Eight Discipline-Problem Based Learning in Industrial Training Program to Develop Future Proof Skills Among Graduate Engineers

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Abstract—The mismatch of skills is one of the main reasons for unemployment. The analysis revealed employers' agreement of graduate engineers' performance in non-technical skills, which is deemed not to meet their expectations. Therefore, to align with the needs of employers, universities are working hard to close the gap and begin to focus on producing work-ready engineers who are good assets for the industry and those who can work with minimal supervision independently. The various jobs and non-technical skills triggered a vast change to the labour market with a prime shift in the skills required to thrive in the anticipated new environment and business structures requested from Industrial Revolution 4.0 (IR4.0). The nine skills would be Leadership, Flexibility and Adaptability, language literacy, Critical thinking and solving problems, Holistic, Entrepreneurial and Balance, Resilience, Values and Ethics, Compassion and Mindfulness, Creativity and Innovation. These skills or talents that recognize employees as competent are called future-proof non-technical skills. This article aims to upgrade the nine non-technical abilities shown for the future by means of industry training, particularly for students of Engineering. In addition, it also shows the capacity of 8-Discipline-Problem based learning (8D-PBL). In the industrial training evaluation technique, things need to be highlighted to accomplish industrial training.

Keywords—eight, discipline, methodology, industrial training, internship, assessment

1 Introduction

Compared to previous years, the Covid-19 pandemic caused the work placement of graduates to get much worse. Everyone knows that this is only a beginning, and if proper action is not taken, the situation will become worse. This unforeseen circumstance pressures everybody to up-skill themselves, and for those who want to survive during this pandemic, up-skill is no longer optional. To overcome this issue, Higher learning institutions and the Ministry of Human Resources are now conducting several up-skill programs for engineering students and graduate engineers, respectively, including developing non-technical skills through the Human Resources Development Fund (HRDF). Through offering on-job training, coaching, mentoring, in-house training, counselling, external training and development, they are responsible for producing work-ready engineers through up-skilling the engineering students [1]. However, the recent study shows that a 1:4 ratio of fresh graduates are unemployed [2]. The main reason for the unemployment is the inadequate non-technical skills among engineering students [1]. Furthermore, to recruit engineering graduates, employers have demanded non-technical skills in their company to indicate their importance in an industrial environment. As for practice and experiencing these particular nine future-proof non-technical skills, industrial training is crucial. Students from engineering may examine and deal with problems which occur in their working environment. To develop technical abilities in the particular period for the internship, an extensive and extensive internship programme is needed.

The majority of university systems rely on the Humboldt legacy, emphasizing research and teaching freedoms. At first, the teacher-led universities were strongly autonomous and independent. Still, they were lost in time and gave room to the neoliberal postmodernist concepts that took control of the university's leadership and changed university-learning processes. The student is considered a client and the instructor a tool for the effective production and use of resources. Thus, choices are not made by instructors but by employees, at the top levels of the organization, in favour of the sovereignty of these customers. Educational policies should thus be continuously examined and reflected on the administration of universities or adapted to new methods or teaching models. Social needs suggest that attempts to enhance training at all levels should consist of instructors, university employees and schools, government policies and society, which should take part in efforts and change plans, including corporations and diverse organizations and associations. Thus, new measures are becoming more and more critical.

In this context, the existing industrial training program has some drawbacks, including insufficient documentation, a lack of industrial training procedures and guidelines, a lack of recorded industrial training syllabus and standards of practice, and a lack of defined goals and curricular structure. In addition, existence of a gap in students' industrial training diagnostic, formative, and summative assessments; learning outcomes after completion of training; and host company supervisor competency in implementing industrial training and training engineering students [3]; which shows almost the same outcome according to the research conducted by [4] after five years. This illustrates that changes made to correct the enhancement of non-technical skills through industrial training still do not resolve the real root cause and still have a discrepancy in what we have developed and what the employer wants.

2 Literature review

The higher institutions are implementing project-based learning [5] [6], work-based learning [7], and problem-based learning [8] to improve non-technical skills. Where else, industries are using 8D-PBL to perform systematic root cause analysis and enhance non-technical skills. According to [9], there is a gap between higher institutions and industry practices in forming non-technical skills. The level of 8D use is much higher in industries than in universities. Even though it was implemented a few decades ago, the exposure of 8D to the academic community is still at an early stage. This illustrates that in improving non-technical skills, there is a communication gap between industry and universities.

2.1 What are eight disciplines?

Lean manufacturing is a hot topic discussed in an industrial environment which emphasize waste management. Many approaches are actively practising in workplaces, such as PDCA (Plan, Do Check & Action) and DMAIC (Define, Measure, Analyse, Improve, Control) to prevent waste due to errors. These methods are a subset of 8D-PBL. Organizations typically utilize the 8D approach to resolve issues on the customer's site successfully. Although the 8D process was developed as a sophisticated instrument to solve problems, it is now most frequently utilized as a tool to handle automobile complaints. The marketing of 8D means that 8D reports are frequently needed by the customers when the root cause is difficult to establish for random failures.

Reading shows, Ford Motor Company implemented an 8D problem-Solving Approach, a team-oriented problem-solving in early 1980 [10] to perform root cause analysis in a short period to rectify process, product, engineering, and human-related issues. Since 8D-PBL is designed fairly simple to adopt by any engineering environment and easy to understand by all.

2.2 Components of eight disciplines

Table 1 displays the 8D-PBL components. According to the overview, 8D-PBL is the employers' preference because of systemic methods developed, and almost all non-technical skills are involved during the problem-solving process. Furthermore, each discipline emphasizes the actions and attitude required by engineers in an industrial environment when investigating an industrial problem. The elements involved in 8D-PBL, Problem Based Learning (PBL), and project-based learning (PjBL) as Table 1 clearly shows that 8D-PBL is a hybrid of PBL & PjBL.

Table 1. Comparison of type of based learning

No	8 Disciplines	Problem-Based Learning	Project-Based Learning
1	Planning	Group setting	Problem statement
2	Team approach	Problem Identification	Project designing
3	Problem description	Idea generation	Planning
4	Interim containment actions	Learning Issue	Monitoring
5	Root causes analysis	Self-directed learning	Validation
6	Permanent corrective actions	Synthesis and application	Learning outcome
7	Validation of permanent actions	Reflection and feedback	–
8	Prevent recurrence	–	–
9	Team recognition	–	–

Table 2. Literature review protocol

Description	Conditions/Results
Objective	To understand the suitability of 8D-PBL as a Structured Industrial Training logbook.
	To determine the ability of 8D-PBL to improve the non-technical skills.
	To analyze the employers view about 8D-PBL capability as an industrial training curriculum tool.
Source of Data	Web of Science & Scopus.com
Area of Interest	Improve Nine Future Proof Soft Skills among engineering students.
Search All field/Keywords	8D, Problem, Solving, Engineering
Covered Period	29/October/2019
Preliminary Document Selected	19-WoS & 164-Scopus
Engineering Related Papers screened	19-WoS & 164-Scopus
Documents Analysis	With the aid of VOS viewer, information based on content that is analyzed

Table 2 review the literature from WoS and Scopus. This 8D methodology is almost linked to teamwork, customer satisfaction, problem-solving skill and quality, which was revealed from the network visualization in Figures 1 and 2. However, these terms of internship, university and engineering are absent from the network visualizer. From this, we can derive that in comparison to its widespread use in industry, 8D exposure at the university level is still in its early development.

The purpose of this 8D is to evaluate, change, and also mitigate persistent issues. If properly implemented, it can assist businesses in finding solutions to complex problems, such as non-conformity resolution [11]. For example, in Poka-Yoke, Pareto analysis and Ishikawa chart, employees are experienced and educated; the applied method is ideal for non-conformity resolution [12]. The 8D, on the other hand, aims to confront problems and recognize weaknesses in management processes that emerged as a result of the problem [13]. In addition, this particular 8D-PBL approach has been used to define an organization's core mechanism that will direct the understanding of the significance of "doing it right the first time" when combined with poor quality, cost analysis, and the voice of the customer [14]. Moreover, this 8D highlights value management as an effective strategy for maximizing consumer value. In terms of functionality, value is defined rather than cost in this context [15]. The seven new approaches in 8D, known as quality planning, would be the tree diagrams, arrow diagrams, matrix data diagrams, relation diagrams, process decision diagrams and affinity diagrams [16].

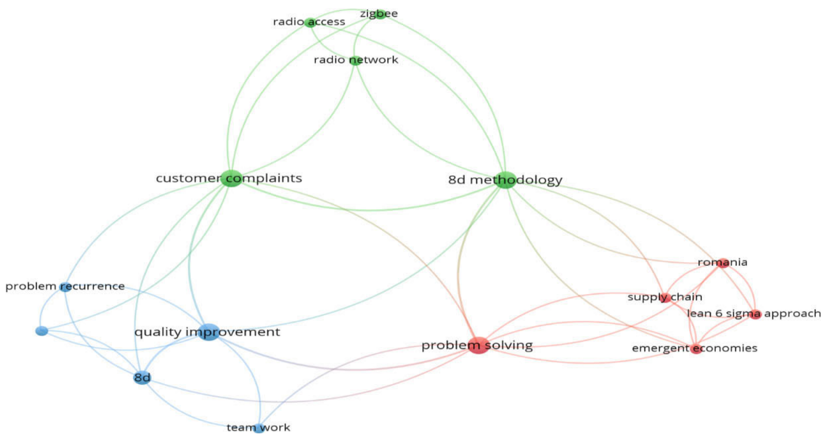

Fig. 1. 19 WoS papers examined with VOSViewer

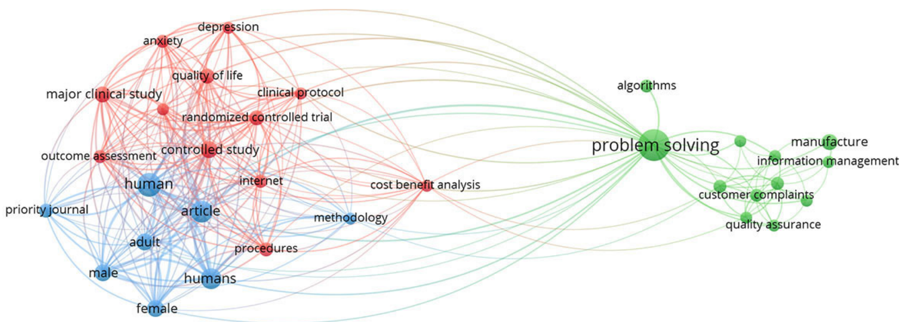

Fig. 2. 164 Scopus papers examined with VOSViewer

3 Research methodology

This paper adopts a mixed-method in sequential exploratory design, in which qualitative and quantitative research were combined. 59 applicants from various departments and essence of organizations took part in quantitative research via a Google Form Survey (Refer Figure 3 and Table 3). Participants with beginner to advanced rank in management had responded to the survey questionnaire.

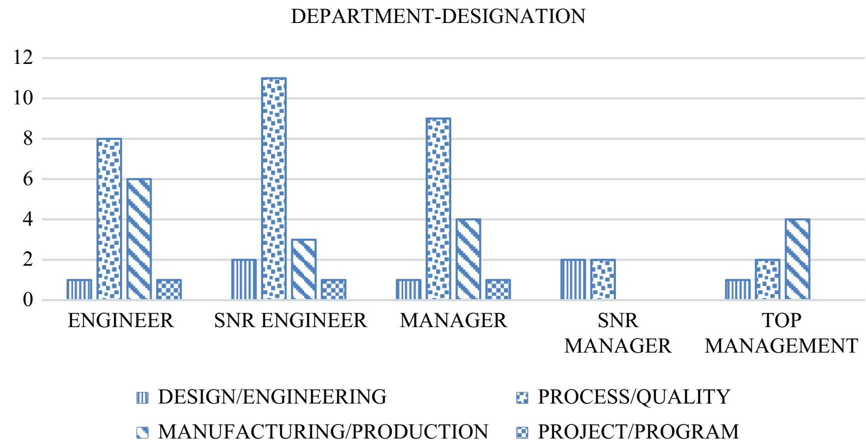

Fig. 3. Participants' position and field of business

Table 3. Participants' designation (quantitative survey)

Description		Number	%	Valid %	Cumulative %
Valid	Engineer	16	27.2	27.2	27.2
	Senior Eng.	17	28.7	28.7	55.8
	Manager	15	25.5	25.5	81.5
	Senior Manager	4	6.9	6.9	88.2
	Top Management	7	11.7	11.7	99.8
	Total	59	100.0	100.0	

As for the second part of the survey, which involved a qualitative survey, twelve out of 59 respondents answered a semi-structured interview. The interview involved two sections. First, the interview began with a question and answer session, followed by a 6-point Likert scale evaluation on the importance of 8D in improving non-technical skills among engineering students. The classification of the second stage quantitative sample participants is detailed in Table 4, and the survey results are shown in Table 8.

Table 4. Participants' designation (quantitative survey)

Description		Number	%	Valid %	Cumulative %
Valid	Senior Eng.	2	16.6	16.6	16.7
	Senior Manager	10	83.4	83.4	100.0
	Total	12	100.0	00.0	

4 Results and discussions

33 respondents believe it is crucial to impart 8D-PBL in universities to engineering students before graduating (Table 5). Contrary to that, 40.7 % of respondents agreed that 8D-PBL could be learned when they join the workforce upon graduation. The remaining two participants did not agree that 8D-PBL was important for engineering graduates. Based on the survey, it could be acknowledged that 8D-PBL is deemed to be important for engineers, according to 96.6 % of respondents. The only difference between the data is whether 8D should be taught as early as in university or in the industry later.

Table 5. Engineering students' perception on the importance of 8D

Level		Frequency	%	Valid Percent	Cumulative Percent
Valid	PREREQUISITE	33	55.9	55.9	55.9
	CAN LEARN DURING WORK	24	40.7	40.7	96.6
	NOT IMPORTANT	2	3.4	3.4	100.0
	Total	59	100.0	100.0	

During the second stage of the survey, 12 respondents were randomly chosen for a semi-structured interview. The data from the semi-structured interview revealed that 8D will boost the 9 future-proof skills and develop problem-solving performance. Based on Table 6, most of the participants indicated that 8D could be used to improve non-technical skills. "Strongly disagree", "Disagree", or "Somewhat Disagree" were not among their responses. The only distinction is in the level of acceptance. "Strongly Agree" has the highest average of 2.00, implying that by 8D, 9 future proof talents will be developed.

Table 6. The importance of 8D in developing 9 future proof talents

8D Methodology	Mean Value	N	Standard Deviation
Strongly Disagree	0.00	0	0.00
Disagree	0.00	0	0.00
Slightly Disagree	0.00	0	0.00
Slightly Agree	1.50	2	0.71
Agree	1.75	4	0.50
Strongly Agree	2.00	6	0.00
Total	1.83	12	0.39

(Refer Table 7) 12 program learning outcomes (PLO) based on Engineering Accreditation Council (EAC, 2017) have been established and to be trained in the syllabus to produce work-ready engineers. However, there is still a gap in achieving the goals because engineering students lack the necessary industry knowledge to be recognized as engineers who are ready for employment [7].

Table 7. Ministry of Higher Education (MOHE) suggestion for Program Learning Outcome (PLO)

Program Learning Outcomes	
PLO1	Engineering Knowledge- Complex engineering problems can be solved with the best approaches that are based on knowledge of math, and Physics.
PLO2	Problem Analysis- Problem analyzing is crucial. This involves analyzing root causes, interpreting data and applying corrective action continuously.
PLO3	Investigation- Capable of using math, science, and electrical engineering knowledge to conduct 5W1H, analyze the interconnection, DMAIC, and 8 Quality or Process analytical methods to investigate intricate engineering problems.
PLO4	Modern tool usage- Proficient of carrying out engineering exercise and utilizing present engineering and IT techniques for intricate engineering problems while mindful of technological limitations.
PLO5	Design/Development of Solutions-: Ability to employ immediate, long-term, and preventive action with mathematics, physics and electrical engineering knowledge.
PLO6	Communication- Proficiency in communicating verbally and in writing concepts effectively with the engineering team and the common public regarding the intricate engineering actions.
PLO7	Individual and Teamwork- Ability to function effectively as an individual, a partner, or a leader in various teams.
PLO8	Lifelong learning- Ability to recognize the requirement to make for autonomous and long-term learning in technological revolutions in general.
PLO9	The Engineer and Society- Capability to grasp the implications of universal and contemporary disputes, engineers' societal responsibilities, comprising health, surety , authorized, and cultural matters, and the resulting accountabilities relating to qualified engineering practices and complex engineering hitches.
PLO10	Environment and Sustainability- Ability to consider and evaluate the practicability and impact of technical engineering conventions on complex engineering problems in social and environmental contexts.
PLO11	Ethics- Skills in comprehending virtuous principles and to adhere to adept ethics, accountability, and engineering practice criterions.
PLO12	Project management and Finance- Proficient in demonstrating knowledge and interpreting engineering concepts, management and financial decision-making to manage their projects and/or projects in a multidisciplinary setting.

Table 8. 8D methodology correlation with the 9 future proof soft skills against PLOs

Eight Disciplinary (8D)	Future Proof Skills Identified By MoHE										
	PLO	Values and Ethics	Compassion and Mindfulness	Creativity and Innovation	Holistic, Entrepreneurial and Balance	Resilience	Critical Thinking and Problem Solving	Leadership	Flexibility and Adaptability	Communication and Language Proficiency	None of the Above
D0) Planning	PLO11 PLO12	M7, M8, M9, M10	E2, M4, M5, M6, M8	E1, M2, M9	E1, M8, M10	M8	E1, M1, M2, M7	E1, M2, M3, M4, M7, M8	M4, M6, M8, M10	M1, M7, M8	
D1) Team formation	PLO6 PLO7	M1, E2, M7	M1, M7	M1, M2	M1, M3	M1, M6	E1, M2, E2	E1, M2, E2, M4, M5, M7	E1, M2	E1, M2, M6	
D2) Problem Statement	PLO2	M5, M6, M7, M8	M1, M8, M9	E1, M2, E2, M7, M8, M9	M1, M4, M6, M8	M1, E2, M8, M10	E1, M2, M3, E2, M6, M7, M10	M1, M8	M1, M8	M6, M7, M8	
D3) Immediate Action	PLO1 PLO4 PLO5	M1, E2, M6, M8, M9	M1, M2, M8, M9	M1, M2, M6, M8, M9	E1, M1, M6, M8, M10	M1, M2, M6, M8, M10	E1, M2, M3, E2, M4, M6, M7	M6, M7, M8	M1, M2, E2, M5, M6, M8, M10	M2, M6, M7, M8	
D4) Root cause analysis	PLO2 PLO3	M6, M8, M9, M10	M8	E1, M1, M2, E2, M5, M6, M7, M8, M9	M2, M6, M8	M6, M8	E1, M1, M2, M3, E2, M4, M6, M8, M10	M2, M6, M7, M8	M1, M6, M8, M10	M2, M6, M7, M8	
D5) Permanent Action	PLO4 PLO5	M1, M5, M6, M7, M8, M10	M1, M2, M4, M8, M9, M10	E1, M1, M2, M3, E2, M4, M6, M7, M8, M9, M10	E1, M1, M4, M6, M8	M1, M6, M7, M8, M10	M1, M2, E2, M4, M6, M7, M10	M1, M2, M6, M7, M8	M1, M2, M6, M7, M8	M2, M6, M7, M8	
D6) Validation	PLO1	E1, M1, M7, M8	M1, M2, M7, M8, M10	M1, M2, E2, M4, M8, M9, M10	M1, M2, M4, M5, M8	M1, M2, M7, M8, M10	E1, M1, M2, M3, M4, M6, M10	M2, M7, M8	M2, E2, M5, M7, M8, M10	M2, M6, M2, M7, M8	

(Continued)

Table 8. 8D methodology correlation with the 9 future proof soft skills against PLOs *(Continued)*

Eight Disciplinary (8D)	Future Proof Skills Identified By MoHE										
	PLO	**Values and Ethics**	**Compassion and Mindfulness**	**Creativity and Innovation**	**Holistic, Entrepreneurial and Balance**	**Resilience**	**Critical Thinking and Problem Solving**	**Leadership**	**Flexibility and Adaptability**	**Communication and Language Proficiency**	**None of the Above**
D7) Preventive action	PLO4	E1, M1, M6, M7, M8	M1, M7, M9, M10	E1, M1, M2, M3, M4, M6, M7, M8, M9, M10	M1, M2, M6, M7, M8	M2, M6, M8, M10	E1, M2, E2, M4, M6, M10	M2, M6, M7, M8, M10	M2, E2, M5, M6, M7, M8, M10	M2, M6, M7, M8	
D8) Value the effort	PLO9 PLO7	E1, E2, M6, M7, M8, M9, M10	E2, M7, M8,	M2, M7, M9	M1, M4, M6, M8, M10	M1, M7, M8, M10	M2, M10	M1, M2, M3, M4, M6, M7, M8, M10	M1, M2, M7, M8	M2, M5, M7, M8	

*(*Engineer: E1, E2 & Manager: M1, M2, M3, M4, M5, M6, M7, M8, M9, M10)*

The latter part of the survey involved interviewing two engineers, and ten managers. The results of the semi-structured interview are shown in Table 8. Again, each discipline's purpose was examined, and all participants had differing opinions of the discipline and its roles. However, each participant agreed that all the disciplines help to improve, at minimum, one soft skill. Most of the 9 future-proof talents were used in 8D to complete the task, as listed in Table 9. As a result, the internship is an excellent period for engineering graduates to exercise 8D in the process of becoming "work-ready engineers".

Table 9. 8D and nine future proof talents survey findings

Outcome of the Interview	Disciplines	Respondent	Dimension
i) The importance of acting quickly to problems that arise at work cannot be overstated. The faster you respond, the better your chances of saving money and avoiding waste are. ii) Work as a team with another department in an organization	D0, D1, D2, D3, D4, D5, D6, D7, D8	E1, E2, M1, M5, M6, M7, M8, M9, M10	Principles and Beliefs
i) Different departments may be to take responsibility for failure. Acknowledge the situation and moving on to the problem-solving step instead of pointing out the error. ii) To expedite the root cause analysis, distribute the task to the team.		E2, M1, M2, M4, M5, M7, M8,. M9, M10	Compassion and Mindfulness
i) Credibility in recognizing significant, fundamental changes and information on sequential improvements. ii) Improved efficacy and problem-solving skills. iii) Designing a new approach to avoid the problem from recurring.		E1, E2, M1, M2, M3, M4, M5, M6, M7, M8, M9, M10	Creativity and Innovation
i) Increase in the administration's understanding of issues and ways to solve them. ii) The new improvised plan will require added investment, but it will help toengender valuable products and profit in the long run.		E1, M1, M2, M3, M4, M5, M6, M7, M8, M10	Holistic, Entrepreneurial and Balance
i) Valuing the team's effort after a fruitful corrective action execution will instill new hope in the group.		E2, M1, M2, M6, M7, M8, M10	Resilience
i) Improved ability to carry out corrective actions ii) The ability to contribute new ideas and make suggestions is unrestricted.		E1, E2, M1, M2, M3, M4, M5, M6, M7, M8, M9, M10	Serious thinking and problem solving
i) Congregate upper-level administration under one roof to hear the proposed advancement plan and make instantaneous decisions.		E1, E2, M1, M2, M3, M4, M5, M6, M7, M8, M10	Leadership
i) As long as the issue is resolved, everyone should express their thoughts and opinions.		E1, E2, M1, M2, M4, M5, M6, M7, M8, M10	Flexibility and Adaptability

(Continued)

Table 9. 8D and nine future proof talents survey findings *(Continued)*

Outcome of the Interview	Disciplines	Respondent	Dimension
i) Further engagement of participants in issue solution and visible interaction improve the effectiveness of correcting measures. ii) Skills in concisely conveying a message that everyone can understand (written and verbal)		E1, M1, M2, M5, M6, M7, M8	Communication and Language proficiency.
i) The trainer (Industry) must understand the Industrial Training- Training Need Analysis ii) Trainer should competent to train the students		E1, E2, M1, M2, M3, M4, M5, M6, M7, M8, M9, M10	Trainer competency

5 Discussion and conclusion

The industrial training curriculum, assessment method, and trainer competency are very important components in the industrial training program to turn the engineering students into work-ready engineers. Based on the preliminary data, 8D-PBL is suitable as a logbook and part of the record book. This becomes a supporting document for graduate engineers to use for their interviews as most employers know the function and importance of 8D-PBL. In addition, it carries weight to the fresh graduate's resume and acts as evidence that students went through certain industrial practices during their training program. This will thus increase the confidence level of the interviewer on the interviewee.

Since host-company-trainer has to train students from different universities, it is really important to have a standardized industrial training assessment method and curriculum to ease the trainer to conduct the training and to assess the students. The trainer becomes familiar with the assessment structure if it's standardized among universities. As the literature review shows, the trainer or company supervisor is familiar with 8D-PBL; therefore, it is suitable to train the engineering students with the methods they know well rather than based on a non-guided approach. This approach also increases the reliability of training outcomes as it does not require any additional assessment of the trainer's competency.

In conclusion, 8D methodology is a trustworthy document for company-supervisor and academics-supervisor since the matter drives the engineering students to involve in real industrial activity. Therefore, one of the main constituents in the engineering internship program has to be 8D methodology. Moreover, as shown in Figure 4, 8D-PBL can be a solution for gaps that have been pointed out by previous researchers and 8D-PBL is thus strongly recommended in the Engineering Industrial training program.

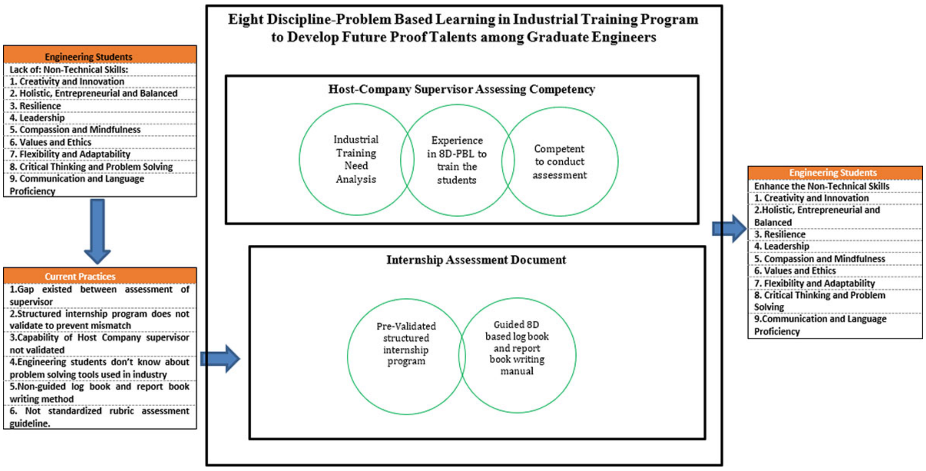

Fig. 4. Theoretical framework of 8D-problem based learning in industrial training program to develop future proof talents among graduate engineers

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