



Results of experimental Study on Learner-Centered learning through the Integration of WorldSkills Occupational and Assessment Standards into Curriculum Content

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Abstract - This study evaluates the impact of integrating the WorldSkills Occupational and Assessment Standards for Mechanical Engineering-CAD into the CAD-I and CAD-II course curricula of the Technical Education program in Industrial Machinery and Equipment Maintenance and Service at the Mongolia-Korea Polytechnic College. Implemented using a learner-centered pedagogical framework supported by Project-Based Learning (PBL) and digital learning resources (Moodle LMS and YouTube), the curriculum reform aimed to bridge the gap between national vocational training and international industry benchmarks. Evaluation was conducted over two academic years (2024–2026) using student academic progress data, performance in institutional and national-level "Mongolia Skills 2025" competitions, and Leslie Rae's four-level evaluation model. The results indicate a significant improvement in academic quality (rising to 90.0% in CAD-II during the initial phase) and stabilization at a high-performance level (88.9% achieving Grades A and B) under elevated international assessment thresholds. Students trained under the revised curriculum achieved an average score of ~85% in the institutional competition and secured 5th and 6th places in the National Championship. The study demonstrates that aligning TVET curricula with global occupational standards and learner-centered digital instruction significantly enhances practical CAD modeling, technical drawing, and autonomous problem-solving competencies, providing a structured methodological foundation for competitive vocational education.

Key Keywords-Mechanical Engineering-CAD, WorldSkills, Occupational Standards, Learner-Centered Learning

I. INTRODUCTION

Today's labor market demands, rapid technological advancements, and industrial digital transformation increasingly require technical and vocational education and training (TVET) institutions worldwide to prepare highly skilled, competitive, and innovative specialists. Under these

circumstances, aligning training programs with international occupational standards while implementing learner-centered teaching methodologies-based on students' needs, active participation, and creative problem-solving-has become a pivotal driving force for enhancing educational quality [1, 3].

Learner-centered education transforms students from passive recipients of information into active knowledge creators who independently solve problems, think critically, and develop practical professional competencies under real-world conditions. This pedagogical approach aligns seamlessly with competency-based TVET principles and provides a solid theoretical and methodological foundation for effectively integrating international skill standards into instructional practices [11, 12].

This study investigates the impact of integrating WorldSkills Occupational and Assessment Standards for Mechanical Engineering-CAD into the CAD-I and CAD-II course curricula of the Industrial Machinery and Equipment Maintenance TVET program, combined with a learner-centered instructional approach. To evaluate the effectiveness of this curriculum reform, a comparative analysis was conducted using student performance data from the Mongolia Skills competition, academic progress, and course completion rates to assess its influence on developing practical professional skills.

The research employed methods such as data collection, document analysis, observation, comparative evaluation, and quantitative statistical analysis. By examining the alignment between the WorldSkills standards, learner-centered pedagogy, and TVET curriculum reform, this study aims to contribute to a methodological framework for preparing internationally qualified technical specialists.

II. MATERIALS AND METHODS

A. Mechanical Engineer-CAD

CAD (Computer-Aided Design) involves utilizing software applications to create, modify, analyze, and optimize technical drawings and digital models. Mechanical Engineering-CAD encompasses the precise modeling, parametric design, and assembly planning of machinery, structural components, electronic enclosures, and industrial equipment using 2D sketches and 3D solid representations [3].

In advanced industrial economies, CAD-related competencies are introduced in upper-secondary specialized curricula for students pursuing engineering pathways [4]. In Mongolia, higher education engineering programs typically allocate one or two academic semesters to CAD instruction.

Within the TVET sector, specialized CAD modules are delivered through modular frameworks, with Autodesk Inventor serving as a mandatory subject in CAD-I and an advanced elective in CAD-II for the Industrial Machinery Maintenance program.

B. World Skills Professional and Assessment Standards

Founded in 1946, WorldSkills International represents over 80 member countries. Mongolia joined as the 69th member in 2014, competing in national and global skill events in 2015, 2017, 2019, and 2024. For the 2026 WorldSkills Competition, Mongolia is actively preparing candidates for the Mechanical Engineering-CAD skill area.

The tasks and assessment criteria for each skill at the WorldSkills competition are developed by leading engineers and technical professionals from around the world in accordance with the WorldSkills Occupational Standards.

The WorldSkills Occupational Standards define the knowledge, skills, and attitudes based on best practices at the global level, while the WorldSkills Assessment Standards specify the competencies that professionals are expected to possess in order to meet international occupational requirements [5].

C. Mechanical Engineering-CAD Professional Standard

Knowledge, skills, and attitudes, depending on their importance, within the framework of global professional standards the Mechanical Engineering-CAD professional standard is weighted as shown in TABLE I [5]

TABLE I. IMPORTANCE OF MECHANICAL ENGINEERING-CAD PROFESSIONAL KNOWLEDGE, SKILLS, AND ATTITUDES

	<i>Group</i>	<i>Importance</i>
1	Work organization and management	10
2	Materials, software, and hardware	5
3	3D modeling	30
4	photos (2D) , create animations	10
5	Copying a CAD model from a real object	15
6	Technical drawings and measurements	30
	<i>Total</i>	<i>100</i>

D. Mechanical Engineering - CAD Professional Assessment Standards

The WorldSkills Competition assessment standards reflect the latest industry innovations and high assessment standards through open and transparent monitoring and continuous improvement.

The 2026 standards consist of 4 modules, each containing mandatory content. The assessment standards are inextricably linked to the professional standards.

Module 1 - Mechanics design test

Design task execution
Motion/physics simulation
Parameter spreadsheets
Photo rendering
3D printing

Module 2 - Mechanics processing

Sheet metal modeling
Frame assemblies
Technical drawing
Visual presentations

Module 3 - Mechanics assembly and production detailed picture project

Complex part modeling
Assembly constraints
Geometric dimensioning and tolerance
Output and generations

Module 4 - Physics from the model return engineering

Physical measurement
Point-cloud evaluation
Tolerance allocation
Surface texture determination
3D Scanning

E. Learner-centered learning

Learner-centered pedagogy positions the student at the core of the instructional ecosystem, cultivating practical skills through authentic industrial tasks and performance-driven projects. Utilizing active methods such as project-based learning (PBL) and problem-based learning, this approach provides the necessary framework for implementing competency-based TVET models aligned with international standards [11, 12].

III. RESULTS

A. Equivalence of professional standards in the vocational training program for the repair and maintenance of industrial machinery and equipment

A comparative evaluation was performed between the Mechanical Engineering-CAD standards of the WorldSkills and the existing Industrial Machinery Maintenance curriculum to establish structural content alignment, as summarized in TABLE II [5].

TABLE II. PROGRAM CONTENT EQUIVALENCE

<i>Courses that include professional knowledge, skills and attitudes in mechanical engineering-CAD</i>	<i>Indirectly, courses related to the knowledge, skills and attitudes of Mechanical Engineering-CAD professionals</i>	<i>Basic vocational courses in the repair and maintenance of operational equipment</i>

Human development, communication ethics, and law	Mongolian history, culture, and customs	Materials science
Mathematics I	History and culture of thought	Economic theory
Mathematics II	Mongolian language and literature, composition	Fundamentals of electrical engineering
Physics I	Ecology and environmental protection	Gas-liquid basis
Physics II	English	Tools and equipment for manual processing of materials
Technical cartography	English II	Theoretical mechanics
Computer information technology	Professional English	Thin metal work
Occupational safety and health	Physical education	Material resistance
Providing disaster prevention knowledge		Turning and milling work
Car parts		Industrial Automation-I
Production technology and equipment		Diagnosis and repair of gas and liquid system failures
Technical metrology		CNC-I
CAD-I		Diagnosis and repair of gas and liquid system failures
CAD-II		Equipment assembly
		Project work
		Industrial internship
		Industrial Automation II
		CNC-II

Analysis seed from the result to watch Production machinery and equipment device maintenance and service professional program general base and specialization section lessons in the content Mechanic engineer - CAD professional other country standard knowledge, skill ability, attitude most composition part directly and directly otherwise reflected is. However, CAD professional art ability, performance requirements systematically to provide WorldSkills to standard and evaluation The criteria are CAD-I and CAD-II courses. with content more in detail to coordinate necessary is.

Mechanic engineer-CAD professional standard which one academic with content not equal there is knowledge, skill ability, attitude composition parts specifically, separately in TABLE III.

TABLE III. KNOWLEDGE AND SKILLS NOT COVERED IN THE PROGRAM CONTENT

<i>Work organization and management</i>	Importance of presenting designs accurately and clearly to potential users
	Importance of maintaining up-to-date knowledge and skills regarding emerging technologies
	Responsibility for providing innovative and creative solutions to technical and design challenges

	Welcome allowed information technological system and related professional design program supply
<i>Materials, software, and hardware</i>	CAD process used foreign additional devices
	Plotter, printer, 3D printer, 3D scanner use
	Picture design program supply within special professional technical action operation
<i>Real CAD model from object to unload</i>	CAD work operation to support, to facilitate possible special product type, variety, use
	3D scanning of models to do

From the table It can be seen that the contents of the following topics remain: world-standard work organization and management, material software, hardware, and CAD model reconstruction from real objects, which shows that we need to provide skills to work on other additional devices in addition to CAD software.

B. Assessment standard compliance

Fusion-360 software, 3D scanners, and 3D printers to align the unit courses of the Professional Engineering Drawing Reading, Modeling, CAD-I, and CAD-II courses with assessment standards as show in TABLE IV.

TABLE IV. ASSESSMENT STANDARD EQUIVALENCE

Educational Level Standard	Course Module	Core Competencies & Learning Outcomes	Autodesk Inventor 2026	Fusion-360	3D Scanning	3D Printing	Other General Skills
Vocational Education (Level IV)	Reading & Drawing	Select technical drawing types Select sheet formats Draw title blocks Apply dimensions & annotations Project generation And so on	Read working drawings	Convert STL files to solid bodies Use organic modeling methods And so on	Extract required dimensions Model printed parts Perform 3D scanning of objects	Assemble and test printed parts Determine printing resolution Apply ISOCEUR	English language proficiency Data collection Data analysis Engineering calculations
Technical Education Curriculum	CAD-I	Install Autodesk Inventor Create new design files Toolbar & interface operations Create 2D sketches Create 3D sketches, Extrude, and Revolve And so on	Create 3D solid bodies Edit geometry Assembly modeling Create working drawings And so on				
Technical Education Curriculum	CAD-II	Multi-body part toolbar operations Multi-body part modeling Parameter-driven design And so on	Sheet metal modeling Sheet metal pattern and mirror operations Create sheet metal drawings And so on				

C. the CAD-I and CAD-II curriculum.

Mechanic engineer - CAD professional standard knowledge, skill ability, attitude requirements for CAD-I and CAD-II courses with content in accordance with training program reform done. 2024 - 2025 academic annual spring CAD-II, 2025–2026 academic annual autumn CAD-I course in the semester program, thematic the plan help help update developed and implemented and implementation seed as a result based on 2025 - 2026 academic annual spring CAD-II course in the semester the program again improve updated and trained try implemented [5, 6].

D. Results of training and testing

Student centered training method legal implementation

In implementing the revised CAD-I and CAD-II course curricula, a learner-centered approach was adopted, and the training was organized around learners' active participation, independent learning, problem-solving, and creative modeling activities. During the training, project-based learning and problem-based learning methods were employed, with greater emphasis placed on CAD modeling tasks related to real industrial needs, practical activities, and independent performance.

The CAD-II course plan allocated 32 hours for seminar sessions, which was limited for fully implementing the revised course content. Therefore, considering learners' different levels of prior knowledge and learning pace, additional video lessons and learning materials were provided through the Moodle platform and YouTube channel to increase opportunities for independent learning. These digital learning materials enabled learners to review the course content at their own pace, practice independently, and develop their skills, while also providing additional support for participants preparing for the Mongolian Skills competition. (Fig. 1, Fig. 2) [7]-[10].

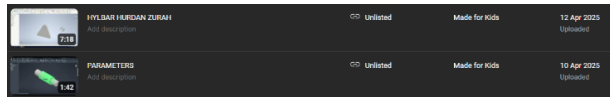


Fig. 1. Youtube c lessons

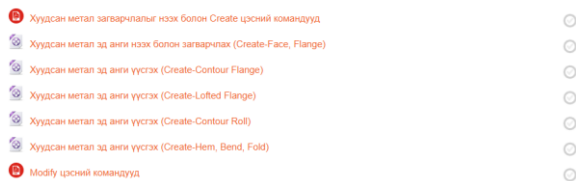


Fig. 2. Moodle system courses

Mongolian Skills-2025 school level competition results

According to the assessment plan developed in accordance with the WorldSkills Assessment Standards, the performance of participants in the school-level Mongolian Skills-2025 competition was evaluated TABLE V. Learners who studied under the revised curriculum demonstrated significantly higher performance than those educated under the previous curriculum. In particular, learners who applied knowledge and skills in metal fabrication acquired from previous practical training to model physical products in a CAD environment achieved a performance level of approximately 85%, whereas newly enrolled learners in the same academic year performed below 50%.

TABLE V. RESULTS OF THE MONGOLIAN SKILLS-2025 SCHOOL-LEVEL COMPETITION

№	Талчлагын шалгуур үзүүлэлт	Авчт оноо	Сүүлчин-1	Сүүлчин-2	Сүүлчин-3	Сүүлчин-4	Сүүлчин-5	Сүүлчин-6	Сүүлчин-7	Сүүлчин-8	Сүүлчин-9
1	Берийн нэрээр компьютерийг дагууцаж хавтас үүсгэсэн	4	4	4	4	4	4	4	4	4	4
2	Цугт ахлын турш болон эмээлийн дагуу загварчлагын	8	8	8	8	8	8	8	8	8	8
3	Хайв гаруй ахлын турш болон эмээлийн дагуу загварчлагын	8	8	8	8	8	8	8	8	8	8
4	Доошгүй ахлын турш болон эмээлийн дагуу загварчлагын	7	7	7	7	7	7	7	7	7	7
5	Хүлээн авчлан болон эмээлийн дагуу загварчлагын	8	8	8	8	8	8	8	8	8	8
6	Хүйхэн загваруудаа ахлын турш дэргин нур дээр берийн нэрийн нэм ил өргөлтийг дагуу хавтасдаа хавтасан	4	4	2	4	2	0	0	2	2	0
Мэдүүлж-1 оноо:		40	38	38	40	38	38	38	38	38	37
7	Хүхэг дээг ахныг grounded болон	2	2	2	2	2	2	2	2	2	2
8	Рөөдөр туршийн дагуу угсарсан	10	10	10	10	10	10	10	10	10	10
9	Рөөдөр туршын үхэр нойртой хослооройгоо нэмэ тайтай байгаа угсарсан	5	5	5	5	5	5	5	5	5	5
10	Угсаргаа дээр берийн нэрийн нэмэн цуг өргөлтийг авч хавтасдаа хавтасч	3	3	1	3	2	1	1			
Мэдүүлж-2 оноо:		20	20	18	15	19	18	16	12	0	0
11	Ах цахь сонгох	2	2	2	2	2	2	2			
12	Ахын турш-2 талдас хархын грохц болон ахсонгоор прохц, хархын	6	6	6	6	6	6	6			
13	Ах эмээх тавхсан	2	2	2	2	1	0	2			
14	Шалдас сонгохыг ахалсан	2	2	0	2	0	2				
15	Түгсдэг туршын урсгал	2	2	0	2	0	2				
16	Угсаргаа дээр берийн нэрийн нэмэн цуг өргөлтийг авч хавтасдаа хавтасан	1	1	2	2	1	1				
Мэдүүлж-3 оноо:		15	13	14	10	10	10	0	0	0	0
17	Рөөдөр туршийн ахлын нэрээр нур өргөлтийг авч хавтасдаа хавтасан	3	2	2	3	3	2				
18	Рөөдөр туршийн Ах Оюу 20х210см эмээлийн үүсгэсэн	7	6	7	5	4	4				
19	Видеоо берийн нэрээр нур өргөлтийг авч хавтасдаа хавтасан	3	3	3	3	2	3				
20	Видеоо нэрээр нур ахын нурдвал нур хүйн нур сууныг үргэлжлээр хүйн	22	22	22	22	17	0	0	0	0	0
Мэдүүлж-4 оноо:		22	21	22	22	17	0	0	0	0	0

Mongolian Skills-2025 National Competition Results

At the national-level Mongolian Skills-2025 competition in the Mechanical Engineering-CAD skill, the learners included in the study achieved fifth and sixth places. The participants had completed the revised curriculum; however, the relatively limited period available for preparation and

practice prior to the competition may have influenced their performance (Fig. 3).

[illegible]

Fig. 3. Mongolian Skills-2025 national competition results and evaluation sheet

CAD-I, CAD-II course results

The 2024-025 academic year, a cohort of ten students ($n_1 = 10$) completed the CAD-I course under the traditional curriculum and the CAD-II course under the newly reformed curriculum. In contrast, during the 2025-2026 academic year, a cohort of nine students ($n_2 = 9$) completed both courses under the newly updated, higher-rigor curriculum aligned with international standards. An analysis of the curriculum reform outcomes and competency progress across these two subjects was conducted [15].

Within the scope of this study, the academic performance of the 2024-2025 cohort ($n_1 = 10$) and the 2025-2026 cohort ($n_2 = 9$) was comparatively evaluated.

1. 2024-2025 Results (Progress Phase):

When CAD-I was taught under the traditional curriculum and CAD-II was delivered using the updated framework integrated with the WorldSkills standards, the mean score increased from 82.7 to 91.4, with the quality pass rate (Grades A and B) rising to 90.0%. This demonstrates a clear performance improvement, confirming that the updated, digitally supported, learner-centered pedagogy directly enhanced student competencies.

2. 2025-2026 Results (Standard Stabilization Phase):

With both courses fully updated to international standards and increased in rigor, students demonstrated a higher baseline mean score of 87.9 in CAD-I. The mean score for CAD-II stabilized at 86.9, reflecting the elevated evaluation threshold and increased cognitive load. Nevertheless, 66.7% of total students achieved top-tier performance (Grades A and B), successfully satisfying international competency benchmarks (TABLE VI).

TABLE VI. CAD-I, CAD-II COURSE RESULTS

2024-2025					
Student		2024.12.24		2025.05.20	
1	Student-1	95	A	100	A
2	Student-2	91	A	100	A
3	Student-3	81	B	88	B
4	Student-4	75	C	88	B

5	Student-5	78	C	95	A
6	Student-6	88	B	85	B
7	Student-7	78	C	100	A
8	Student-8	65	D	78	C
9	Student-9	85	B	85	B
10	Student-10	91	A	95	A
2025-2026					
	Student	2025.12.26		2026.05.20	
1	Student-1	98	A	97	A
2	Student-2	91	A	95	A
3	Student-3	100	A	98	A
4	Student-4	85	C	78	C
5	Student-5	78	C	78	C
6	Student-6	95	B	88	B
7	Student-7	68	C	75	C
8	Student-8	88	B	85	B
9	Student-9	88	B	88	B

Program results

The impact of the curriculum reform was evaluated and compared between the 2024-2025 and 2025-2026 academic years using Leslie Rae's four-level evaluation framework [13, 14].

1. **Reaction and Behavior level:** Following the comprehensive curriculum redesign and the integration of digital learning platforms (Moodle and YouTube), student satisfaction remained consistently high, and learners developed autonomous problem-solving behaviors suitable for tackling high-complexity tasks.
2. **Training and Final Level:** While the initial progress of the reform was observed in the 2024-2025 academic year (demonstrating a +40% gain in academic quality), performance stabilized at a high level during the 2025–2026 academic year despite the increased technical rigor of both courses aligned with global standards, with 88.9% of students achieving top-tier grades (A and B), as summarized in TABLE VII. This validates that the curriculum grounded in international standards effectively imparts practical competency to learners.
- 3.

TABLE VII. Leslie Reig's Criteria

Level	2024-2025 academic year	2025-2026 academic year
Reaction level (Reaction)	- High student and instructor satisfaction with curriculum updates. - Active student engagement in self-paced learning plans.	- High satisfaction with Moodle LMS and YouTube digital integration. - Increased student motivation to independently solve complex engineering tasks.
Training Level (Learning)	- Academic performance quality improved to 90.0% (CAD-II). - Student success and top placements in the school-level skills competition.	- Both CAD-I and CAD-II fully evaluated under rigorous international standards. - Academic performance quality stabilized at a high level of 66.7% (Grades A and B).
Behavior state level (Behavior)	100% completion rate in industrial internship. - Demonstrated enhanced autonomy in operating automated	Developed mature competencies in reading complex international engineering drawings and 3D modeling.

	control equipment compared to peers.	Improved execution speed and precision in comprehensive design tasks.
Seed final Level (Results)	3 graduates pursued advanced degree studies; 2 competed in the National Skills Competition. 90% relevant employment rate among graduates.	- Achieved 5th and 6th placements in the National Skills Competition 2025. - High retention rate of graduates working directly in their professional field or pursuing higher education.

IV. CONCLUSIONS

This study synthesized the experimental outcomes of integrating the WorldSkills Occupational and Assessment Standards for Mechanical Engineering CAD into the CAD-I and CAD-II curricula of the Industrial Machinery Repair and Maintenance program at the Mongolia-Korea Polytechnic College, implemented through student-centered instructional methodology. Based on the research findings, the following conclusions are drawn.

Curriculum Content Reform and Alignment:

A comparative analysis of the six core knowledge and skill domains of the WorldSkills standards against course learning outcomes revealed that while foundational concepts were incorporated, achieving international-level performance requires systematic inclusion of emerging technologies, such as 3D scanning, additive manufacturing (3D printing), and peripheral device operation into the CAD-I and CAD-II coursework.

Impact of Student-Centered and Digital Pedagogy:

To address seminar time constraints and promote autonomous learning, a student-centered framework was implemented, supported by digital learning materials and video lectures via Moodle LMS and YouTube. This approach empowered students to advance their knowledge and skills at their own pace while enhancing their motivation to independently resolve complex tasks.

Student Competency Progress and Achievements:

Academic Performance: During the initial phase of curriculum reform (2024-2025), the average student score increased from 83.0 to 91.4 ($\Delta\bar{X} = +8.4$), with the quality rate rising from 60% to 90%. In the 2025–2026 academic year, when both courses were comprehensively updated to meet elevated international standards, 88.9% of students achieved top-tier grades (A and B), demonstrating high-level performance stabilization.

Competitive Performance: Students trained under the revised curriculum achieved an average score of approximately 85% in the institutional *Mongolia Skills 2025* competition and placed 5th and 6th at the National Championship. This confirms that a curriculum aligned with international standards effectively equips students with practical competencies.

Future Directions:

The findings indicate that integrating international standards into technical curricula paired with student-centered instruction provides a robust foundation for preparing world-class technical specialists. To further enhance outcomes in future the WorldSkills competitions, it is essential to allocate sufficient pre-competition training schedules and allocate additional practical hours for supplementary software tools (e.g., Fusion 360) and 3D scanning technologies within the curriculum framework.

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