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Modern Industrial Technologies And Specialized Practical Competency Development In Mechanical Engineering Training In Public TVET Institutions, Western Kenya

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Abstract: ***The adoption of modern industrial technologies is transforming the practical competencies required in mechanical engineering, creating a need for Technical and Vocational Education and Training (TVET) institutions to align training with contemporary industrial practices. This study analysed the influence of modern industrial technologies on the acquisition of specialized practical competencies among mechanical engineering students in selected public TVET institutions in Western Kenya. Guided by Kolb's Experiential Learning Theory, the study employed a convergent parallel mixed methods design. Quantitative data were collected from 79 educators using questionnaires, while qualitative data were obtained from 8 industry supervisors through semi structured interviews. Quantitative data were analyzed using inferential statistics (regression) and findings showed that the model was statistically significant; technology integration explained 64.5% of the variance in the dependent variable (technology impacted learning outcome). Trainee confidence and training effectiveness were significant predictors, while adequacy of technological training resources was not statistically significant. Qualitative data were thematically analyzed and indicated that limited access to modern facilities, older machinery, and production pressures constrained hands-on exposure to contemporary technologies. The findings recommend establishing regional training hubs that prioritize competency based training and alignment with industrial standards, rather than focusing mainly on resource provision, to enhance students' specialized practical competencies.***

Keywords: ***Modern industrial technologies; specialized practical competencies; mechanical engineering; TVET; technology-enhanced training; experiential learning***

I. INTRODUCTION

The increasing adoption of automated and digitally enabled production systems has consequently changed the competencies expected of mechanical engineering graduates. Technologies such as Programmable Logic Controllers (PLCs), computer-aided manufacturing, automated production systems, and advanced fabrication processes require learners to acquire practical competencies beyond conventional manual operations. However, evidence from Kenyan technical training institutions suggests that access to contemporary equipment and technology-supported learning remains uneven. Students may continue to train using older machinery despite technological changes in industrial workplaces, creating a potential gap between institutional training environments and current occupational requirements (Bett et al., 2025). Limited technological resources, inadequate exposure to contemporary equipment, and constraints affecting practical training may further restrict opportunities for learners to develop specialized competencies (Muchira et al., 2023).

This challenge is particularly relevant in Western Kenya, where mechanical engineering training serves an industrial environment that includes sugar processing, manufacturing, fabrication, and maintenance activities. The region therefore provides an important context for examining whether technological exposure within TVET institutions corresponds with the practical competencies required in contemporary mechanical engineering practice. Although Kenyan reforms

emphasize technology-enriched and competency-based training, empirical evidence remains limited on the extent to which modern industrial technologies are associated with the development of specialized practical competencies among mechanical engineering students in public TVET institutions.

A. STATEMENT OF THE PROBLEM

Rapid technological change in manufacturing and engineering has increased the demand for technical graduates who can operate and adapt to contemporary industrial technologies (Danielson et al., 2011; Rosandich, 2021). This presents a challenge for TVET institutions, which are expected to provide practical learning environments that reflect current workplace technologies (TVETA, 2023). Despite ongoing TVET reforms and investments in modern training equipment in selected institutions, disparities in access to contemporary technologies remain, with some institutions continuing to rely on older machinery and conventional training practices (Muchira et al., 2023; Bett et al., 2025). Such differences may limit learners' opportunities to develop specialized practical competencies relevant to modern mechanical engineering workplaces.

The challenge is particularly relevant in Western Kenya, where mechanical engineering graduates serve industries involved in sugar processing, manufacturing, fabrication, and industrial maintenance. As industrial processes increasingly incorporate automation and modern mechanical systems, continued reliance on obsolete or predominantly manual training equipment may create a gap between institutional training and workplace technological requirements (Bett et al., 2025). From an experiential learning perspective, limited access to appropriate technologies may also reduce opportunities for students to engage in meaningful hands-on experiences through which practical competencies are developed (Kolb, 1984).

Although Kenyan TVET reforms emphasize competency-based and industry-relevant training, limited empirical evidence exists on how modern industrial technologies relate to the development of specialized practical competencies among mechanical engineering students in public TVET institutions in Western Kenya. Existing studies have largely examined broader issues of TVET reform, employability, or industry collaboration, leaving limited evidence on the relationship between technological training conditions and specialized practical competency development within the region. This gap limits understanding of whether technology-related training factors adequately support the practical learning outcomes expected of mechanical engineering students. Therefore, this study examined the relationship between modern industrial technologies and the development of specialized practical competencies in mechanical engineering training in selected public TVET institutions in Western Kenya.

B. PURPOSE OF THE STUDY

The purpose of this study was to analyze the influence of modern industrial technologies on the acquisition of specialized practical competencies in mechanical engineering training in selected public TVET institutions, Western Kenya.

✓ *RESEARCH QUESTION*

How do modern industrial technologies influence the acquisition of specialized practical competencies in mechanical engineering?

✓ *RESEARCH HYPOTHESIS*

H_O: Modern industrial technologies do not significantly predict specialized practical competency development in mechanical engineering training in selected public TVET institutions in Western Kenya.

✓ *THEORETICAL AND CONCEPTUAL FRAMEWORK*

This study is grounded on David Kolb's (1984) Experiential Learning Theory (ELT), which conceptualizes learning as a continuous cycle through which knowledge is created through the transformation of experience. ELT provides an analytical foundation for examining how exposure to modern industrial technologies contributes to practical competency development among mechanical engineering students. Kolb's model comprises four interconnected stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation.

In this study, concrete experience occurs when students engage directly with modern industrial technologies and technology supported practical workshop activities. Reflective observation involves examining these experiences and using feedback to improve understanding and performance. Abstract conceptualization enables students to connect technological experiences with engineering principles, while active experimentation involves applying acquired knowledge and skills to new technical tasks and problem solving situations.

Technologies such as CAD, CNC, and automated production systems can therefore provide opportunities for learners to move through the experiential learning cycle. Nasution, Arwizet, and Fernanda (2024) reaffirm the relevance of ELT in developing mechanical engineering skills; particularly through technology based practical learning.

Conceptually, the study examined the relationship between technology related factors: adequacy of technological training resources, technology enhanced training effectiveness, and trainee confidence in using new technologies and learning outcomes reflecting specialized practical competency development. The framework assumes that access to appropriate technologies and effective technology enhanced training provides meaningful practical experiences, while students' confidence facilitates active engagement and experimentation. Where access to contemporary technologies is limited or training opportunities are inadequate, the experiential learning cycle may be constrained, limiting opportunities for students to develop specialized practical competencies.The framework therefore links modern industrial technology exposure to practical learning outcomes in mechanical engineering training.

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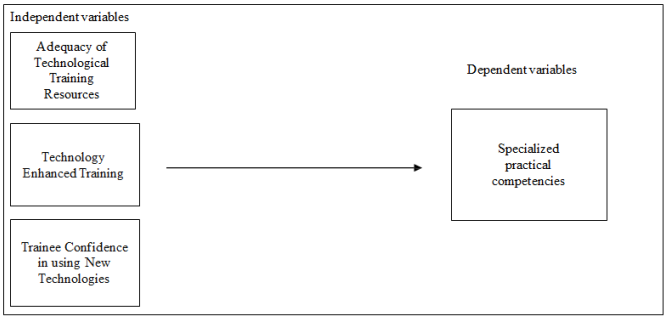


Figure 1: Conceptual framework

II. LITERATURE REVIEW

Technological advancement has transformed the competencies required in mechanical engineering and the approaches used in TVET. Digitalization, automation, CAD, CNC, and simulation technologies increasingly provide learners with opportunities to connect theoretical knowledge with practical applications (Kipper et al., 2021). From the perspective of ELT, such technologies support practical learning by enabling learners to experience, reflect, conceptualize, and experiment with technical processes (Kolb, 1984; Mugo, 2023).

Empirical studies indicate positive relationships between technologies supported training and practical learning outcomes. Liu, L., Li, W., & Chen, X. (2023)reported improved machining accuracy following exposure to CNC simulation, while Adebayo and Okolie (2022) found improved skill test performance after integrating 3D CAD exercises into polytechnic training. However, technology availability alone may not guarantee competency development. The effectiveness of technology enhanced instruction and students' confidence in using new technologies may determine how effectively available technologies translate into practical learning.

In Kenya, technology integration in TVET remains uneven due to inadequate equipment, limited instructor capacity, infrastructure requirements, and other resource constraints (TVETA, 2022, 2023). Some mechanical engineering programs consequently continue to rely on conventional machinery despite the increasing use of automated and digitally controlled systems in industry (Musyimi, 2021). Limited exposure to contemporary technologies may therefore create a gap between institutional training and workplace requirements.

The issue is particularly relevant in Western Kenya, where mechanical engineering graduates serve manufacturing, agro processing, fabrication, and industrial maintenance sectors. The region provides an important context for examining whether technological resources and technology supported training adequately prepare learners for contemporary technical work. Despite ongoing TVET reforms emphasizing competency based and industry relevant training, limited empirical evidence exists on how technological training resources, technology enhanced training effectiveness, and trainee confidence relate to practical learning outcomes in public TVET institutions in Western Kenya.

This study addresses this gap by examining the relationship between these technology related factors and specialized practical competency development in mechanical engineering training in selected public TVET institutions in Western Kenya.

III. MATERIALS AND METHODS

This study adopted a convergent parallel mixed methods design to examine the relationship between modern industrial technologies and specialized practical competency development in mechanical engineering training (Creswell & Creswell, 2018). Quantitative and qualitative data were collected concurrently, analyzed independently, and integrated during interpretation to provide both numerical and contextual evidence.

The study was conducted in selected public Technical and Vocational Education and Training (TVET) institutions in four counties of Western Kenya: Kakamega, Bungoma, Vihiga, and Busia. Eight public TVET institutions offering mechanical engineering programs were purposively selected. The quantitative strand involved 79 educators, including trainers, Heads of Department, Industrial Liaison Officers, and CBET champions. Of these, 76 returned completed questionnaires, representing a 96.2% response rate. The qualitative strand involved eight industry supervisors who were purposively selected based on their direct involvement in supervising mechanical engineering trainees, all of whom participated in the interviews yielding 100% response rate.

Data were collected using structured questionnaires for educators and semi structured interview schedules for industry supervisors. The questionnaire measured technology related factors including adequacy of technological training resources, technology enhanced training effectiveness, and trainee confidence in using new technologies, as well as learning outcomes reflecting specialized practical competency development. The interview schedule provided contextual evidence on technological exposure and practical training experiences.

A pilot study was conducted and yielded a Cronbach's alpha coefficient of 0.82. Content and construct validity were established through expert review by three specialists in TVET and research methodology. For the qualitative strand, trustworthiness was enhanced through systematic coding, audit trails, and comparison of codes with interview transcripts.

Quantitative data were analyzed using Statistical Package for the Social Sciences (SPSS) with inferential statistics (multiple regression) used to examine the extent to which technological training resources, technology enhanced training effectiveness, and trainee confidence predicted learning outcomes. Qualitative interview data were transcribed, coded, and thematically analyzed following Braun and Clarke's (2006) approach. Findings from the two strands were integrated during interpretation to identify areas of convergence and provide contextual explanations for the quantitative results.

Ethical approval was obtained from the Moi University Institutional Research Ethics Committee (IREC) and the National Commission for Science, Technology and Innovation (NACOSTI), together with the relevant institutional permissions. Participants provided informed consent and participated voluntarily. Confidentiality and anonymity were

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maintained throughout data collection, analysis, and reporting. The study's cross sectional design and reliance on self reported quantitative data may limit causal interpretation and introduce response bias; these limitations were addressed through the mixed methods design and triangulation of evidence.

IV. RESULTS AND DISCUSSION

✓ *Demographic Information of the Respondents*

Demographic Category	Sub-Category	Educators	Industry Supervisors	Total Percentage
Response Rate	Targeted Actual	79 76	8 8	87 (100 %) 84(96.6%)
Gender	Male	63 (82.9%)	8 (100.0%)	71 (84.5%)
	Female	13 (17.1%)	0 (0.0%)	13 (15.5%)
Academic Qualification	Diploma/Higher Diploma	23 (30.3%)	—	30.3%
	Bachelor's Degree	52 (68.4%)	—	68.4%
	Master's / Doctorate	1 (1.3%)	—	1.3%
Institutional Designation	Trainers / Instructors	61 (80.3%)	—	80.3%
	HODs/ ILOs / Champions	15 (19.7%)	—	19.7%
Industry Experience	5 – 10 Years	—	2 (25.0%)	25.0%
	11 – 15 Years	—	4 (50.0%)	50.0%
	> 15 Years	—	2 (25.0%)	25.0%

Table 1: Demographic Information of the Respondents

Table 1 above presents the characteristics of the respondents who participated in the study. The high level of participation, involving both educators and industry supervisors, provides a broad basis for examining the relationship between institutional training and workplace practice.

The respondent profile indicates that the educators were predominantly professionally qualified and directly engaged in training delivery. 68.4% of the educators held bachelor's degrees, while 30.3% held diploma or higher diploma qualifications and 1.3% held masters qualifications.

The industry supervisors brought considerable workplace experience to the study, with all reporting at least five years of industrial experience and 75% having more than a decade of exposure. This strengthens the relevance of their perspectives when interpreting findings concerning workplace expectations, technological practices and practical competencies. Their experience provides an important external reference against which institutional perceptions of industry engagement and technology supported training can be considered.

The gender distribution was male dominated, particularly among industry supervisors. Educators were predominantly male (82.9%), while females constituted 17.1% of the sample. This composition reflects the respondent pool from the mechanical engineering training and industrial settings examined.

Taken together, the respondent profile provides an appropriate experiential foundation for examining industry partnerships, technological integration and practical competency development. The combination of technically qualified educators, institution level personnel and experienced industry supervisors allows the subsequent findings to be interpreted across both the training provider and workplace dimensions of mechanical engineering skills development.

A. INFLUENCE OF MODERN INDUSTRIAL TECHNOLOGIES ON SPECIALIZED PRACTICAL COMPETENCY DEVELOPMENT

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of
1	.803[a]	.645	.630	.54844

a. Predictors: (Constant), Adequate technological training resource, Technology enhanced effective training, Confident in new technology

Table 2: Multiple regression model summary

Table 2 presents the multiple regression model summary analysis. The model showed a strong multiple correlation between the technological predictors and learning outcomes ($R = .803$). Coefficient of determination ($R^2 = .645$) indicates the three predictors collectively explained 64.5% of the variance in technology influenced learning outcomes. The adjusted R^2 of .630 indicates that, after adjustment for the number of predictors in the model, the regression model accounted for approximately 63.0% of the variance in learning outcomes. The standard error of the estimate was .54844, indicating the typical magnitude of prediction error in the dependent variable

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	38.724	3	12.908	42.915	.000[b]
Residual	21.356	71	.301		
Total	60.080	74			

a. Dependent Variable: Technology impacted learning outcome

b. Predictors: (Constant), Adequate technological training resource, Technology enhanced effective training, Confident in new technology

Table 3: Anova

Table 3 presents the ANOVA results for the multiple regression model. The regression model was statistically significant, $F(3, 71) = 42.915$, $p < .001$. This indicates that the three predictors, considered collectively, significantly predicted variation in technology influenced learning outcomes. Therefore, the overall regression model was statistically significant at the 0.05 level. The ANOVA result establishes the significance of the regression model as a whole, while the contribution and statistical significance of each individual predictor are examined using the regression coefficients presented in the table below.

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Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-.017	.384		-.043	.966		
Technology enhanced effective training	.361	.093	.323	3.897	.000	.731	1.368
Confident in new technology	.556	.099	.507	5.602	.000	.610	1.638
Adequate technological training resource	.112	.061	.148	1.851	.068	.788	1.269

a. Dependent Variable: Technology impacted learning outcome

Table 4: Regression coefficients

Table 4 presents the regression coefficients for the three technological predictors of students' learning outcomes. Confidence in new technology emerged as the strongest significant predictor ($\beta = .507$, $t = 5.602$, $p < .001$), followed by technology enhanced effective training ($\beta = .323$, $t = 3.897$, $p < .001$). Adequate technological training resources, however, had a positive contribution though it did not have statistical significance ($\beta = .148$, $t = 1.851$, $p = .068$). The VIF values ranged from 1.269 to 1.638, indicating that multi collinearity was not a concern among the predictors.

The stronger contributions of confidence and technology-enhanced training suggest that learning outcomes may depend more on how students engage with technology and how it is integrated into instruction than on resource adequacy alone. The qualitative findings provided useful insights; for example, IS-O4 noted that *exposure to technologies such as 3D printing and CAD/CAM remains limited because students largely encounter older machines*, while IS-O1 observed that *students often struggle with CNC and digital production equipment*. Similarly, IS-O6 emphasized the *need for hands on troubleshooting rather than demonstrations*. . These accounts suggest that availability alone does not necessarily guarantee productive technological learning. The educational value of such resources may depend on the extent which students have regular opportunities to use relevant technologies, solve problems with them and develop confidence though actual engagement.

This interpretation helps explain the non-significant unique contribution of technological resource adequacy. It suggests that resource availability alone may be insufficient to explain variation in learning outcomes when equipment is outdated, not sufficiently accessible to learners or does not reflect technologies currently encountered in industry. This finding is consistent with evidence that technology integration in Kenyan TVET institutions is constrained by inadequate equipment and other resource limitations (TVETA, 2022, 2023), while some mechanical engineering programs continue to rely on conventional machinery despite the increasing use of automated and digitally controlled systems in industry (Musyimi, 2021). The qualitative evidence therefore adds a dimension to the regression result by distinguishing between having technological resources and providing meaningful exposure to relevant technologies. This distinction is particularly important in mechanical engineering training, where practical competence depends on repeated interaction with equipment and technologies rather than their physical presence in the workshop alone.

The significant contribution of technology enhanced effective training provides further evidence for this distinction. If current industrial technologies are not consistently available for direct student use, technology enhanced instructional approaches may provide additional opportunities for learners to visualize processes, practice procedures, test solutions and connect theoretical knowledge with practical applications. The qualitative emphasis on hands on troubleshooting is particularly relevant here because it suggests that effective technology integration should move beyond demonstrations towards active learner participation. This finding is consistent with studies reporting positive relationships between technologies supported CNC and CAD based learning activities and technical learning outcomes (Adebayo & Okolie, 2022; Li et al., 2023). At the same time, the present finding that resource adequacy was not statistically significant indicates that the educational value of technology may depend not only on what equipment is available, but also on how it is incorporated into the learning process.

The strong contribution of confidence in using new technologies further raises the question of how students develop the confidence required to engage with unfamiliar industrial technologies. The qualitative findings indicate that limited exposure to CNC, CAD/CAM, 3D printing and other digital production technologies may restrict opportunities for students to practice and troubleshoot such technologies. Repeated practical engagement can provide learners with opportunities to move beyond exposure to experimentation and greater confidence. This interpretation aligns with Kolb's Experiential Learning Theory, which conceptualizes learning as a cycle involving concrete experience, reflective observation, abstract conceptualization and active experimentation (Kolb, 1984). Technology enhanced training can support this cycle by enabling learners to engage with technical processes, reflect on performance and connect experience with engineering concepts and experiment with alternative solutions. Confidence can consequently be understood not simply as an individual attribute but as something that may develop through meaningful opportunities to interact with technology and solve authentic practical problems.

The convergence of the quantitative and qualitative findings therefore points to a broader issue that may be conceptualized as technological currency gap. In this study, the concept refers to a possible mismatch between the technologies to which students are exposed within institutional training environments and those increasingly encountered in contemporary industrial practice. The regression results show that technological factors collectively accounted for a substantial proportion of variation in learning outcomes, while the qualitative evidence indicates that students' exposure to current industrial technologies may remain limited. The issue is therefore not simply whether institutions possess technological equipment, but whether the equipment is current, relevant, accessible to learners and effectively integrated into practical instruction.

Taken together, the findings suggest that strengthening technology related practical learning requires a combination of

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relevant technological resources, effective technology enhanced instruction, meaningful hands on exposure and opportunities for learners to develop confidence through experimentation and problem solving. The mixed methods evidence is important because the regression analysis establishes the statistical pattern, while the industry supervisor accounts provide contextual insight into the conditions that may help explain that pattern. The technological currency gap consequently provides a useful way of understanding the challenge of aligning mechanical engineering training with changing industrial technologies in the participating TVET institutions.

The non-significant effect of adequate technological training resources further highlights the distinction between resource availability and technological relevance. This finding is consistent with the concerns identified in previous studies TVETA (2022) and (Musyimi, 2021). Although institutions may possess workshop equipment, such resources may have limited influence on learning outcomes when they are obsolete, insufficiently integrated into instruction, or substantially different from technologies used in industry. Overall, the regression findings demonstrate that the technological predictors collectively explain a substantial proportion of variation in learning outcomes, but the individual effects indicate that student confidence and technology enhanced training are particularly important, while physical resource adequacy alone may be insufficient to develop specialized practical competencies.

V. SUMMARY AND CONCLUSION

The findings indicate a gap between students' exposure to technology during training and their preparedness for contemporary industrial practice. Although technology enhanced training and confidence in using new technologies were positively associated with technology influenced learning outcomes, the adequacy of technological training resources remained a concern. The findings therefore suggest that the presence of technological equipment within TVET institutions does not necessarily guarantee exposure to technologies that are sufficiently relevant to current industrial practice.

The study conceptualizes this situation as a technological currency gap, referring to a mismatch between the technologies available within training institutions and those increasingly used in contemporary manufacturing. The issue is therefore not simply the availability of equipment, but its relevance, currency, and alignment with workplace technologies. Where students have greater exposure to older or predominantly manual equipment than to contemporary technologies such as CNC, CAD/CAM, automated production systems, and digital diagnostic technologies, they may develop foundational practical competencies without equivalent familiarity with modern production environments. This may contribute to a gap between classroom based practical competence and the technological expectations of contemporary industry.

The regression results further show that technology related factors collectively made a substantial contribution to technology influenced learning outcomes, with confidence in new technology and technology enhanced training emerging as significant predictors, while the adequacy of technological resources did not reach statistical significance. This suggests that technology integration involves more than the provision of equipment. The educational value of technology depends on how relevant technologies are to current industrial practice, how effectively they are incorporated into instruction, the preparedness of educators, and the opportunities provided for authentic practical and industrial exposure.

From the perspective of experiential learning, meaningful engagement with contemporary technologies can provide opportunities for learners to connect practical experience with reflection, conceptual understanding, and experimentation. However, where access to current industrial technologies is limited, opportunities for such industry aligned learning experiences may also be constrained. The study therefore concludes that strengthening the alignment between TVET technological resources, instructional practices, and evolving industrial requirements is important for developing specialized practical competencies that remain relevant to modern manufacturing.

VI. RECOMMENDATION

Based on the findings, public TVET institutions should strengthen the integration of contemporary industrial technologies into mechanical engineering training by not only prioritizing the acquisition, but also maintenance, upgrading, and relevance of technological resources. Technology investment should not focus solely on the quantity or availability of equipment but should consider its alignment with technologies currently used in industry. Particular attention should be given to areas such as CNC machining, CAD/CAM, automated production systems, digital diagnostics, and other technologies relevant to contemporary manufacturing.

Technology investment should be accompanied by appropriate trainer preparation and structured practical activities so that access to equipment translates into meaningful competency development. Continuous professional development, industrial attachment, and other forms of industry exposure for mechanical engineering trainers should therefore be strengthened to enable educators to remain familiar with evolving industrial technologies and practices.

TVET institutions should also strengthen formal industry partnerships through clearly defined Memoranda of Understanding that support industrial attachment, equipment and resource sharing, industry visits, guest instruction, joint practical projects, and regular feedback on emerging workplace competency requirements. Communication among educators, industrial supervisors, and industry partners should be strengthened, while logbooks and workplace assessment processes should be standardized to ensure that students' industrial experiences are systematically documented and assessed.

Finally, institutions should institutionalize periodic technology audits and curriculum reviews involving industry practitioners. Such reviews should identify obsolete technologies, assess the relevance of existing training equipment, identify emerging workplace requirements, and

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guide decisions on technology upgrading and curriculum adaptation. These measures would help reduce the technological currency gap between TVET training environments and contemporary industrial workplaces while supporting the development of relevant and transferable practical competencies among mechanical engineering students.

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