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Assessing the Impact of Industrial Attachment Training on Tertiary Graduates in Ghana: Evidence from Technical Universities

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***Abstract*—Industrial placement training aims to familiarise students with real working conditions and scenarios and to equip them with the skills needed in the professional environment. This study assesses the effectiveness of industrial placement training in Ghana's technical universities in improving the graduates' skills and employability. The study used primary data from questionnaires administered to four hundred and twenty (420) respondents, selected using stratified and systematic random sampling methods. The data were analysed using the Quantile Regression Model (QRM) and the Classification and Regression Tree (CART). The study found that surveillance had the highest and most consistent positive impact across the distribution, with coefficients ranging from 0.18 to 0.62 at lower and intermediate levels. Preparation had a moderate positive effect, peaking around the median quantile (<0.28) but declining at higher quantiles to near zero or slightly negative values. The effect on relevance was slightly smaller but increased at all quantiles, approaching zero at the lower quantiles and increasing to approximately 0.25 at the higher quantiles. The number of graduates in employment was 69.50, of whom 24.20 were in permanent employment, 39.20 were self-employed, and 36.60 were in part-time or contract work. Despite these results, around 40 percent of respondents reported that they were not ready for a job, confirming the persistence of skills gaps. The findings show that industrial attachment remains essential in tertiary technical education, but its effectiveness requires coordinated supervision and appropriate and adequate task matching to theoretical academic education.**

***Keywords*—Industrial Attachment, Quantile Regression, Technical Universities, Graduate Employability Indicators, Tertiary Graduates, Skills Distribution Index**

I. INTRODUCTION

Globally, industrial attachment is regarded as one of the most relevant aspects of academic curricula for all tertiary education and Technical and Vocational Education and Training (TVET) programmes (Bukari *et al*., 2026; Krull *et al*., 2001; Machart, 2017; Xie *et al*., 2023). For example, in the USA, the Cockrell School of Engineering operates the Cooperative Engineering Education Program, where students undertake at least one summer and one long semester of full-time industry work (Cockrell School of Engineering, n.d.).

In Asia, Xi'an Jiaotong University has extensive industry–academia collaborative talent-cultivation projects in partnership with companies such as Texas Instruments, STMicroelectronics, Huawei, Tencent, Xiaomi, Alibaba Cloud, and Baidu. The collaborations provide industry support and practical conditions for training technical and innovative talent (Xi'an Jiaotong University, 2024). The Kumasi Technical University (KsTU) of Ghana also has a formal students' industrial attachment policy that defines industrial attachment as work-based experience that provides students with a real organisational context in which to develop professional skills. The policy explicitly states that attachment is intended to link in-school training with on-the-job training and to improve students' labour-market relevance (KsTU, 2021). All these internship programs seek to provide students with practical industry experience related to their studies. The university specifically identifies technical experience, application of classroom knowledge, professional experience, and improved employment prospects as benefits.

According to Omane-Adjekum (2026), almost all tertiary institutions in Ghana have a mandatory period during which students undergo industrial training to equip them with relevant experience for the job market by providing insight into the world of work (Tight, 2023). The industrial attachment program is also meant to help students to appreciate the practicality of whatever theoretical knowledge they are acquiring in their education. There is therefore the need to periodically assess whether the industrial attachment program is achieving its intended purpose. The study aims at assessing the impact of industrial attachment training on tertiary education in Ghana, through evidence from technical universities and the effect it is having on Graduates' Competencies and readiness for the job market. The assessment seeks to answer the following questions: (1) What are the existing industrial attachment programs for Technical Universities in Ghana? (2) How effective are the industrial attachment programs in enhancing the practical skills and competencies of tertiary students? (3) How influential is the industrial attachment training on graduates' technical, problem-solving, communication, teamwork, and professional competencies?

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And finally, (4) how is the industrial attachment contributing to graduates' readiness and employability in the Ghanaian job market?

The assessment will help match the ever-evolving technology needs of industries increasingly requiring highly skilled graduates with relevant technical knowledge, practical skills, and workplace competencies to contribute effectively to industrialization in Ghana and across Africa. Industrial attachment provides technical university students with an opportunity to apply classroom knowledge in real-world industrial settings, gain practical experience, develop industry-relevant competencies, and become better prepared for the demands of the job market. Therefore, the effectiveness and relevance of industrial attachment are critical to ensuring that students acquire the skills and competencies required to transition successfully from tertiary education into employment. This global trend, combined with the multiple roles played by industrial partners, can also help in the continuous development of lecture materials that match the evolving technology trends.

Industrial training is a key component of technical university education in Ghana, which aims to bridge the gap between classroom knowledge and the practical skills needed in the workplace. Through work experience, students are expected to develop relevant technical skills, gain practical experience, and improve their employability. However, participation in an industrial attachment does not necessarily guarantee such results. The quality of the supervision, the preparation of students prior to placement, the relevance of the tasks assigned to their studies, and the level of cooperation between universities and industry can all have a significant impact on the quality of the placement experience. Evidence from Ghanaian technical universities identified problems such as insufficient supervision, inappropriate placement, lack of logistical support, and poor cooperation between universities and industry, which can limit the effectiveness of industrial placement programmes (Nunfam *et al*., 2022).

Despite the importance of industrial engagement for the development of graduate skills and employability, empirical evidence remains limited in the technical university context of Ghana and in the wider VET context. Current studies focus to a large extent on placements, programme challenges, the employment status of graduates and the general relationship between education and employability (Ababio *et al*., 2024; Nunfam *et al*., 2022). More importantly, conventional analytical approaches tend to focus on average effects, which may mask differences in how the employment relationship affects graduates with low, medium, and high levels of technical aptitude.

Consequently, it is still unclear whether factors such as the quality of supervision, institutional preparation, relevance of placement and cooperation between industry and academia affect all graduates in the same way or whether their impact varies according to the level of skills acquisition.

This study addresses this methodological gap by using the principal statistical model of quantile regression. Unlike conventional multiple linear regression, which estimates relationships around a conditional mean, quantile regression examines relationships at different points in the distribution of outcomes (Koenker & Bassett, 1978; Koenker, 2005). This will allow the study to determine whether determinants of industrial attachment outcomes vary between lower, middle and upper-level graduates. In addition, bootstrap quantile regression is used to provide a more robust statistical inference.

To complement the results of the quantile regression, the study also uses the decision tree model, specifically the classification and regression tree (CART) analysis. CART is useful for identifying important predictors, nonlinear relationships, interactions, and thresholds that conventional regression models may miss easily (Gordon *et al*., 1984). Thus, while the quantile regression shows how the impact of industrial attachment factors varies between different levels of graduate technical attainment, the decision tree identifies which factors, interactions and thresholds are most relevant for predicting successful outcomes.

Integration of the quantile regression and CART is therefore the main methodological contribution of this study. It goes beyond the analysis of average effects by providing both explanatory and predictive evidence on the results of industrial attachments. Using data from selected Ghanaian technical universities, the study aims to identify how the quality of supervision, institutional preparation, relevance of placement, and cooperation between industry and academia are related to the acquisition of technical skills and employability. The findings should provide evidence for improving vocational training programmes and strengthening cooperation between universities and industry in Ghana and in comparable training systems in other developing countries.

II. Literature Review

A. Industrial Attachment in Ghanaian Tertiary Institutions

In Ghanaian tertiary education, industrial placement is a learning activity where students in their final year undertake practical training in their field of specialization. This experience should strengthen the links between higher education institutions and industry and ensure that education remains relevant to the needs of the market.

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However, studies report major problems with this ideal outcome, including inadequate supervision during traineeships, mismatches between placement and career objectives, short traineeships, which prevent the acquisition of deep skills, and poor coordination between universities and industry (Sarpong-Nyantakyi & Mensah, 2025).

The concept of employability and work readiness is presented in the literature as a complex combination of technical competence, personal attributes, interpersonal behaviour, adaptability, and strategic career development skills. (Mwamba & Mwelwa, 2025). Regardless of the field, employers value the combination of personal qualities and work-related skills, such as communication, adaptability, teamwork, and problem-solving (Tran, 2016). Although terminology varies, there is a consensus that these skills are essential for career success and come from both formal education and non-university experience. As a result, governments and educational institutions are increasingly integrating employability-related opportunities into academic programmes, through tasks and activities that support labour market readiness and ensure that graduates have the technical and interpersonal skills needed to be employable.

Work readiness is a related but relatively new concept in the field of career development, with no common definition or list of attributes. Some definitions focus on the attitudes and characteristics that make graduates employable (Ng, 2022), where graduates are defined as adult learners aged over 20 with a degree or postgraduate education

B. Components of Effective Industrial Attachment

1) Duration and Timing of Placements

In Kenyan TVET contexts, the length of industrial attachment is critical for the development of employability skills, with evidence from industry supervisors and focus group discussions suggesting a minimum of three months with full reporting to supervisors is recommended, and one month is considered too short (Mwaura *et al*., 2022). Longer practicums allow trainees to develop practical work skills in real work settings, which better prepares them for the workplace and avoids challenges when transitioning to employment. Focus group participants from three TVET institutions concurred that the three-month industrial attachment is often insufficient, as some trade skills require more practice than is provided (Biraori & Ouko, 2023). When asked, trainees consistently prefer longer practicums (six to nine months) versus the traditional three-month attachment, as duration impacts technical competency as well as confidence with job-related tasks.

2) Quality of Supervision and Mentorship

Effective supervision and mentorship are important contributors to the extent to which industrial attachment programmes help trainees convert theoretical knowledge into practical skills; empirical evidence from various contexts indicates that lack of mentorship and weak supervision are correlated with low levels of internship goal achievement, skills acquisition, and labour market readiness (Sarpong-Nyantakyi & Mensah, 2025; Uwilingiyimana *et al*., 2026), which are identified as shortcomings in Ghanaian technical university programmes (e.g., HND Graphic Design at Takoradi Technical University) in which some placements do not provide relevant supervision or task allocation that facilitates the intended learning outcomes (Sarpong-Nyantakyi & Mensah, 2025).

The same issues are seen in broader African studies; in Rwanda, a lack of mentorship and poor coordination between universities and industries limits graduate work-readiness (Uwilingiyimana *et al*., 2026). For industry, active supervision that offers consistent feedback and that aligns tasks with skill development goals is critical; where this alignment is not present (due to miscommunication or lack of supervisory capacity), the internship experience is perfunctory rather than formative (33.3% of students surveyed reported inadequate mentorship as a challenge during placement) (Uwilingiyimana *et al*., 2026).

C. Stakeholder Roles

1) Academic Institution

Industrial attachment programmes are managed by academic institutions to bridge the gap between academic preparation and workplace exposure, with attachments integrated into curricula and addressing employability gaps identified through graduate outcomes studies (Sarpong-Nyantakyi & Mensah, 2025). This is especially true in Ghana, where technical universities such as Takoradi Technical University are expected to supervise attachments in ways that integrate placements with student career specialisations, technical tasks, and mentorship quality (Sarpong-Nyantakyi & Mensah, 2025). The literature also states that ineffective collaboration between academia and industry hinders practical learning opportunities (Uwilingiyimana *et al*., 2026). It is recommended that quality assurance units in universities be strengthened to vet attachment sites before placement, rejecting organisations that do not meet institutional criteria (Sarpong-Nyantakyi & Mensah, 2025).

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2) Industry Partners

Industry partners are crucial for industrial attachment programmes to serve their intended purpose of placing students in work environments where they are integrated into real work settings and where the task relevance, supervision quality, and mentorship depth are aligned with institutional training standards and sector-specific requirements. Reports from Ghana and Rwanda suggest that strong coordination between industry and academic institutions results in placements where tasks align with market practices and better skills acquisition, especially in specialized areas such as graphic design where digital tools, UI/UX design, motion graphics, and branding techniques are prominent (Sarpong-Nyantakyi & Mensah, 2025; Uwilingiyimana *et al*., 2026). On the other hand, lack of coordination can mean that placements are not well-aligned, and that students do not get enough exposure to updated technologies, and that the attachment weakens graduate employability. Well-defined mechanisms to provide quality industry mentorship are required, as the Rwanda experience has shown that lack of supervision by industry mentors dilutes the attachment experience even when the attachment process is recognized through policy (Uwilingiyimana *et al*., 2026).

D. Theoretical Review

1) Human Capital Theory

Human Capital Theory outlines how education, training, and economic outcomes such as graduate employability are related, which was developed from the works of Adam Smith, Schultz, and Becker and characterizes training as an investment in human capital that prepares the trainees to work in certain jobs (Aggarwal *et al*., 2025). Competencies are considered a type of capital for socio-economic development (Wahungu *et al*., 2023). Contemporary applications of the theory hold that technical education must be responsive to market demand, so that the skills, technical abilities, digital expertise, and soft skills of workers are fully utilized in a knowledge-based economy. The theory postulates that employers pay employees based on the productivity of their jobs, which is based on the skills and knowledge they have acquired from education and training, and that educated employees are more productive and are offered higher wage levels.

2) CareerEDGE Model

The CareerEDGE model (Pool & Sewell, 2007) is a graduate employability framework that embeds learning and personal development into educational programmes. It comprises five interconnected modules: subject knowledge and understanding and skills, work and life experience (e.g. industrial attachment, mentorship, and networking), general skills (soft competencies and entrepreneurial capabilities), emotional intelligence, and career development learning (Kester & Aderinoye, 2007; Sarpong-Nyantakyi & Mensah, 2025).

In the architecture of the model, experience placements, internships, and life experiences that prepare students for employment constitute the experience component, which aligns with industrial attachment in technical university programmes which is particularly relevant to the TVET sector in Ghana. The general skills module is also in line with observed graduate training gaps, as employers have identified areas of weakness in communication, problem-solving, teamwork, and professional conduct among graduates in competitive fields like graphic design (Sarpong-Nyantakyi and Mensah, 2025).

3) Experiential Learning Theory

Experiential Learning Theory (ELT) is a conceptual framework proposed by David Kolb in 1984 that describes a cycle of hands-on learning in real-world settings contributing to skill development and workplace readiness (Hashim, 2023). The ELT cycle can be applied to industrial attachment programmes to explore factors influencing training effectiveness for students and academic staff (Shahanga & Akyoo, 2025). The ELT cycle also includes learning styles: the 'diverging' style (creative and observation), 'assimilating' style (investigation and conceptualisation), and 'converging' style (practical application and analytical thinking) (Hashim, 2023), which may be activated by industrial attachment experiences based on workplace tasks and mentor guidance. For academic staff in Tanzanian training institutions, experiential learning ensures that teaching content is aligned with labour market needs due to direct exposure to employer demands (Shahanga & Akyoo, 2025).

E. Empirical Review

1) Graduate Employment Rates

Results of tracer studies from Ghana indicated that 69.50% of graduates from Kumasi Technical University between 2015 and 2021 were employed (24.20% permanent, 39.20% self-employed, 36.60% part-time or contract), with 58.50% working in TVET organisations and 41.50% outside TVET (70.40% private sector, 29.60% government). Graduates' satisfaction ratings with training facilities differed by employment outcomes, with Fashion/Textile graduates reporting 124% higher satisfaction with laboratory and workshop infrastructure compared to construction-related graduates, and self-employed graduates reporting 176% higher satisfaction than those in contract employment (Ababio *et al*., 2024).

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Conversely, a study of HND Graphic Design students at Takoradi Technical University revealed that although 90% of graduates found work or were self-employed, 40% self-reported as 'not job ready', with specific gaps being lack of skills or experience (17%), knowledge about relevant software tools (7%), and understanding of on-the-job practices versus classroom teaching (2%) (Sarpong-Nyantakyi & Mensah, 2025).

2) Skill Acquisition and Competency Development

Industrial attachment programmes in Ghanaian TVET contexts have been shown to develop both technical competence and transferable skills directly relevant to the labour market (Ababio *et al*., 2024), which is in line with broader evidence that well-designed internships allow for the application of theoretical knowledge and enhance employability via tangible gains in foundational skills (Gutiérrez-Pulido and Orozco-Rodríguez, 2025).

Technical skill acquisition is closely tied to the nature of tasks undertaken and the quality of supervision received. However, documented gaps in the HND Graphic Design programme at Takoradi Technical University show that some graduates lack competence in contemporary design software and techniques, like UI/UX design, motion graphics, or digital branding strategies, because of placement mismatches or short attachment durations (Sarpong-Nyantakyi and Mensah, 2025). This is also borne out in empirical accounts from Rwanda, which suggest that inadequate mentorship and weak university-industry coordination can limit the skills acquired during attachments (Uwilingiyimana *et al*., 2026).

3) Practices in Other Ghanaian Technical Universities

Although Kumasi Technical University is not exceptional in this regard, and other technical universities in Ghana are also reported to operate similar practices that reflect institutional strategies within the broader national policy frameworks (Ababio *et al*., 2024), TVET institutions are designed to integrate work-based learning into higher education programs in ways that connect academic preparation to labour market entry (Ababio *et al*., 2024; Sarpong-Nyantakyi and Mensah, 2025). The conversion of polytechnics to technical universities is a national policy priority, driven by the desire to graduate competencies aligned with economic needs (Sarpong-Nyantakyi and Mensah, 2025). Institutional tracer studies throughout Ghana have shown that TVET graduates have mixed employment outcomes (Ababio *et al*., 2024), and even mandatory industrial attachment is not sufficient to prevent mismatches between taught skills and labour market demand, as curriculum reform must also be in place (Boateng and Ofori-Sarpong, cited in Ababio *et al*., 2024).

Research has shown that quality of industry-based training directly impacts graduate employment outcomes (Adu-Darko *et al*., 2025), and technical universities that have formalized placement procedures, such as internships or industrial attachments that are structured into study programs, have seen positive employment outcomes, supporting continued focus on workplace immersion in student training.

4) International Benchmarks

Review of industrial attachment practices in international contexts provides useful benchmarks for evaluating programme structure and quality (Organization, Amin & Ntembe, 2021). In Rwanda, for instance, higher learning institutions are expected to adapt internship models for different industries and to facilitate industrial cooperation by clearly specifying internship requirements at the end of final-year completion to ensure that practical training matches field expectations (Iyamuremye *et al*., 2022; Tusiime *et al*., 2022). This aligns with broader global trends, from the United States to emerging African economies, where practical experience is regarded as a factor in employability and innovation (Rwigema, 2021). Rwandan policy reforms have also associated industrial attachment with national economic strategies like Vision 2050, which seeks to transition Rwanda to a knowledge-based economy (Rwigema, 2021). The weakness in mentorship, placement, coordination, and graduate job readiness due to misalignment between curriculum and workplace demands (Moses & Saine, 2025) provides a comparative lens to show that policy recognition must be coupled with operational frameworks that govern and improve inter-sector collaboration (Chakroun, 2019).

F. Conceptual Framework

1) Industrial Attachment Features

Structural and qualitative features of industrial attachment programmes are treated as independent variables hypothesised to influence graduate outcomes such as employability and skill development (independent variable: how placements are structured, delivered, and experienced by students during workplace integration). Duration and timing of attachments is one such independent variable, where, in Kenyan TVET contexts, three months is a minimum period to gain operational experience, but not sufficient to fully acquire skills in some trades (Mwaura *et al*., 2022), and longer attachments of six or nine months have been linked to higher achievement of attachment objectives, as there is more task engagement.

TVET contexts, short placements limit opportunities to acquire up-to-date knowledge of industry or technological expertise relevant to technical university specialisations.

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Another independent variable is quality of supervision and mentorship during attachments; in Ghanaian TVET institutions, poor supervision and mentorship negatively impact attachment goals, which in turn leads to lower attainment of hard skills and soft competencies such as teamwork, communication, adaptability, and problem-solving (Sarpong-Nyantakyi and Mensah, 2025).

2) Graduate Employability Indicators

Graduate employability indicators are dependent variables that gauge the extent to which industrial attachment contributes to work-readiness and labour market integration (i.e. employment attainment and technical, interpersonal, and cognitive competencies required in the workplace). Tracer studies that capture employment outcomes as quantitative measures of graduate employability. For instance, between 2015 and 2021, 69.50% of Kumasi Technical University graduates were employed after graduation, with 24.20% in permanent employment, 39.20% self-employed, 36.60% part-time or contract-based, 58.50% in TVET organisations, 41.50% in non-TVET sectors, 70.40% in private-sector employment, and 29.60% in government employment (Ababio *et al*., 2024). Another quality indicator of programme quality is perceived job readiness among graduates, which can also vary across programmes; for example, research among HND Graphic Design graduates at Takoradi Technical University indicated that about 40% perceived themselves as \"not job ready,\" 5% as \"highly job ready,\" and 10% as \"somewhat job ready\" after graduation (Sarpong-Nyantakyi and Mensah, 2025).

III. Materials and Methods

A. Research Design and Approach

The research paper followed a quantitative survey cross-sectional design to assess the effectiveness of Industry Attachment Training (IAT) on tertiary graduates' competencies and employability in Ghanaian technical universities, especially the Kumasi Technical University. This design suits well in determining the relationships between variables at one given point in time, and it is common in education and labour market research (Creswell, 2003). Fig.1 shows the research methodological framework, from idea conceptualization to interpretation and conclusion.

B. Study Population and Sampling

The population of the study included students who had undergone industrial attachment. Through stratified and systematic random sampling techniques, a sample of four hundred and nineteen (419) respondents was used. The sampling guaranteed the representation of the programmes, academic levels and attachment characteristics.

C. Data Collection Instrument

A structured questionnaire was used to collect data that included demographic variables, industrial attachment variables (preparation, relevance, supervision), development of technical skills, development of soft skills, and employability perceptions. Items gauging perceptions and experience were placed on a Likert scale, which is in line with empirical studies based on the survey (Likert, 1932)

D. Model Specification and Data Analysis Techniques

1) Multiple Linear Regression Model

The following multiple linear regression model was defined to estimate the mean effect of the components of industrial attachment on the technical skills:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \varepsilon_i \qquad (1)$$

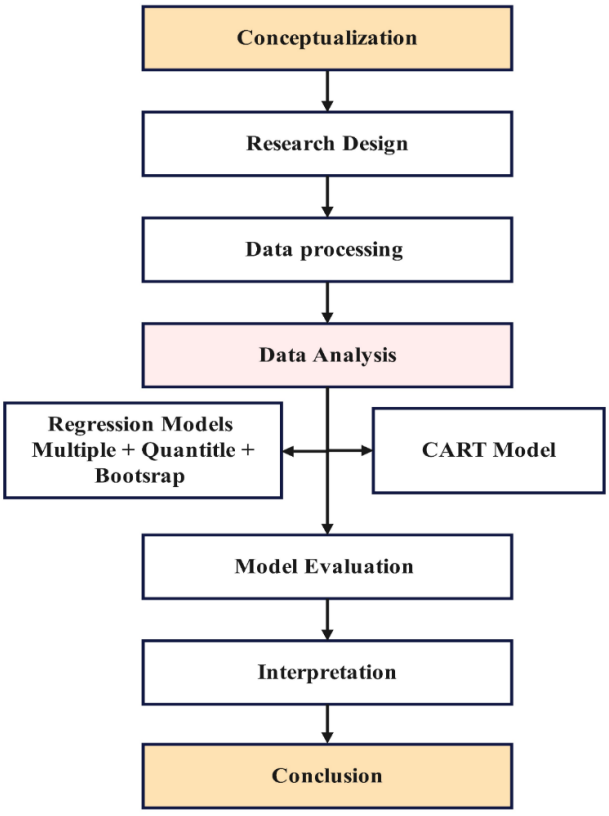


Fig. 1. Research Methodological Framework

where: Y_i *is the* Technical Skills Index, X_{1i}, X_{2i}, and X_{3i} represent preparation, relevance, and supervision, respectively.

This model is based on the classical linear regression model (Wooldridge, 2010), which assumes that the data are linear, independent, and that the errors are homoscedastic.

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2) Quantile Regression Model

Quantile regression was used to take into consideration the heterogeneity among the distribution of technical skills. The conditional quantile is given by:

$$Q_Y(\tau \mid X_i) = \beta_0(\tau) + \beta_1(\tau)X_{1i} + \beta_2(\tau)X_{2i} + \beta_3(\tau)X_{3i} \quad (2)$$

The estimator is obtained by minimizing the objective function:

$$\hat{\beta}(\tau) = \arg\min_{\beta} \sum_{i=1}^{n} \rho_\tau (Y_i - X_i'\beta) \quad (3)$$

where the quantile loss function is:

$$\rho_\tau(u) = u(\tau - I(u < 0)) \quad (4)$$

Quantile regression is not based on an assumed constant variance and is resistant to outliers; thus, it is appropriate when dealing with heterogeneous data (Koenker & Bassett, 1978; Koenker, 2005).

3) Bootstrap Quantile Regression

Bootstrap Quantile Regression Bootstrap resampling was utilized in order to achieve strong standard errors. The bootstrap estimator is:

$$\hat{\beta}^*(\tau) = \frac{1}{B}\sum_{b=1}^{B} \hat{\beta}^{(b)}(\tau) \quad (5)$$

and the standard error is computed as:

$$E(\hat{\beta}(\tau)) = \sqrt{\frac{1}{B-1}\sum_{b=1}^{B}\left(\hat{\beta}^{(b)}(\tau) - \hat{\beta}^*(\tau)\right)^2} \quad (6)$$

where B=1000. Bootstrap methods improve inference when analytical solutions are complex or unavailable (Efron and Tibshirani, 1993).

4) Classification and Regression Tree (CART) Model

The decision tree model was used to capture non-linear relationships and the effects of interactions. The CART algorithm recursively splits the data in the minimum possible impurity. The Gini index can be defined as:

$$G(t) = 1 - \sum_{k=1}^{K} p_k^2 \quad (7)$$

The best split is one that minimizes:

$$\Delta G = G(t) - \left(\frac{N_L}{N}G(t_L) + \frac{N_R}{N}G(t_R)\right) \quad (8)$$

Decision trees are widely used for classification and prediction tasks due to their interpretability (James *et al*., 2013).

5) Cost-Complexity Pruning

In order to prevent overfitting, cost-complexity pruning was used:

$$R_\alpha(T) = R(T) + \alpha \mid T \mid \quad (9)$$

where α controls the trade-off between model complexity and fit. The optimal tree is selected based on cross-validation (Gordon *et al*., 1984).

6) Model Evaluation Metrics

To determine the predictive power of the classification model, it was compared with:

Accuracy:

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \quad (10)$$

Kappa Statistic:

$$\kappa = \frac{P_o - P_e}{1 - P_e} \quad (11)$$

These are typical metrics used to evaluate classification models, with Kappa being a measure of agreement greater than chance (Cohen, 1960).

7) Variable Importance (Mean Decrease Gini)

Variable importance was measured using the Mean Decrease Gini:

$$VI_j = \sum_{t \in T_j} \Delta G_t \quad (12)$$

This metric quantifies the contribution of each predictor to reducing impurity in the tree (Gordon *et al*., 1984).

8) Descriptive Statistics

The characteristics and perceptions of the respondents were summarized using descriptive statistics, such as frequencies and percentages. This method gives a clear picture of how the sample has been distributed and response patterns (Agresti, 2018).

E. Ethical Considerations

Respondents were involved voluntarily, and their confidentiality was upheld to the latter. The information was used for academic purposes only, as per the research ethics.

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IV. Results And Discussion

A. Demographic Data

According to the demographic information on the 420 respondents as shown in Table I, a huge proportion of 94.3% had experienced an industrial attachment, and only 4.3 percent of the respondents had no experience in an industrial attachment. The sample was rather male-dominated (90.7%), and females constituted only 9.3%. In terms of age, the most proportionate number of the respondents (52.9%) was between the ages of 20 and 25 years, with the smallest number (3.8%) being below 20 years.

Academically, over two-thirds were BTECH students (68.6%), with just 1.4% of the total being described as Others. The highest proportion of the respondents (59.8%) engaged in their attachment in a privately structured company, in contrast to only 10.5% in individual or sole proprietorship organizations. The majority of attachments (67.6%) were between 3 and 6 months, and the least (15.2%) was over 6 months. Lastly, the biggest proportion of participants (52.4%) were undertaking Automotive Engineering with the least program category being Agricultural Mechanization (4.5%).

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TABLE I
DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Variable	Category	Frequency	Percent (%)
Industrial Attachment Participation	Yes	396	94.3
	No	18	4.3
	During the attachment	1	0.2
	Not yet	5	1.5
Gender	Male	381	90.7
	Female	39	9.3
Age	Below 20	16	3.8
	20–25	222	52.9
	26–30	75	17.9
	Above 30	107	25.5
Level of Study	Diploma	44	10.5
	HND	82	19.5
	BTECH	288	68.6
	Others	6	1.4
Type of Organization	Government Organization	125	29.8
	Individual or Sole Proprietorship	44	10.5
	Private Structured Company	251	59.8
Duration of Attachment	Less than 3 months	72	17.1
	3–6 months	284	67.6
	More than 6 months	64	15.2
Program of Study	Automotive Engineering	220	52.4
	Dispensing / Pharmaceutical Technology	58	13.8
	Electrical / Electronic Engineering	44	10.5
	Mechanical Engineering	35	8.3
	Agricultural Mechanization	19	4.5
	Other (Civil, Secretaryship)	44	10.5

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TABLE II
MULTIPLE LINEAR REGRESSION RESULTS ON THE EFFECT OF INDUSTRIAL ATTACHMENT ON STUDENTS' TECHNICAL SKILLS

Predictor	Estimate	Std. Error	t value	p-value
Intercept	2.18974	0.22965	9.535	< 2e-16***
Preparation	0.18432	0.03228	5.710	2.16e-08***
Relevance	0.12275	0.03690	3.327	0.000957***
Supervision	0.20970	0.05147	4.074	5.53e-05***

Significance codes: *** p < 0.001

B. Multiple Regression of Industrial Attachment on Technical Skills

The results of the regression show that the industrial attachment plays a significant role in improving the technical and practical skills of the students. The three predictors, preparation, relevance of the attachment experience, and supervision, are all statistically significant at the 1 per cent level, and this indicates that there is strong evidence that the three have a beneficial effect on the technical skill index. In particular, supervision impacts the most (0.20970), then preparation (0.18432) and relevance (0.12275), implying that more directed and effective attachment experiences have a higher impact on skills training. The positive coefficients also appear to suggest that any improvement in any of these components results in a corresponding improvement in the technical competency of students.

C. Heterogeneous Effects of Industrial Attachment on Technical Skills Development

The quantile regression results indicate that the overall effect of industrial attachment on students' technical skills is heterogeneous across the distribution of skills.

The positive effect is the highest at the lowest quantile ($\tau = 0.10$) and, therefore, it means that students with initially low technical abilities gain a lot with the help of structured guidance in the attachment stage. These effects are also positive on preparation and relevance, though relevance cannot be considered statistically strong at this point because there is a confidence interval that crosses the zero mark. At the median ($\tau = 0.50$), all predictors are positive and statistically significant, with supervision again playing the biggest role, meaning that structured mentorship always has a positive impact on the skill acquisition of a standard student. The impact of the components of industrial attachment is more differentiated at higher quantiles ($\tau = 0.75$ and $\tau = 0.90$). Technical skill development is heavily concerned with supervision and relevance, as both have a relatively strong and constant impact in the upper-middle distribution (0.75). Nevertheless, in the highest quantile ($\tau = 0.90$), preparation is not significant enough, which might indicate that more competent students are not dependent on the aspect of pre-attachment preparedness, but rather the quality of the experiential relevance and quality of supervision.

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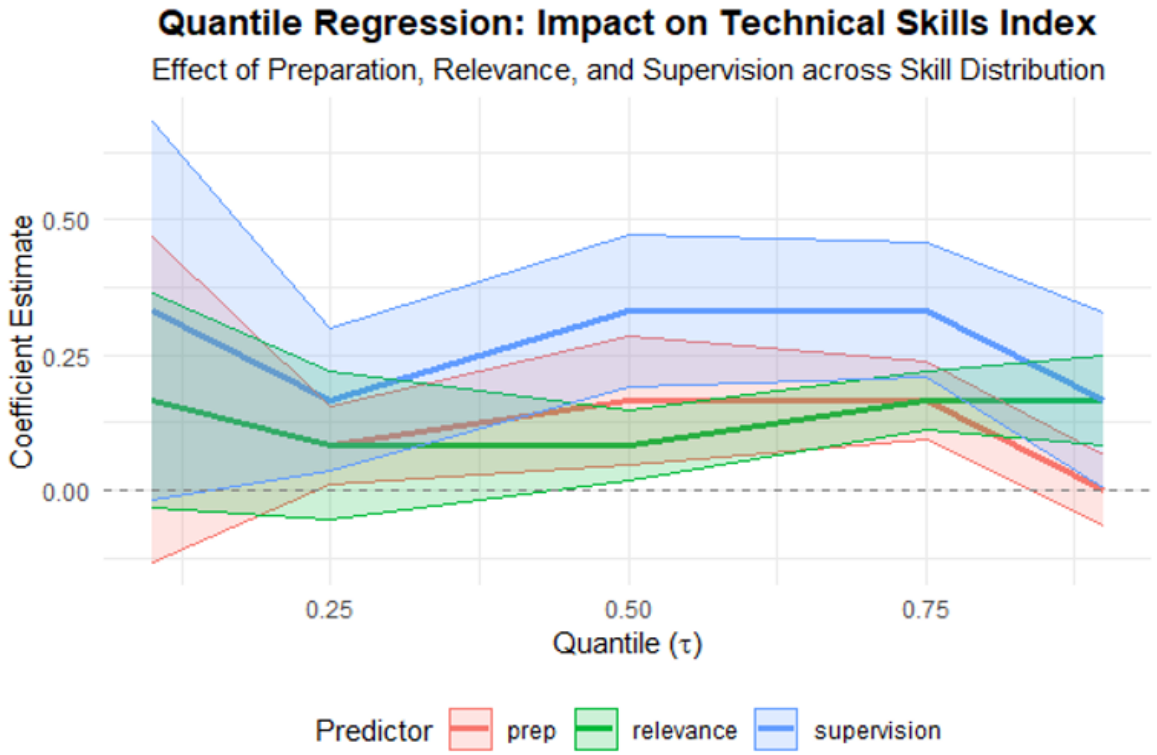


FIGURE 2: A QUANTILE PLOT OF THE EFFECT OF PREPARATION, RELEVANCE, AND SUPERVISION ACROSS THE SKILL DISTRIBUTION

The results of the bootstrap quantile regression, as shown in Table IV, have strongly suggested that the impact of industrial attachment on students in terms of technical skills is not consistent over the entire range of skills. At the lower quantile ($\tau = 0.10$), none of the predictors is statistically significant at the 5% level, except the intercept. However, supervision showed a marginal association with the outcome at the lower quantile ($p = 0.052$), although it did not reach statistical significance at the 5% level. Preparation and relevance, however, fail to demonstrate statistically reliable effects at this level, suggesting that weaker students do not necessarily gain at this stage through the interference of these components unless supported by stronger supervisory assistance. The results are more stable and statistically significant at the median ($\tau = 0.50$) and upper quantiles ($\tau = 0.75$ and $\tau = 0.90$). Supervision always proves positive and dominant in all these distributions, affirming its central position in increasing technical competence. The importance of preparation increases with the median level of the population and level of ability, whereas relevance increases with the high quantiles, which means that students with high ability will benefit more with meaningful and contextually fitted industrial exposure.

On the upper end, preparation becomes unimportant and it seems that the good students perform better not because of prior preparedness but because of the relevance and the quality of the supervision.

D. Skills Distribution Index for Workplace Behaviour, Communication, and Teamwork

The results of the quantile regression show that the relationship between preparation, relevance, and supervision with the technical skills index is not linear as it differs throughout the distribution. Supervision exhibits the greatest and most reliable positive effect, mainly at lower and middle quantiles, indicating that it would be particularly useful in individuals with weaker to middle levels of skills, though its effect is slightly smaller at the highest quantile. The positive influence of preparation is moderate also in most quantiles, which are highest over the median but decreases at the upper tail, where it becomes insignificant or even negative, which implicates diminishing returns corresponding to highly skilled individuals. Relevance has a comparatively smaller but more consistently growing impact, with a greater impact towards higher quantiles, which suggests that relevance of content to needs is more relevant to high-performing individuals, who are already high performing.

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TABLE III

QUANTILE REGRESSION RESULTS FOR THE EFFECT OF INDUSTRIAL ATTACHMENT ON STUDENTS' TECHNICAL SKILLS (T= 0.10, 0.25, 0.50, 0.75, 0.90)

Quantile (τ)	Predictor	Coefficient	Lower Bound	Upper Bound
0.10	Intercept	1.00000	0.99419	2.50824
	prep	0.16667	0.01283	0.41686
	relevance	0.16667	-0.07834	0.47428
	supervision	0.33333	0.03223	0.55365
0.25	Intercept	2.66667	1.16537	2.90277
	prep	0.08333	0.08333	0.08333
	relevance	0.08333	0.02708	0.31043
	supervision	0.16667	0.04522	0.32347
0.50	Intercept	2.08333	1.84732	2.11216
	prep	0.16667	0.16667	0.32675
	relevance	0.08333	0.04958	0.11727
	supervision	0.33333	0.20422	0.45660
0.75	Intercept	2.00000	2.00000	2.52563
	prep	0.16667	0.16667	0.27657
	relevance	0.16667	0.11220	0.20261
	supervision	0.33333	0.18088	0.33333
0.90	Intercept	3.50000	3.25019	3.74450
	prep	0.00000	0.00000	0.00000
	relevance	0.16667	0.07202	0.16667
	supervision	0.16667	0.16667	0.30548

Table V results show that industrial attachment positively influences the acquisition of soft skills, especially communication, teamwork, and workplace behaviour, with a strong effect. In the context of workplace behaviour, assessed in terms of exposure to work ethics, a significant majority of respondents had positive results, with 71.3% (21.2% strongly agree and 50.1% agree) stating that they had been exposed to modern technologies and work ethics during their attachment, and only 6.7% reported the opposite.

Likewise, the improvement of communication and teamwork skills seems to be even more applied, with 85.2% (27.7% strongly agree and 57.5% agree) of the respondents showing that the training improved these two attributes, and there is little variation, with 4.7% saying it did not. The relatively low percentages of neutral answers in both of the indicators imply that the majority of the students had a definite understanding of improvement.

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TABLE IV

BOOTSTRAP QUANTILE REGRESSION RESULTS FOR THE EFFECT OF INDUSTRIAL ATTACHMENT ON STUDENTS' TECHNICAL SKILLS (R = 1000)

Quantile (τ)	Predictor	Value	Std. Error	t value	p-value	Significance
0.10	Intercept	1.00000	0.48466	2.06330	0.03971	*
	prep	0.16667	0.14485	1.15064	0.25054	ns
	relevance	0.16667	0.10951	1.52196	0.12878	ns
	supervision	0.33333	0.17089	1.95052	0.05179	.
0.25	Intercept	2.66667	0.43105	6.18644	0.00000	***
	prep	0.08333	0.03653	2.28128	0.02304	*
	relevance	0.08333	0.06396	1.30295	0.19331	ns
	supervision	0.16667	0.07042	2.36675	0.01840	*
0.50	Intercept	2.08333	0.30481	6.83496	0.00000	***
	prep	0.16667	0.05753	2.89715	0.00397	**
	relevance	0.08333	0.03244	2.56876	0.01056	*
	supervision	0.33333	0.06933	4.80776	0.00000	***
0.75	Intercept	2.00000	0.18732	10.67705	0.00000	***
	prep	0.16667	0.03679	4.53068	0.00001	***
	relevance	0.16667	0.02902	5.74246	0.00000	***
	supervision	0.33333	0.06751	4.93724	0.00000	***
0.90	Intercept	3.50000	0.30903	11.32572	0.00000	***
	prep	0.00000	0.03529	0.00000	1.00000	ns
	relevance	0.16667	0.04377	3.80821	0.00016	***
	supervision	0.16667	0.07350	2.26751	0.02387	*

*Significance codes: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, $p < 0.1$, ns = not significant*

Fig. 2 shows the quantile regression estimates of heterogeneous effects across the technical skills distribution. The effect of supervision was 0.34 at the lower quantile (τ = 0.10), remained relatively stable at approximately 0.33 across the middle quantiles (τ = 0.50–0.75), and declined to 0.17 at the upper quantile (τ = 0.90). Preparation showed a stronger effect at the lower quantile, decreasing from 0.38 (τ = 0.10) to 0.17 (τ = 0.25), before remaining relatively stable at 0.20–0.22 across τ = 0.50–0.75 and approaching zero at τ = 0.90. In contrast, the effect of relevance increased progressively from 0.17 (τ = 0.10) to 0.25 (τ = 0.90). The patterns indicate that the associations between the predictors and technical skills vary across the conditional skills distribution, with supervision and preparation showing stronger associations at lower-to-middle quantiles, whilst relevance becomes more noticeable toward the upper end of the distribution.

Table VI depicts a gradual decrease in the relative error with an increase in the number of splits, signalling a better fit of the decision tree on the training data, with the relative error of 1.0000 at the root node and reducing to 0.5127 at four splits. In the same way, the error, which was estimated using the cross-validation process, is reduced to 1.1139 and 0.5886 respectively, indicating a better performance in generalization with the increasing complexity of the model. The initial decrease in x-error becomes much more gradual upon the initial split, with diminishing marginal improvements on each subsequent split, and thus the possibility of stabilization of model performance. The standard errors associated are quite stable even within different models, suggesting the same level of variability in cross-validation estimates.

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TABLE V
THE IMPACT OF INDUSTRIAL ATTACHMENT ON THE DEVELOPMENT OF SOFT SKILLS, INCLUDING COMMUNICATION, TEAMWORK, AND WORKPLACE BEHAVIOUR

Indicator	Category	Frequency	Percent (%)
Workplace Behaviour - Work Ethics			
I was exposed to modern technologies and work ethics	Strongly Agree	89	21.2
	Agree	210	50.1
	Neutral	92	22.0
	Disagree	18	4.3
	Strongly Disagree	10	2.4
	Total	419	100.0
Communication & Teamwork Skills			
The training enhanced my communication and teamwork skills.	Strongly Agree	116	27.7
	Agree	241	57.5
	Neutral	42	10.0
	Disagree	14	3.3
	Strongly Disagree	6	1.4
	Total	419	100.0

Based on Table VII, the model has an overall accuracy of 0.6585, much higher than the no information rate of 0.4634, as based on the very small p-value, so the classification is not random with respect to the class balance. The Kappa value of 0.3636, however, indicates that there is not very good agreement at all without chance.

The Mean Decrease Gini values quantify the relative importance of each variable in reducing classification impurity within the model, with higher values indicating greater discriminatory contribution. The variable Assessment feedback helpful (Q_{29}) has the highest importance at 18.3617, followed by Met my expectations (Q_{30}) and good university industry collaboration (Q_{28}), indicating that these predictors contribute most strongly to partitioning the data. A moderately high level of importance is also observed for KsTU adequately prepared me (Q_{25}), Duration sufficient (Q_{32}), and Host company sufficient supervision (Q_{27}), suggesting they provide substantial additional explanatory power. In contrast, Level of preparation (Q_6), Quality of supervision (Q_8), and particularly Relevance to program of study (Q_7) exhibit relatively low importance values, implying limited contribution to reducing node impurity.

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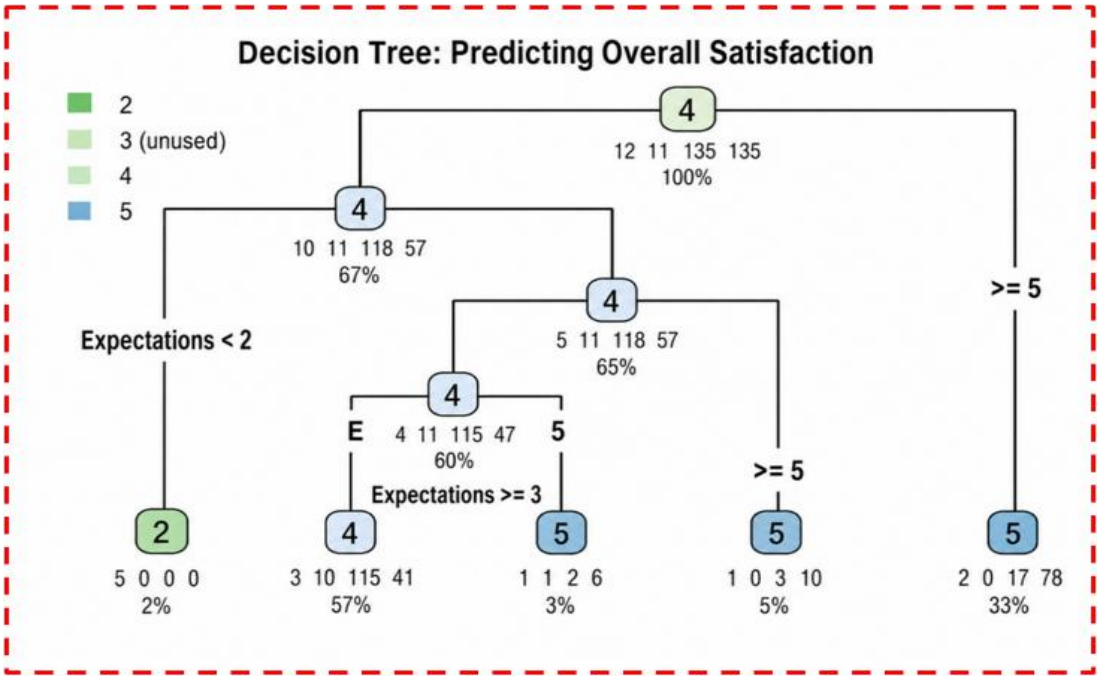


Figure 3: Decision Tree Diagram Showing Evidence-Based Recommendations For Improving Industrial Attachment Programmes And Strengthening Industry-Academia Linkage

TABLE VI
THE COMPLEXITY PARAMETER

CP	n split	Relative Error	Cross-Validated Error (x error)	x std
0.3861	0	1.0000	1.1139	0.0531
0.0380	1	0.6139	0.6392	0.0515
0.0253	3	0.5380	0.6139	0.0510
0.0100	4	0.5127	0.5886	0.0504

TABLE VII
OVERALL STATISTICS

Metric	Value
Accuracy	0.6585
95% CI	(0.5676, 0.7416)
No Information Rate	0.4634
P-Value [Acc > NIR]	1.016e-05
Kappa	0.3636

According to the decision tree in Fig. 3, the pre-attachment expectations (which are defined within the Preparation and Institutional Support head (variables Q_6, Q_{25}, Q_{26}) are the leading cause of the overall satisfaction. The highest number (67% of the sample) of the respondents rated their expectations highly (score of 4) and most frequently reported the highest level of satisfaction (57 out of 118 people). Conversely, the lowest expectations (score below 2) only represented 2% of the sample and did not seem to exhibit a differentiation pattern in satisfaction probably due to the limited number of data points. The moderate-expectations group (3) also did well, but with a smaller percentage of maximum satisfaction (47 of 115) as compared with the high-expectations group. This statistically indicates that there is a strong positive correlation between pre-placement preparation and institutional support (Q_6, Q_{25}, Q_{26}) and post-placement satisfaction, meaning the mechanisms of orientation and providing pre-attachment support can contribute to improved outcomes substantially.

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The items in the secondary splits include variable N, which could probably be the items above the category of Quality, Relevance and Supervision (Q_7, Q_8, Q_{27}-Q_{29}) or Experience Evaluation (Q_{13}, Q_{30}, Q_{32}), and are quantified through the number of meaningful interactions within the industry, the quality of supervision, or the number of tasks completed. The tree uses a threshold of N≥5 where the biggest branch (33% of the sample, 78 individuals) demonstrates that reaching this degree of engagement is related to high levels of satisfaction. But there are two smaller branches (3% and 5% of the sample) with mixed or lower results of satisfaction under the same condition, illustrating that the impact of N can be non-linear or controlled by other immeasurable factors in the Quality and Experience domain. These splits are to be taken with caution considering that the subgroups are quite small (as small as 2 to 5 per cent) and that the subgroups shall be verified on a larger scale. The evidence is in help inform recommendations to enhance institutional support and preparation (Q_6, Q_{25}, Q_{26}), at least five quality supervision contacts (Q_7, Q_8, Q_{27}–Q_{29}), and systematic assessment of the attachment experience (Q_{13}, Q_{30}, Q_{32}) to establish stronger industry-academia links.

TABLE VIII
VARIABLE IMPORTANCE OF EVIDENCE-BASED RECOMMENDATIONS FOR IMPROVING INDUSTRIAL ATTACHMENT PROGRAMMES AND STRENGTHENING INDUSTRY–ACADEMIA LINKAGES

Variable	Mean Decrease Gini
Q_{29} Assessment feedback helpful	18.3617
Q_{30} Met my expectations	15.5440
Q_{28} Good university industry collaboration	14.2555
Q_{25} KsTU adequately prepared me	13.5413
Q_{32} Duration sufficient	12.2449
Q_{27} Host company sufficient supervision	11.9635
Q_{26} University provided enough guidance	10.3680
Q_6 Level of preparation	6.3577
Q_8 Quality of supervision	4.4546
Q_7 Relevance to program of study	2.7795

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TABLE IX
RELATIONSHIP BETWEEN INDUSTRIAL ATTACHMENT AND GRADUATE EMPLOYABILITY OUTCOMES, SUCH AS TIME TO FIRST JOB AND JOB RELEVANCE.

Statement	Response	Frequency	Percent (%)
The experience increased my chances of securing employment after graduation	Strongly Agree	137	32.7
	Agree	227	54.2
	Neutral	43	10.3
	Disagree	5	1.2
	Strongly Disagree	7	1.7
I feel adequately prepared for future industry challenges	Strongly Agree	158	37.7
	Agree	235	56.1
	Neutral	17	4.1
	Disagree	4	1.0
	Strongly Disagree	5	1.2
Perceived Impact on Employability Prospects (Merged Categories)	Yes (Positive perception)	373	89.0
	Maybe / Uncertain	10	2.4
	No (Negative perception)	3	0.7
	Already employed	2	0.5
	Other positive expressions	31	7.4

E. Relationship Between Industrial Attachment and Graduate Employability Outcomes

Table IX indicates that in the statement "The experience made me more likely to get a job after graduating", most of the respondents (54.2%) were on an agreement level. In the same case where the respondents were asked to decide whether they felt prepared enough to face the challenges in the industry in future, most respondents (56.1%) chose the agree option and only the few (1.0%) chose the disagree option. These results show that a large majority see industrial attachment as increasing the employability opportunity and industry preparedness, which would then naturally be translated to reduced period to first employment and relevance of the job. Also, on the scale of the perceived impact on the probability to get a job, the most (89.0%) said that they have had a positive perception (Yes), the minor group (0.5%) said that they were already employed before the attachment. Only 0.7% had a negative perception. It is likely that the statistically significant relationship between involvement in industrial attachment and favourable self-assessed employability outcomes are seen in the high percentage of positive responses (89.0%) when a comparison is made with the very low percentage of negative responses (0.7%).

The results of the present study support and expand the existing knowledge on industrial attachment and employability, in the context of Technical and Vocational Education and Training (TVET) systems. The robust and steady impact of supervision by the quantile is in line with previous research that points out that good mentorship and supervision are essential to achieving translation of theoretical knowledge into practical expertise (Sarpong-Nyantakyi and Mensah, 2025, Uwilingiyimana *et al*., 2026). This research however offers more information by demonstrating that the effect of supervision is more effective in low and middle skilled people and that mentoring has a compensatory effect on initial deficits of skills. The moderate yet decreasing effect of preparation in the higher quantiles is observed which favours the argument that academic preparation does not prerequisite high level skill development without the substantial exposure to the workplace. This result corresponds to the literature that shows that theoretical education that is not linked to practice restricts the outcomes of employability (Anjum, 2020, Shahanga and Akyoo, 2025). Further hints that experiential learning becomes increasingly critical as one becomes more advanced is the declining returns of preparation with higher skills. The growing significance of relevance in higher quantiles is congruent with research that points to the necessity of correspondence between the curriculum and what business does (Sarpong-Nyantakyi and Mensah, 2025). This implies that to high-performing individuals, the quality and applicability of the assigned tasks are more important than general exposure. It validates some of the fears expressed in the literature of the fact that discrepancies between academic and job expectations are a barrier to the acquisition of a skill, especially in a specialized area like that of graphic design. The results of employment in this study, which are 69.50% employment of graduates, are comparable with the tracer studies in Ghana (Ababio *et al*., 2024). Yet, the fact that after graduation approximately 40% of graduates are not job-ready confirms the previous evidence of the unresolved skill gaps despite the relatively high employment rates (Sarpong-Nyantakyi and Mensah, 2025). This implies that employment per se is not an adequate measure of programme effectiveness since a significant number of graduates might still fail to have the competencies necessary to become sustainably successful in their careers. The theoretical frameworks presented in the literature, specifically CareerEDGE model and Experiential Learning Theory, are also supported by the findings of the CART model, which claimed that the main predictors were supervision and relevance. The models highlight that work experience, mentoring, and skills development are considered important components of employability (Mahajan *et al*., 2022; Hashim, 2023)

F. Ethical Considerations

Respondents were involved voluntarily, and respondent confidentiality was upheld to the letter. The information

V. Conclusions

The key findings of the study reveal emphatic evidence that effective and well-coordinated supervision and task relevance are the most important determinants of skills acquisition and employability outcomes during industrial attachment training, as projected and identified by the decision tree model across all levels of the skills distribution.

The study further concludes that despite the positive contribution of industrial attachment to graduate employability through the acquisition of soft skills, it also highlights weak industry-academia collaboration as a result of mismatches between programme curriculum and industry needs, which continue to detract from the positive rationale for the implementation of industrial attachment training and, as such, requires an effective, well-structured, and coordinated effort and plan approach between academia and industry in bridging the gap to provide the requisite soft skills for labour market demands.

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