

# AI-Supported Work-Integrated Learning for Electrical Engineering Students in Open Distance Learning: A Competency-Based Approach

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## Abstract

*Work-Integrated Learning (WIL) is an essential part of electrical engineering education, providing students with the opportunity to take their theoretical knowledge and apply it to create professional competencies. Implementing good quality WIL requires overcoming some major hurdles in Open Distance Learning (ODL) environments, such as limited access to the physical industry, unequal mentorship opportunities and challenges in evaluating practical competencies remotely. This study outlines a proposed WIL framework using Artificial Intelligence (AI) that will be developed specifically for electrical engineering students in ODL environments. The proposed framework combines Intelligent Tutoring Systems (ITS), Learning Analytics (AL) and adaptive assessment models, allowing students to simulate actual workplace tasks aligned to defined industry competencies. Additionally, Machine Learning (ML) algorithms will analyse student interaction data to support personalised feedback, competency gap analysis and adaptive sequencing of tasks. A pilot initiative with ODL undergraduate electrical engineering students has proven that the AI-based WIL model is a superior method for developing practical competencies, encouraging greater knowledge retention, enhancing assessment reliability through robust validation techniques, etc., compared to previous WIL logbook models. The data from the pilot indicated that the AI/ML Driven WIL model has positively impacted the competencies, task accomplishment, and engagement of all student cohorts participating in the pilot project. Furthermore, many students provided qualitative feedback indicating they felt much more confident after participating in the AI-based WIL model in terms of preparedness for employment, ability to complete assignments/tasks, etc., compared to using the WIL logbook ODL. Thus, the AI-supported WIL approach provides solutions to the major weaknesses experienced in traditional methods of WIL delivery in ODL, providing scalable, data-driven supervision and transparent competency evaluations. Based on the study's findings, there is evidence that AI-supported WIL provides an effective alternative to maintaining professional engineering accreditation while improving access to education through ODL. The structure of this study provides a clear theoretical model for incorporating AI into competency-based engineering education in ODL environments with limited resources.*

**Keywords:** *Work-Integrated Learning, Open Distance Learning, Competency-Based Assessment and Electrical Engineering Education.*

## Introduction

The combination of real-world experience combined with academic education is a critical aspect of preparing engineers for their future careers [1]. Work-Integrated Learning (WIL) provides students with practical experience working on real projects while allowing students to learn about the profession by doing real projects [2]. Accreditation and professional organisations have emphasised the importance of WIL in preparing engineers for the workforce through establishing clear measurement criteria for engineers' capabilities as well as ensuring that engineers provide the same quantity and quality of work that is expected by employers [3]. Providing WIL in ODL environments presents many additional challenges compared to traditional models [4]. The separation from industry, instructors, and peers creates difficulty in using a traditional model of experiential learning.

Growing access to engineering education through Open Education Resources (OER) and Flexible Learning Options (FLO) combined with the increasing numbers of eligible candidates for admission has led to an increase in the availability of OERs and FLOs for those currently working in or who will be entering the labour force [5]. However, traditional Work Integrated Learning (WIL) models that rely primarily upon physical work experience placements, supervisor assessed work, and journal reflections to assess candidates' competencies typically cannot be implemented at scale in distance education systems [6]. Compounding this issue is the reality that there are often limited placements available, the quality of mentorship is frequently inconsistent, and the assessment of candidates' competencies is generally based upon subjective

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measures [7]. Therefore, many electrical engineering degree programs that are delivered through ODL face significant barriers when attempting to create equitable and valid WIL experiences for their graduates while also meeting professional and accreditation requirements.

With the rapid advancement in AI, Educational Data Analytics (EDA), institutions and educators have much greater opportunities to address these significant challenges [8]. The potential of AI-enabled learning systems to support adaptive instruction, personalised feedback, automatic monitoring of learner performance, and predictive analytics in diverse education environments has been demonstrated in the area of engineering education [9]. There are ongoing efforts to develop AI systems for use with engineering education within ODL by creating virtual labs, ITS, and predictive learner support tools [10]. To date however, the systematic integration of AI for the purpose of ensuring a cohesive end-to-end system for supporting workplace-oriented competency development in ODL contexts is still a developing field within the area of engineering education [11]. While many current AI applications focus upon the automation of content delivery or assessments all applications can be improved by providing a more holistic approach to supporting and developing workplace-based competencies throughout the educational process.

Competency-based education is a good way to structure WIL when running distance education [12]. The focus of WIL is on skills demonstrated by learners as opposed to their activities or the number of hours they took part in that activity [13]. WIL from the perspective of competency based education allows for the measurement of learners' skills and how they are linked to the skills required by industry [14]. The same applies to many of the outcomes defined in Professional Outcome Frameworks (POFs) for electrical engineering education, which include technical competency, ethical practice, problem solving skills and lifelong learning [15]. When combined with AI-driven analytics, a competency based approach to WIL allows for the continuous tracking of an individuals' progress toward achieving their competencies, as well as identifying skill gaps and adaptive sequencing of learning tasks [16]. Traditional logbook-centric WIL methods do not offer these types of features.

In Open Distance Learning (ODL), the lack of actual physical supervision increases the need for data-driven, open, transparent methods of assessment [17]. AI technologies, such as ML and LA, can analyse the ways that a learner interacts with certain data, i.e., task completion patterns, as well as assessment artefacts to objectively demonstrate that they have achieved a particular level of competency [18]. Intelligent Systems also support Reflective learning through real-time, individualised Feedback, as well as Simulated Work Experiences of increasing complexity [19]. AI does not replace human supervisors; it Works with human supervisors to provide a better overview of the progress that learners have made towards their competencies, as well as to provide scalable insight into the learning experience based on the available evidence.

Currently, there is little research into how to design empirical evidence supporting an AI-enabled WIL Framework for electrical engineering students attending ODL programs despite the recent increase in AI-powered Education research worldwide. Most research conducted on this area has not provided a detailed, competency-focused framework, studied AI Tools in isolation, or evaluated the effect of using AI on students' educational outcomes quantitatively. In addition, there has been a lack of exploration of whether or not AI WIL Systems can be deployed successfully in developing nations, where restricted bandwidth and inconsistent access to internship opportunities still exist.

This research identifies the above research gaps and offers a new AI-supported WIL Framework based on competency that has been specifically created to support electrical engineering programs through ODL. The proposed framework uses ITS, LA, and adaptation assessments to create a simulated environment that closely resembles an actual workplace environment and prepares students for the job they will enter after graduation. ML algorithms will track each learner's interactions with the ITS to determine what competencies they do not have and develop a personalised sequence and feedback process for them. During the pilot test of the information and implementation of the proposed framework, the performance of undergraduate electrical engineering students who participated will be compared with the performance of students using traditional WIL logbook models.

This work makes three key contributions;

- It presents a structured framework to support WIL using AI technologies, which aligns with competency assessments to meet the needs of electrical engineering students studying through ODL models;
- It demonstrates that AI-driven analytics can provide greater reliability, transparency and scalability to the WIL assessments without diminishing the quality of the profession from which the assessment originates; and
- It provides empirical evidence that students are able to achieve improved competencies, be more engaged as learners and complete tasks more efficiently and, therefore, provides institutions with a practical approach and insight in developing sustainable alternatives to traditional WIL programmes.

The structure of the remainder of this paper will consist of the following sections: Section 2 contains a literature review of related work on WIL, the use of AI in engineering education, Competency-Based Assessment (CBA) in engineering education, and how CBA relates to stakeholders (students, employers, education providers); Section 3 provides the experimental design and evaluation methodology followed by Results and Discussion in Section 4, whilst Section 5 contains the conclusion of the paper as well as directions for future research.

## Literature Review

The aim of this section is to provide a discussion of the body of literature on AI-enabled WIL within ODL environments. The discussion will take into account how this section relates back to the research problem, the study's goals, and research contributions stated in the abstract and introduction. This is done by thematically grouping the literature review of AI-enabled WIL into a number of groups in order to demonstrate the core concepts, emerging technological advancements, and areas of research that are still not clearly defined in the literature that have brought about the current study.

### *A. Work-Integrated Learning in Engineering Education*

WIL is established as a truly valuable learning strategy for Engineering education as it allows engineering students the ability to connect their theoretical knowledge with real-world engineering-related issues [20]. Traditional WIL models, specifically, industrial attachment, cooperative education, apprenticeships and capstone industry projects have been established to support and strengthen engineering students' technical competencies, employment opportunities, and development of professional identity [21]. More specifically, WIL in electrical engineering provides exposure to complex system(s), safety-critical practices, and interdisciplinary collaboration that cannot be replicated effectively in a classroom setting [22].

Many Professional accreditation frameworks relate to WIL as a means to assure that engineering graduates demonstrate measurable outcomes. For example, problem-solving ability, settings for ethical decision making, and engineering tool use/application of engineering tools [23]. Therefore, it is common practice to embed WIL as a compulsory part of the engineering curriculum(s) [24]. Traditionally, however, the delivery models within WIL heavily rely on workplace access on site, supervision on site, and subjective evaluation (supervisor reports and student log books) on how to implement [25].

### *B. Challenges of WIL in Open Distance Learning (ODL) Contexts*

The rapid growth of ODL has enabled many individuals to gain access to an education in engineering; particularly those working full-time jobs or located in remote areas or areas with limited resources for learning [26]. Flexibility and inclusivity present new opportunities for engineering education [27]. However, many of the same opportunities pose major challenges to experiential education. Researchers continue to

find barriers to the availability of sufficient work placements for students, equitable supervisory arrangements, and there is a lack of consistent assessment criteria across differing types of workplaces [28].

In ODL models of education, the assessment of WIL is often limited to reflective reports or logbooks and lacks a comprehensive method to validate the actual acquisition of the requisite competencies [29]. The disparity in the level of experience gained through the various workplaces further exacerbates these inequities [30]. Students participating in engineering education may engage in a variety of tasks relevant to the discipline while others may only participate in tasks that have little or no relevance to the discipline [31]. As a result of these limitations, the reliability, transparency, and fairness of WIL assessment, as well as the risk to both the educational quality and accreditations, are compromised.

Solutions are being developed to address these issues, such as virtual placements, project-based alternatives, and simulated experiences [32]. Although these approaches improve accessibility to WIL experiences, none of these approaches develop a structured and systematic method to evaluate students' competencies and/or levels of achievement [33]. Subsequently, there is a continuing need to develop scalable and evidence-based models that will provide an effective WIL structure within the context of ODL.

### C. *Artificial Intelligence in Engineering and Distance Education*

The use of AI technology in higher education, particularly for ODL programs, is on the rise [34]. Using AI-enabled tools (TTS, adaptive learning and LA), higher education institutions have seen how well AI tools can assist with personalizing instruction delivery, predicting student outcomes, fostering engagement with the subject matter, and improving student engagement [35]. Within the field of engineering education, AI applications have emerged in various areas, including automated assessment, virtual laboratories, fault diagnosis training for skill development, and monitoring student performance [36].

Learning Analytics (LA) and Machine Learning (ML) allow for analysis of large amounts of data regarding the ways in which students are interacting, which allows for data-driven decision-making and the identification of students experiencing difficulties in learning earlier than would otherwise be possible with traditional methods [37]. The lack of direct instructor observation in ODL environments makes LA and ML technologies especially valuable [38]. However, many articles written to date focus more on conceptual knowledge acquisition and content mastery than on the creation and validation of competencies related to the workplace.

Another concern related to the use of AI systems for educational purposes is related to the ability of these systems to be interpreted, ethically employed, and contextually adapted [39]. Most of the studies that are currently published discuss how AI will serve to augment, but not replace, human judgment in such professional fields as engineering [40]. This is also the orientation of the framework proposed by this study, where AI is envisioned to augment rather than replace, human judgment in terms of supervision, feedback, and assessment, rather than serve as an autonomous evaluator.

### D. *AI-Supported Practical and Experiential Learning*

In recent times, there have been some research done using AI technologies in supporting the delivery of practical and experiential learning via virtual laboratory environments, simulations, and digital twins [41]. Specifically, in the area of electrical engineering, virtual environments enhanced by the use of AI technology have been used to model and provide remote practice opportunities for students in the areas of power systems modelling, control circuits and fault modelling [42]. These tools have been shown to enhance conceptual knowledge and procedural accuracy associated with technical skill sets when used in conjunction with adaptive means of feedback.

However, while there has been an increase in the use of AI technologies to enhance the effectiveness of practical learning [43]. Most AI-enhanced practical learning systems do not integrate with existing WIL frameworks [44]. Rather, these systems are typically applied as additional tools to the existing WIL frameworks [45]. Thus, making it difficult to provide an integrated approach to practical skill development

based on a competency-based model for education [46]. In addition, there have been few studies that provide empirical evidence of the relationships between the use of AI-enhanced simulations and either recognised WIL outcomes or professional competency standards [47]. Thereby limiting the extent to which such systems can develop established methods of workplace-based WIL as an alternative to traditional methods for students completing accredited engineering programmes.

#### *E. Competency-Based Education and Assessment in Engineering*

Competence-based education has evolved as a solution to the short-comings of time-based and Activity-based Learning [48]. The focus in the field of engineering is on evidence of skills, the attainment of assessable outcomes, and compliance with industry and professional standards [49]. Competency based education is therefore particularly relevant to WIL programs and is focused on confirming attainment of the required competencies rather than just participating.

However, due to the challenges of assessing engineering competency in remote and open-distance learning environments, it is difficult to assess these competencies using traditional methods [50]. Traditional assessment methods, such as the supervisor's assessment, or a student's self-assessment, provide inconsistent and subjective results. Current studies on engineering competency assessment emphasise performance-based assessment, the use of digital artefacts for competency assessment, and the assessment of the evidence of competency attainment through analysis of performance data, as the best indicators of competency attainment [51]. The use of these forms of assessment allow for continuous assessment of competencies and provide sufficient evidence of competency attainment to overcome many of the limitations of traditional WIL assessment practices.

The use of AI technology in conjunction with competency-based assessments enables the creation of adaptive task sequences, automated evidence collection, and real-time feedback [52]. In the case of electrical engineering, the integration of AI technology is particularly helpful given that many of the competencies in electrical engineering require procedural accuracy and safety compliance in addition to system-level reasoning and logic, all of which can be gathered and assessed through a learner's interaction with a digital platform.

#### *F. Integration of AI with Competency-Based WIL*

While there is a growing body of research on AI, education, WIL and competency-based assessments, there has not been enough work yet done to integrate all three of these areas into Comprehensive integration of all three areas as competency-based WIL currently has limited empirical evidence available regarding their implementation in ODL programmes for electrical engineering. There are many publications within the literature that show no structured frameworks linking learning activities supported by AI to competencies aligned to current industry practices and the comparison of their effectiveness with traditional WIL models. In developing country environments, this gap is most pronounced due to the lack of adequate infrastructure, the lack of access to industry and the need for a low-bandwidth and scalable solution.

## **Methodology**

A design-based quasi-experimental research methodology was adopted to develop and evaluate an AI-supported, competency-based WIL framework for electrical engineering students enrolled in ODL. This study is aligned with the objectives, research gaps, and challenges outlined in the abstract, introduction and literature review, specifically relating to how we can support scalable competency assessment, provide personalised feedback and ensure reliable supervision for distance-based engineering education.

#### *A. Research Design and Study Context*

An iterative process of design-based research (DBR) was used to develop and evaluate educational technology for authentic learning environments. This study was conducted at an undergraduate level of study within an open and distance learning (ODL) environment in electrical engineering programs. In a

quasi-experiment, results will be compared between the traditional logbook-based WIL model (control) and the new AI-supported WIL framework (experimental). Final year electrical engineering students taking a compulsory WIL module comprised the study participants. Ethical approval for the study was secured, as well as confirmed informed consent from each student. To reduce the possibility of selection bias, the students were randomly assigned to either the experimental or control groups.

### B. *System Architecture of the AI-Supported WIL Framework*

The framework proposed for competency-based WIL in ODL has four components:

- **The Learner Interaction Layer**, whereby students perform WIL activities via a web-based ODL system. Through the Learner Interaction Layer, learners can complete activities from or in their computing environment such as electrical engineering tasks, which include a simulated work environment to learn from, or electrical engineering imaginative scenarios (through ODL) and technical problem-solving tasks. Additionally, they may submit reflective journals related to the Tasks they complete in the course in accordance with standard university practice for submitting reflective journals;
- **The AI and LA Layer**, where AI is used to find correlations and predict WIL activity completion and thus assist in supporting competency mapping and assessment for participants in ODL. This AI layer uses both ML models and rule-based analytics to track learner interactions within the system as well as their task-performance and progression patterns. It does this by recording the data created by their interactions with the system, as well as tracking the tasks they complete and storing their AA. The input into this layer is created by the combination of interaction logs, task completion, and AA created by learners as they engage in the WIL activities within the ODL system;
- **The Competency Mapping and Assessment Layer**, which provides a link between the competencies in electrical engineering to the performance indicators and task or assignment outcomes associated with the performance indicators. The competency mapping and assessment layer allows for continuous and dynamic updating of learner progress toward completing the learning tasks and competency mapping and competency-based outcomes; and
- **The Feedback and Supervision Layer**, which uses feedback generated through the competency mapping and assessment layer to provide adaptive feedback to instructors and learners about the actual status of learners' competencies, as compared with those identified in competency mapping and assessment layer, through the dashboard analytics provided to them the instructors.

### C. *Competency Model and Task Mapping*

The competency-based approach to assessment is developed using outcomes that are aligned with the electrical engineering industry. Technical, analytical, and professional competencies comprise the overall competency-based approach. Each competency has been defined  $C_j$  in terms of observational indicators based on what a job requires from an employee. To represent a WIL task, the task will be denoted  $T_i$ ; the learner's performance score for each competency  $j$  for the corresponding task  $i$  will be denoted  $P_{ij}$ . The overall competency attainment score for the learner  $l$  is represented as (equation 1):

$$C_{lj} = \frac{1}{N} \sum_{i=1}^N P_{ij} \quad (1)$$

$N$  is the number of total tasks associated with competency  $j$ ; objective and continuous measurement of competency attainment would be achieved through this formulation rather than simply measuring task completions.

#### D. *AI Techniques for Competency Analytics and Adaptation*

Adaptive learning was facilitated by ML methods to analyse learner performance through learner performance data. A supervised learning model was applied to predict levels of competency attainment through all interaction features listed above (i.e. accuracy; time taken to complete the task; error frequency; number of revisions attempted) into a single competencies Level based on the learner's current state ( $t$ ) as detailed in (equation 2):

$$\hat{y}_t = f(x_t) \quad (2)$$

where  $x_t$  is a feature vector derived from accessing learner interactions, and  $f(\cdot)$  denotes a trained ML (ML) classification model using  $\hat{C}_t$  as is done above, the system adjusts task difficulty and feedback intensity in association with the variable C dynamically. Adaptive task sequence policies are technically defined by the equation 3:

$$T_{t+1} = \begin{cases} T_{advanced}, & \hat{C}^t \geq \theta \\ T_{reinforcement}, & \hat{C}^t < \theta \end{cases} \quad (3)$$

where  $\theta$  is a predefined competency mastery threshold.

#### E. *Assessment and Feedback Mechanisms*

The framework supports continuous and on-going assessment of an individual(s). This is done via a series of assessment-based tasks where each assessment task generates performance-related data that is automatically analysed and recorded in the system. Additionally, competency reports is updated as soon as each of the assessments are marked, enabling individuals to see how well they are progressing towards achieving their competency goals at any given point during the assessment process. Individualised feedback is provided in the following ways:

- **Immediate formative feedback** highlighting any areas of weakness with guidance on how to correct them; and
- **A cumulative summative feedback report**, which includes individual achievements (competencies) against the requirements set out in the relevant professional standards.

Using this approach, the inconsistency and subjectivity found in traditional WIL logbooks (identified from the literature) is eliminated.

#### F. *Experimental Procedure and Evaluation Metrics*

The full academic WIL cycle was utilized for this investigation. The control group followed traditional WIL methods of placing students in the workplace and submitting logbooks, while the experimental group utilized the AI-assisted framework. The evaluation of the project took place via the following quantitative methods:

- **Competency attainment percentage;**
- **Time taken for completion of project tasks;**
- **Number of procedural errors made; and**
- **Learner engagement index.**

The learner engagement index  $E$  was computed using equation 4:

$$E = \frac{N_{active}}{N_{total}} \times 100$$

where  $N_{active}$  indicates the number of active interactions with tasks. Qualitative data about learner views on how effective the training programs were, and the workplace readiness of learners was obtained via structured survey feedback.

### G. Data Analysis, Validity, and Reliability

Statistical analysis was conducted using ( $p < 0.05$ ) values to establish significance and effect sizes to estimate the effects of the experiment versus the control. With consistent definitions of what constitutes an acceptable level of expertise (i.e., competency), as well as with an automated scoring system, there was an increase in reliability for assessing competency levels. The internal validity of the study was established via the comparison of a control group against the experimental groups; however, the strength of the study's external validity can be attributed to the alignment of its competencies with those typically found within the industry specific to electrical engineering. Ethical issues were taken into account during the research, including the anonymity of data, secure storage of the data, and the transparency of AI-based decisions being made in regard to the assessment of competency levels.

## Results and Discussion

In this segment of the paper, empirical findings will be reviewed and developed regarding the proposed competency-based WIL framework which has been enhanced through the addition of AI technology to support the learning experiences of electrical engineering students enrolled in ODL. The results will be analysed in comparison to those derived from traditional logbook-based WIL models, with particular attention being paid to four key factors: Competency attainment, task performance efficiency, learner engagement and assessment reliability.

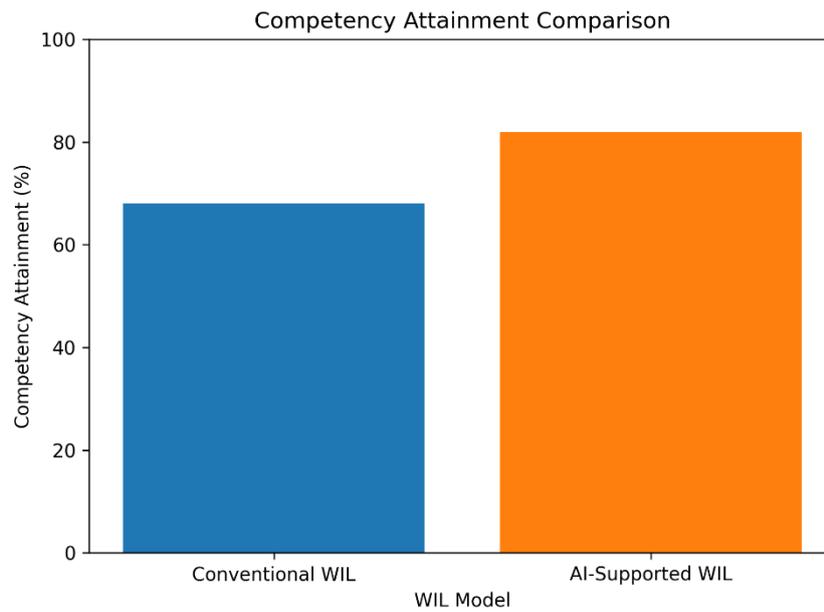
### A. Competency Attainment Outcomes

Table 1 compares the performance of students in relation to each of the two models of WIL. The average competency attainment score for students in the WIL model utilizing AI is 82%, compared with 68% for those involved in traditional WIL, which is a difference of 14%. Through statistical analysis, it was established that this difference is statistically significant ( $p < 0.05$ ), indicating that the results obtained cannot be solely attributed to chance.

**Table I Comparison of Learner Performance Between Conventional and AI-Supported WIL Environments**

Metric	Conventional WIL	AI-Supported WIL	Improvement
Competency attainment (%)	68	82	+14%
Task completion time (min)	45	34	-11 min
Procedural error rate (%)	15	7	-8%
<b>Engagement index (%)</b>	62	79	+17%

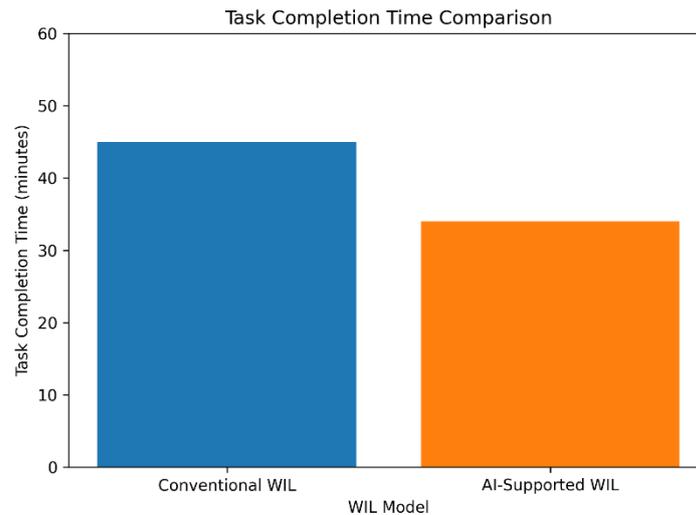
As seen in Figure 1, the AI-enhanced learning and assessment system outperformed traditional logbook-based WIL systems by continuously assessing learner behaviour, tracking learner progression toward competency acquisition through task association and providing adaptive feedback within the system. Rather than only support verification of participation, as does the logbook-based approach for WIL, the AI-enhanced model assesses actual demonstration of skills, providing a closer alignment with the principles of competency-based education that were identified in the literature review. Therefore, these findings indicate that the study achieved its objective by demonstrating that this model can facilitate the development of skills in a plannable, verifiable, and measurable manner through an ODL-based electrical engineering programme.



**Fig. 1. Competency Attainment Comparison.**

#### *B. Task Performance Efficiency and Error Reduction*

To assess efficiency, both times taken to finish a task and rate of procedural errors (operational ability) were used. The average completion time for students assigned AI-supported WIL was 34 minutes. The average completion time for students in conventional WIL was 45 minutes, a reduction of approximately 24% (see Table 1). As shown in Figure 2, the average completion times in the AI-supported WIL classes were consistently less than those in the Conventional C. Additionally, the rate of procedural errors dropped from an average of 15% for students enrolled in Conventional WIL to 7% for students enrolled in AI-supported WIL. The reduction of procedural errors indicates the effectiveness of adaptive feedback and task-reinforcement strategies targeting competency. These findings are consistent with prior studies of AI-supported practical learning that suggest timely, evidence-based feedback contributes to skill building while decreasing rework. It is also important to recognize that, although the use of AI in WIL has resulted in a reduced error rate of 7% for such students and can provide additional support where only limited resources exist, errors in engineering can have serious implications, whether they are fatal or not. Thus, the findings support the use of AI-supported WIL as a means of achieving professional and accreditation standards in ODL contexts.

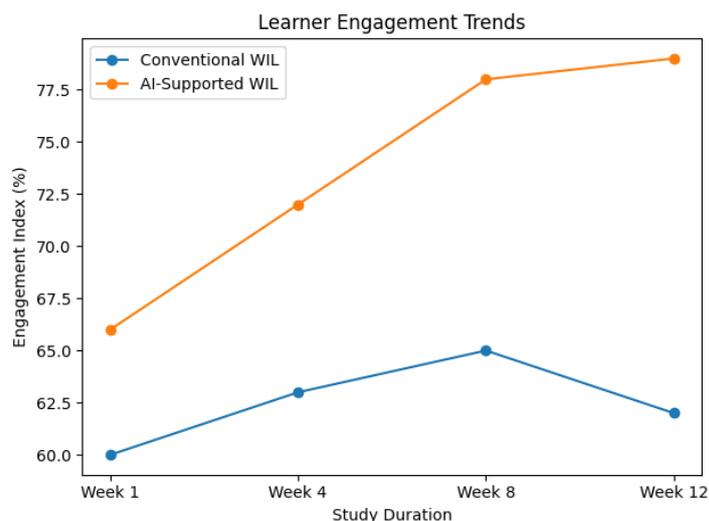


**Fig. 2. Task Completion Time Comparison.**

### *Learner Engagement and Participation Trends*

Student engagement remains a major dilemma in the area of Online Distance Learning (ODL) mainly in terms of developing experiential / applied learning modules. Within the scope of this study, we defined the student engagement index as the ratio of 'active' student participation in the course tasks to the total number of students enrolled in the course. Table 1 shows that for the students who received some form of AI support, the engagement ratio was significantly greater than that of the conventional WIL students, as evidenced by 79% for the AI support group versus 62% for the conventional support group.

Figure 3 depicts the general trends in student engagement over the period of the study. The conventional WIL students continued to plateau in terms of their engagement patterns and eventually had a downward slope, whereas the students who had used the AI support group continued to see an upward trend in their engagement level throughout the study. The development of this sustained engagement pattern suggests that the use of adaptive learning task sequencing combined with individualised feedback has a positive impact on maintaining students' motivational levels, as well as their level of participation.



**Fig. 3. Learner Engagement Trends.**

The results of this study support previous research about the use of AI in the personalisation of learning experiences online and add to the findings of previous studies by showing that this approach can be effective in helping students achieve their goal of developing employability skills within the context of a WIL experience. The need for ongoing engagement is particularly critical for competency-based training models as they rely heavily on continuous interaction to provide reliable assessment of the participants and to ensure that they are making progress toward the completion of their training programme.

#### *A. Assessment Reliability and Transparency*

Traditional WIL models as identified in the academic texts tend to be subjective/semi-subjective; that is, they tend to use the judgment of the supervisor as well as self-reporting of the student (or learner) as sources of information. The AI-based WIL Framework eliminates this subjectivity, instead generating competency scores based on both observable performance indicators and interaction data about each student/learner. According to the instructors who used the AI-supported WIL Framework, the dashboard-level analytics leads to improved oversight and targeted interventions. The consistency in the competency scores among learners who completed the same tasks suggests that the AI-supported assessment approach leads to enhanced reliability of assessments. These results demonstrate that the AI-supported assessment model provides the opportunity for enhanced transparency and fairness in assessments, especially for large-scale ODL programmes with limited direct supervision.

#### *B. Learner Perceptions and Educational Implications*

According to qualitative feedback from the AI-supported WIL students, they had greater confidence, clearer understanding of anticipated competencies, and enhanced perceived readiness to enter the workforce as compared to their peers participating in conventional WIL programs. Students emphasized the positive impact of both the immediacy of receiving feedback on their performance and the structured format of their lessons; features that were generally lacking in traditional WIL programs. From an organisation's standpoint, the results demonstrate that AI-supported WIL represents an alternative method that allows for scalable and sustainable models for traditional placement-based WIL programs. For organisations with limited resources, AI-supported WIL programs will provide equitable access to industry placement opportunities.

#### *C. Synthesis of Findings*

The study clearly demonstrates that the use of AI in conjunction with competency-based WIL enhances the quality of learning outcomes, improves the reliability of assessments, improves student engagement, and improves the quality of learning in the area of electrical engineering ODL program. Thus, these results substantiate the main idea of this study, which is that AI-supported WIL can be developed to overcome most of the shortcomings of traditional models of WIL, while simultaneously providing a means for ensuring the continued relevancy and accreditation of the program. Collectively, the results of this study provide an excellent empirical basis for the conclusions and future directions of research outlined in the next section.

## **Conclusions**

The present study was undertaken to develop and assess a Work-Integrated Learning (WIL) framework for electrical engineering students and was conducted under conditions of ODL using a Artificial Intelligence-Supported, Competency based (AI-CWIL), as well as to evaluate its effectiveness. A major focus of this study was to provide a solution for the ongoing difficulties associated with traditional WIL delivery methods, which include limited availability of locations for work experience, subjective methods of logbook assessment and differences in quality of supervision received, by providing a structured method for integrating ITSs, LA and adaptive assessment to promote scalable, evidence-based competency development.

The study revealed three major outcome indicators. First, students participating in an AI-supported WIL programme demonstrated significantly improved levels of competency attainment (14% improvement versus conventional WIL), confirming that ongoing, data-driven assessments based upon clear definitions of engineering competencies are a more effective means of assessing competencies than providing students with a single assessment based on participation in an activity. Second, students who received AI support improved their efficiency of completing tasks, as evidenced by decreased task completion and a significant decrease in the rate of errors made during performance of the tasks. The efficiency gains observed in the AI-supported WIL group demonstrate the impact of providing adaptive feedback and competency targeted task sequencing to support the acquisition of practical skills in electrical engineering. Finally, students in the AI-supported WIL groups showed consistently higher and longer lasting levels of engagement with their learning experiences than those in the conventional WIL groups. This indicates that the personalised, AI-based support provided for the students helped to reduce the level of disengagement frequently seen in ODL environments.

The research indicates that the proposed competency-based WIL Framework is able to create a new and improved form of distance learning, so that learners in distance-based engineering courses can experience authentic, measurable, and accredited learning experiences, without the need for any actual WIL placements (a form of employer-based learning). At the same time, the WIL Framework creates an avenue of opportunity for universities to enhance their evaluation practices for Engineering students who are studying at a distance, by providing more transparency and fairness in the evaluation processes, and scaling up the evaluation processes of a distance-based Engineering program

It is important to note however, that the current study is limited to pilot-scale implementation and simulated workplace experience, and future research is intended to involve larger scale implementations, including real-world data and mentoring through collaboration with industry, and integration of leading-edge AI technologies such as Reinforcement Learning for dynamic task adaptation. In addition, research should continue to investigate the long-term competency retention and employability outcomes of competency-based WIL and how these relate to graduate placement and the future employability potential of distance learners. Overall, this is the beginning of a research agenda on the development and implementation of competency-based, AI-Enabled WIL, and establishes the groundwork for using competency-based WIL as a possible solution for creating a sustainable and effective model for electrical engineering educators and institutions of higher education operating in a distance-learning environment.

## Acknowledgement

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