiveness in enhancing the outcomes and task-related skills of students. This e-module offers significant advantages in elevating the quality of higher education and equipping students for the forthcoming challenges in technology, experiments, physics, and applied applications.

5 CONCLUSION

In conclusion, this study comprised the effective design and implementation of a TEFA-T model learning e-module, in accordance with established procedures and guidelines. The e-module was designed to be a versatile instructional tool

that is suitable for various activities, including teaching, coaching, and assistance. Its structure comprised a cover, introduction, table of contents, e-module positioning map in the learning process, glossary, introduction, evaluation system, and conclusion. Furthermore, drawing upon theoretical research, empirical assessments, and expert feedback, the TEFA-T model learning e-module was skillfully crafted to foster essential 21st-century competencies, namely soft skills, task skills, and the enhancement of the academic achievement of students. Through the implementation of this e-module, students were able to construct knowledge using both inductive and deductive approaches and engage in diverse learning experiences such as one-way, personal, and multidirectional interactions. The developed e-module was statistically assessed, and its validity was confirmed in terms of both content and construct. In this regard, the content was considered valid, as indicated by the obtained average Aiken's V value of 0.967. It is also important to acknowledge that the e-module proved highly practical, as indicated by the practicality assessment results. This was further evidenced by the obtained responses from both the lecturers and students, which averaged an approximate value of 92.20% and 90.60%, respectively, both falling within the "Very Practical" category. Following implementation, the TEFA-T Learning E-module was found to significantly enhance the academic achievement of automotive vocational students (2-tailed p-value less than 0.05). Therefore, it was concluded that this interactive TEFA-T e-module represented a proven and highly effective innovation in elevating the academic performance of students.

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