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RESEARCH ARTICLE

Analysis of the Engineering Outcome-Based Curriculum

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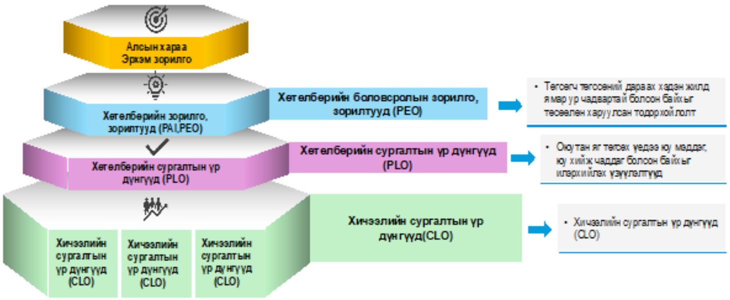
ABSTRACT

Mongolia has been implementing an outcome-based principle in curriculum development for quite some time, but there are still uncertainties regarding the full understanding and execution of its essence. To address challenges in engineering education, the adoption of CDIO (Conceive-Design-Implement-Operate) standards is necessary for curriculum improvement and content reform. Additionally, the methodology for evaluating the effectiveness of such programs is unclear as to whether it fully aligns with the principles of outcome-based education and international standards. Specifically, there is a need to study whether engineering programs meet international outcome-based standards and systematically assess and evaluate the development and implementation of these programs. This is the central research issue of our study.By applying the CDIO methodology and criteria tailored to engineering education through a rubric-based evaluation, it becomes possible to optimize learning outcomes, ensure conformity with general curriculum requirements, and create conditions for improved implementation.

A study was conducted on the foundational sources of outcome-based programs, identifying specific characteristics of engineering education. These were then analyzed against the engineering programs at the Institute of Engineering and Technology, leading to recommendations for future actions.

INTRODUCTION

The National Program for Results-Based Education (Resolution № 52, 2018) was approved, which is intended to develop a framework for training highly qualified specialists that meet the needs of the domestic and foreign labor markets by introducing standards and methodologies for results-based education (Øien, 2021). These standards emphasize the development of industry-relevant competencies, such as problem-solving, critical thinking, and adaptability; alignment of learning outcomes with occupational standards. When formulating educational policies, it is crucial to consider a country's history, traditions, customs, lifestyle, and socio-economic and cultural development. Additionally, the development needs and potential of its citizens, the nation's current and future status, as well as global trends, must be taken into account (Chu. Baigalmaa, 2021). In Science, Technology, Engineering, and Mathematics (STEM), this translates into the development of technical proficiency; strong problem-solving and design capabilities; effective teamwork and communication skills; a commitment to ethical and professional responsibility; proficiency in using modern engineering tools (Abanteriba, S. 2006) . The CDIO approach, initially introduced by the Massachusetts Institute of Technology in 2000 in collaboration with three Swedish universities under the leadership of Professor Edward Crawley, is now implemented in over 200 leading universities worldwide. This framework integrates theoretical and practical components, fostering essential engineering competencies such as teamwork, professional ethics, and the ability to assess external influences.



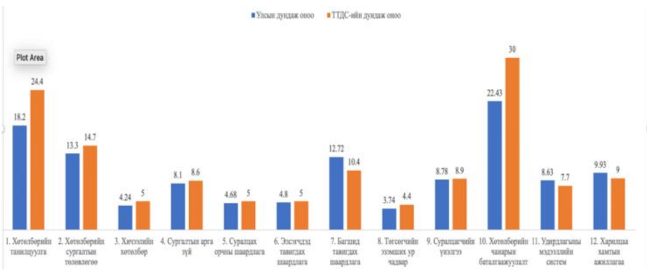
Picture 1. .Outcome-Based Curriculum Results

As shown in picture 1, outcome-based curriculum results are specified from a general to a detailed level.

Learning outcomes are defined at the institutional, program, and course levels. Projected learning outcomes were determined in advance and aligned with stakeholder needs-including employers, professional organizations, faculty, alumni, and students-through surveys assessing expected knowledge, skills, and attitudes students should acquire.

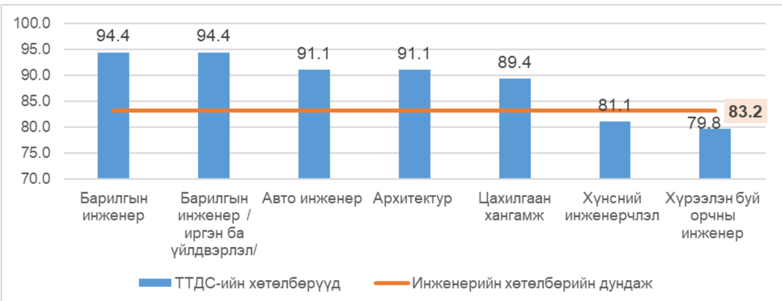
METHODOLOGY

The training programs of the Institute of Engineering and Technology were compared with the average score of 55 schools in the field of engineering, manufacturing, and construction, which corresponds to the program category with index 07.



Graph 1. Comparison between the national level and IET.

Graph1, from 12 standards, shows that nine criteria, namely, program introduction, curriculum plan, course syllabus, teaching methodology, learning environment requirements, admission requirements, graduate requirements, student assessment, and program quality assurance, exist above the national average. However, three criteria, teacher requirements, management information system, and communication and collaboration, are below the national average. The Institute's curriculum falls under Engineering, Manufacturing, and Construction (Index 07), and was compared to the national average scores from 55 universities in the same category.



Graph 2. Comparison of the Evaluation of the IET's Engineering Program, in Percentages

When comparing all of the engineering programs there are the following results.

RESULT

Average Performance

The average of all criteria combined is 88.8%. This is 5.6% higher than the national average evaluation of the 39 engineering programs being implemented nationwide (83.2%), indicating an overall average-level performance.

Between 90–100%: 57.1% of the total programs, or four engineering programs, fall within this range.

Between 80–89%:28.6% of the total programs, or two engineering programs.

Between 70–79%:14.3% of the total programs, or one engineering program.

Below 70%:No programs scored below this threshold.

Comparative Evaluation of Programs

According to general statistical analysis:

Average score (across all criteria): 88.78%

Highest score: 94.44% (Civil Engineering — Road Engineering)

Lowest score: 79.78% (Environmental Engineering)

Table 1. Comparative Results of Programs

Program	Avg Score	%	Category
Electrical Supply	89.4	89.4%	Medium
Automotive Engineering	91.1	91.1%	High
Environmental Engineering	79.8	79.8%	Low
Food Engineering	81.1	81.1%	Medium
Civil Engineering (Road)	94.4	94.4%	High
Civil Engineering (Industrial)	94.4	94.4%	High
Architecture	91.1	91.1%	High

High Performing Programs (90% and above):

Civil Engineering (Road Engineering) — 94.4%

Civil Engineering (Civil and Industrial) — 94.4%

Automotive Engineering — 91.1%

Architecture

— 91.1% hese programs stand out in terms of curriculum content, learning environment, quality assurance, and graduate competencies compared to other programs.

Moderately Rated Programs (80–90%):

Power Supply Engineering 89.4%

Food Engineering 81.1%

These programs perform well overall but have room for improvement in faculty composition, teaching methodology, and collaboration.

Low-Performing Programs (<80%):

Environmental Engineering 79.8%

This program has the lowest score compared to other programs.

Table 2. Comparison of Results by Evaluation Criteria

Criteria	Avg	Max	Min
Program Overview	97.71	100	84
Curriculum Plan	98.10	100	86.67
Course Outline	100	100	100
Teaching Methodology	85.71	100	60

Learning Environment	100	100	100
Admission Requirements	100	100	100
Faculty Requirements	69.52	73.33	46.67
Graduate Competencies	88.57	100	60
Student Assessment	88.57	100	60
Quality Assurance	100	100	100
Information System	77.14	100	60
Collaboration	60.00	60	60

Average Performance

The overall average of all criteria is 88.8%.

100% Performance Criteria: 4 criteria (No. 3, No. 5, No. 6, No. 10) achieved perfect performance with 100%.

90-99% Performance Criteria: 2 criteria (No. 1, No. 2) achieved performance between 97.7%–98.1%.

80-89% Performance Criteria: 3 criteria (No. 4, No. 8, No. 9) achieved performance of 88.6%.

70-79% Performance Criteria: 1 criterion (No. 11) achieved 77.1% performance.

60-69% Performance Criteria: 1 criterion (No. 7) achieved 69.5% performance.

Below 60% Performance Criteria: 1 criterion (No. 12) achieved 60.0% performance.

From this, the three criteria that require the most immediate attention and improvement are:

Communication and Collaboration – 60.0%

Faculty Requirements – 69.5%

Management Information System – 77.1%

Improving these criteria will have a significant impact on enhancing the overall quality of the program.

Table 3. Comparison of Program Evaluations

	All Programs	Engineering	IET Programs
Highest Score	97.8%	96.7%	94.4%
Lowest Score	33.8%	60.1%	79.8%
Average Score	77.8%	83.2%	88.8%

Table 4. Comparison of Evaluation Criteria

Criteria	All Programs	Engineering	IET Programs	Difference
Highest Score	90.2% (Admission Requirements)	97.6% (Learning Environment Requirements)	100% (Curriculum, Learning Environment Requirements, Admission Requirements, Management Information System)	Multiple top scores, but different areas
Lowest Score	66.2% (Communication and Collaboration)	63.1% (Communication and Collaboration)	60.0% (Communication and Collaboration)	Common indicator
Average Score	77.8%	83.2%	88.8%	Relatively high

Table 5. Similarities and Differences

Indicator	University Level	Engineering Program Level	Level of IET
Above Average	Curriculum-plan, environment, student assessment, and admission requirements are good (82.2–90.2%)	Curriculum-plan, environment, student assessment, and admission requirements are good (87.9–97.6%)	Structure, curriculum-plan, environment, admission requirements, and quality assurance are excellent (100%)
Around Average	Teaching methodology, course syllabus, information system, program introduction, and graduate competencies (70.7–78.3%)	Teaching methodology, information system, program introduction, faculty requirements, and program quality assurance (78.8–83.6%)	Teaching methodology, student assessment, and graduate competencies (85–89%)
Below Average	Faculty requirements, program quality assurance, and weak communication and collaboration (66.2–69.7%)	Graduate competencies and weak communication and collaboration (63.1–72.4%)	Faculty requirements, information system, and weak communication and collaboration (60–77%)

Programs with the Highest Performance

Civil Engineering (Highway Engineering), Civil Engineering (Civil and Industrial) – Scored uniformly and with quality across all criteria (94.4%).

Automotive Engineering, Architecture – Stable evaluations, with minimal need for improvement (91.1%).

CONCLUSION

When ranking the program evaluation criteria by level of importance, greater emphasis was placed on the curriculum plan, teacher requirements, and program quality assurance.

The evaluation of the CDIO methodological criteria using a rubric clarified the quality assessment indicators of the programs. By grouping them into three main parts and evaluating the normalized scores of 276 programs across 9 fields from 55 universities and colleges in Mongolia using a six-level scale, valuable insights were obtained.

In the areas of learning outcomes and teaching-learning activities, the engineering, manufacturing, and construction program with index 07 showed average performance compared to other programs.

Recommendations for Universities

Clearly define the program goals, objectives, and learning outcomes in alignment with the National Qualifications Framework and labor market demands. These should be specific, measurable, attainable, and time-bound.

When defining learning outcomes, develop a graduate profile and specify outcomes at each course level.

Develop coherent core curricula that are aligned with each other, ensuring that course content and teaching methods are integrated to support the learning outcomes.

Incorporate CDIO-based pedagogical training into faculty development programs through a phased approach.

Improve internship, laboratory, and industrial learning environments, and strengthen collaboration with employers.

Clearly define and include the role of courses in developing soft skills such as creative thinking, independent learning, and teamwork.

Use both formative and summative assessments in a balanced way to ensure they serve as tools for measuring learning outcomes.

Establish a competency-based assessment system that considers actual performance and project implementation more effectively.

Enhance students' abilities in real-world problem-solving, teamwork, communication, project management, and practical application skills. Ensure curricular alignment across courses to support these capabilities.

Engage employers and graduates in program evaluation and incorporate their feedback gradually, following a structured evaluation model.

REFERENCES

Abanteriba, S. (2006). Development of strategic international industry links to promote undergraduate vocational training and postgraduate research programmes. *European Journal of Engineering Education, 31*(3), 283–301

CDIO Initiative. (2007, June). Work. Proceedings of the 3rd International CDIO Conference, MIT, Cambridge, MA. http://www.cdio.org/knowledge-library

CDIO Initiative. (2009). Using the CDIO syllabus in the formulation of program goals: Experiences and comparisons. Proceedings of the 5th International CDIO Conference, Singapore. http://www.cdio.org

CDIO Initiative. (2010). CDIO standards v.2.0. http://www.cdio.org

Ornstein, A. C., & Hunkins, F. P. (2018). *Curriculum: Foundations, principles, and issues* (7th ed.). Pearson.

Ottemo, A. (2008). *Rekryteringsarbete och genusmönster i rekryteringen till Chalmers utbildningar på EDITZ-området*. Chalmers University of Technology.

Svensson, T., & Krysander, D. (2011). *Project model LIPS*. Studentlitteratur.

Sykes, J. (2003). *Studies from aeronautical history*. Johns Hopkins University Press.

Taylor, D. G., Magleby, S. P., Todd, R. H., & Parkinson, A. R. (2001). Training faculty to coach capstone design teams. *International Journal of Engineering Education, 17*(4–5), 353–358.

The Bologna Process. (n.d.). http://www.ond.vlaanderen.be/hogeronderwijs/bologna

Young, P. W., Malmqvist, J., Hallström, S., Kuttenkeuler, J., Svensson, T., & Cunningham, G. C. (2005). Design and development of CDIO student workspaces—Lessons learned. *Proceedings of the 1st Annual CDIO Conference*, Queen's University, Kingston, Ontario, Canada.

Dolby, N. (2008). Global citizenship and study abroad: A comparative study of American and Australian undergraduates. *Frontiers: The Interdisciplinary Journal of Study Abroad, 5*(7), 51–57.

Dolby, N. (2008). Global citizenship and study abroad: A comparative study of American and Australian undergraduates. *Frontiers: The Interdisciplinary Journal of Study Abroad, 5*(7), 51–57.

Downey, G. (2005). Are engineers losing control of technology? From 'problem solving' to 'problem definition'. *Chemical Engineering Research and Design, 83*, 583–595.

Downey, G. (2005). Are engineers losing control of technology? From 'problem solving' to 'problem definition'. *Chemical Engineering Research and Design, 83*, 583–595. *(Гарчиг бүрэн эхээр сэргээсэн)*

Downey, G., & Lucena, J. (2004). Knowledge and professional identity in engineering: Code-switching and the metric of progress. *History and Technology, 20*(4), 393–420.
Downey, G., & Lucena, J. (2004). Knowledge and professional identity in engineering: Code-switching and the metric of progress. *History and Technology, 20*(4), 393–420.
Dublin Descriptors. (2004). Shared 'Dublin' descriptors for Short Cycle, First Cycle, Second Cycle and Third Cycle Awards. http://jointquality.nl/
Dublin Descriptors. (2004). Shared 'Dublin' descriptors for Short Cycle, First Cycle, Second Cycle and Third Cycle Awards. http://jointquality.nl/
Dutta, D., Geister, D. E., & Tryggvason, G. (2004). Introducing hands-on experiences in design and manufacturing education. *International Journal of Engineering Education, 20*(5), 754–763.
Dutta, D., Geister, D. E., & Tryggvason, G. (2004). Introducing hands-on experiences in design and manufacturing education. *International Journal of Engineering Education, 20*(5), 754–763.
Edström, K. (2012). Student feedback in engineering: Overview and background. In P. Mertova, S. Nair, & A. Patil (Eds.), *Enhancing learning and teaching through student feedback in engineering* (pp. xx–xx). Woodhead Publishing.
Edström, K. (2012). Student feedback in engineering: Overview and background. In P. Mertova, S. Nair, & A. Patil (Eds.), *Enhancing learning and teaching through student feedback in engineering* (pp. xx–xx). Woodhead Publishing.
Edström, K., Tornevik, J., Engström, M., & Wiklund, E. (2003). Student involvement in principled development of engineering education. *Proceedings of the 31st SEFI Annual Conference*, Valencia, Spain.
Edström, K., Tornevik, J., Engström, M., & Wiklund, E. (2003). Student involvement in principled development of engineering education. *Proceedings of the 31st SEFI Annual Conference*, Valencia, Spain.
Engineering Council UK. (2013). Accreditation of higher education programs. http://www.engc.org.uk/professional-qualifications/standards/UK-SPEC

Engineering Council. (2004). UK standards for professional engineering competence: The accreditation of higher education programs. http://www.engc.org.uk/professional-qualifications/standards/UK-SPEC
Engineering Council. (2004). UK standards for professional engineering competence: The accreditation of higher education programs. http://www.engc.org.uk/professional-qualifications/standards/UK-SPEC
Ertugrul, N. (2000). Towards virtual laboratories: A survey of LabVIEW-based teaching/learning tools and future trends. *International Journal of Engineering Education, 16*(3), 171–180.

European Ministers of Education. (1999). The Bologna Declaration. http://www.bolognabergen2005.no/DOGS/00Main_doc/990719BOLOGNA_DECLARATION.PDF
European Ministers of Education. (1999). The Bologna Declaration. http://www.bolognabergen2005.no/DOGS/00Main_doc/990719BOLOGNA_DECLARATION.PDF
Feisel, L. D. (1986, October 12–15). Teaching students to continue their education. *Proceedings of the Frontiers in Education Conference*, University of Texas at Arlington.

Ferguson, E. S. (1992). *Engineering and the mind's eye*. MIT Press.

Finiston, M. (1980). *Engineering our future: Report of the Committee of Inquiry into the Engineering Profession* (Cmnd. 7794). Her Majesty's Stationery Office.

Finniston, M. (1980). *Engineering our future: Report of the Committee of Inquiry into the Engineering Profession*. HMSO.

Fitzpatrick, J. L., Sanders, J. R., & Worthen, B. R. (2010). *Program evaluation: Alternative approaches and practical guidelines* (4th ed.). Pearson.

Gibbons, M., Limoges, C., Nowotny, H., Schwarzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. Sage.

Gibbs, G. (1992). *Improving the quality of student learning*. Teaching and Educational Services.

Gispen, K. (1990). *New professions, old order: Engineers and German society, 1815–1914*. Cambridge University Press.

Goldberg, D. E. (2006). *The entrepreneurial engineer: Personal, interpersonal, and organizational skills for engineers in a world of opportunity*. Wiley.

Gordon, B. M. (1984). What is an engineer? Invited keynote presentation. *European Society for Engineering Education (SEFI) Annual Conference*, University of Erlangen-Nürnberg, Germany.

Gordon-MIT Engineering Leadership Program. (n.d.). http://web.mit.edu/gordonelp