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The perception of complex engineering problems among engineering teachers and students: A case study

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ABSTRACT

The complex engineering problems (CEPs) are characterized by challenges such as: a) involving extensive or inconsistent, incompatible data from engineering and other offshoots, b) unable to be solved in the absence of in-depth engineering knowledge. The engineering teachers are not found successful in the design of a CEP because it does not touch the real issues from industry and / or environment. Therefore, the expertise of applicable skill cannot be evaluated and the reason behind this failure is the lack of or poor intellectual perception of the attributes of CEPs among the teachers. In order to help teachers, the relation between attributes, knowledge profiles and CEPs is elucidated in this work by giving examples. The main objective of this article is to establish an understanding of the student's level of perceiving a complex engineering problem with respect to the learning domain. The Survey was conducted among 70 participants and the quantitative approach employed, utilizing a questionnaire survey and interviewing teachers to gather data from respondents selected through random probability sampling. It is concluded that Industrial training (like apprenticeships), laboratory practices and final year design project are good tools for the complex engineering activities/ exercises. The results obtained in the case study were found promising, therefore, it is recommended to extend this study by using various engineering institutions to ascertain a framework on CEP solving. skills.

1. Introduction

The Washington Accord (WA) establishes mutual recognition of engineering programs and confidence in the graduates of these programs to international accreditation level among the signatories. The WA is centered on substantial equivalence not on the thorough equivalence of course substance and outcomes. The written agreement is the proof of consensus on the qualities of engineering graduates by all signatories. The Washington Accord, initially established in 1989, represents a collaborative multi-lateral agreement among entities responsible for accrediting or recognizing engineering qualifications at the tertiary level within their respective jurisdictions. Their primary objective is to facilitate the mobility of professional engineers by working together [1].

The signatories of the accord are dedicated to promoting and acknowledging exemplary standards in engineering education. Through various initiatives, such as creating model profiles for graduates from specific qualification types, they aim to foster increased global recognition of engineering qualifications. The WA has a specific emphasis on academic programs that pertain to engineering at the professional level. Currently there are 21 countries at the status of full signatories and 7 countries are provisional signatories [IEA, 2022]. Provisional signatories are acknowledged for having suitable systems and processes in place, indicating their progress towards becoming full signatories.

As signatory of Washington Accord, Pakistani degrees are of the same value as in the degrees from the developed countries. Therefore, there is an advantage that makes the WA accredited degree programs over non-accredited degree programs which is the eligibility for the working abroad [2].

There are level II accredited degree programs on the website of Pakistan Engineering Council (PEC) that are outcome-based programs and are accredited by the PEC as well as WA. Level I-degree programs on the PEC website are, in fact, non-outcome-based programs and these are only accredited by the PEC, not by the WA. Under the umbrella of WA, accreditation of institutions includes a two-step process: i) self-assessment and ii) peer evaluation. In the last two decades, there has been a phenomenal increase in the number of engineering institutions, therefore, accreditation has become more important [3].

Many of the graduates whose degree programs are accredited by the WA rush towards abroad for a job, and they couldn't get desired results because they have no special area of interest, no certification, no skill in a particular software or applied engineering tool. A case study was conducted by authors to evaluate the understanding of teachers and students towards the complex engineering problems and the results are discussed. This article has emphasized that an engineering graduate is required to have gained the competence to face, to analyze and to design approaches to solve real life complex engineering problems. The structuring of complex engineering problems (CEPs) with respect to graduate attributes and knowledge profiles are also discussed in this article while the examples for discussion are taken from chemical engineering [4].

1.1 Complex Engineering Problem

The focus of accreditation is to emphasize practicing the concepts of environment and sustainability, public health and safety (EHS), problem-based learning (PBL) techniques, solutions of complex engineering problems (CEPs) and learning through open-ended labs (OELs), etc. Therefore, the capability of engineering graduates must be evaluated on the basis of all 12 graduate attributes[5]. The graduate attributes have competences to use the skills as an engineer as defined in the Table 1.

Table 1

Graduate attributes, simple and explained

Abbreviation	Graduate Attribute	Description
GA-01	Engineering Knowledge	Application of the basic knowledge of mathematics, science, and engineering initially, then, use of special engineering knowledge to solve a complex engineering problem, finally.
GA-02	Problem Analysis	Identification, formulation, and analyzing the complex engineering problems (CEPs) through the research literature and reaching authenticated decisions using underlying engineering principles.
GA-03	Design/Development of Solutions	Design of solutions for complex engineering problems and design processes that pay specific attention to health and safety of community, societal, and environmental issues.
GA-04	Investigation	Investigation of complex engineering problems (CEPs) in a logical way, starting from literature survey, design and conduct of experiments, analysis,

		interpretation of experimental results, and synthesis of information to take valid decisions.
GA-05	Modern Tool Usage	Ability to select/ create and apply proper techniques, and modern Engineering and IT tools (softwares), through modeling, to complex engineering activities (CEAs), with a knowledge of the limitations
GA-06	The Engineer and Society	Using contextual knowledge in a logical way to consider societal, safety, legal, health issues and the resulting obligations to practice engineering profession and giving complex engineering problems solutions.
GA-07	Environment and Sustainability	Understand the impact of created professional engineering solutions for the societal, environmental and sustainable perspectives
GA-08	Ethics:	Committed to professional ethics and responsibilities and norms.
GA-09	Individual and Team Work	Work efficiently, as an individual or as a team member, on multifaceted and /or multidisciplinary roles.
GA-10	Communication	Communicate effectively such as writing reports and design documentation, make presentations, and able to give and receive clear instructions.
GA-11	Project Management	Demonstrate management skills and apply engineering principles as an individual, a member and/or a team leader, to manage projects in a multidisciplinary environment.
GA 12	Lifelong Learning	Have the ability to engage in, independent and life-long learning in the broadest perspectives of technological advancements.

An engineering program should express the ways by which the Range of Complex Engineering Problems is being validated by the graduate attributes. According to the WA (IEA 2015), complex engineering problems are the problems which

a. Require in-depth engineering knowledge

b. Involve confusing (similar / contrasting) technical, engineering and other (cultural, environmental) issues.

c. Require conceptualization and strong analytical power to formulate suitable solutions while it has no obvious solution

d. Encompass the problems of stakeholders covered by standards and professional engineering codes of practice.

e. A problem composed of many component parts or sub-problems.

Table 2

Knowledge profiles and their description

Knowledge Profiles		Description
WK01	Natural Sciences	An academic understanding of natural sciences that is relevant and applicable to the field of engineering.
WK02	Mathematics and Computing	Utilizing the principles of concept-based mathematical thinking, numerical analysis, statistics, and formal aspects of computer and information science to facilitate analysis and modeling.
WK03	Engineering Fundamentals	A methodical and theory-based articulation of engineering fundamentals essential within a specific engineering discipline.
WK04	Engineering Specialist Knowledge	This knowledge encompasses theoretical frameworks and established bodies of knowledge that underpin accepted engineering practices in various areas of the discipline.
WK05	Engineering Design	This knowledge constitutes the necessary support for engineering design within a specific practice area.
WK06	Engineering Practice	The knowledge of engineering practices across various systems within a specific engineering discipline. This includes the understanding and proficiency in applying engineering knowledge, principles, techniques, and methods to deal with different challenges and complications associated with real world systems within the specialized disciplines.
WK07	Engineering in Society	This knowledge revolves around the understanding of the responsibilities of an engineer in society and their professional role regarding public safety. It involves growing awareness for the broader impact of engineering activities, like ethics, economic concerns, social consequences, cultural sides, environmental implications along with sustainability factors. Engineers should be well aware of these aspects to take such decisions that contributes positively towards society with the insurance of safety and public well-being.
WK08	Research Literature	Active involvement in creating research literature relevant to their field and staying informed with modern technological advancements. This can improve their expertise and professional practice because of their participation in creating research literature and discussions with the experts of their fields.

On the basis of teaching, training and lab practices, engineering graduates must be able to solve complex engineering problems which may come across in their engineering practices. Through evaluation visits conducted in various engineering institutes, it is observed that the ability to solve complex engineering problems (CEPs) is very imperfect. The CEPs are clearly indicated in eight of 12 graduating attributes [Jian, 2013]. It is pertinent question to ask, “where do our graduates lack the ability to solve the CEPs?”. The methodology to solve CEPs must be constructed on analysis with the help of in-depth engineering knowledge. The possible reasons could be but not limited to following:

- Lecture delivery technique.
- Easy, simple exercises in textbooks
- Verifying of theory by conducting experiments
- Growth in number of students and decrease in workstations which results in imparting less hands-on experience
- The declining quality of final year design projects and less interested students

The final year design project is a problem to be solved type of practice for graduate students before they sent to work, to prove that they have obtained all the attributes which all the stakeholder wants to see in them. They earn all the graduate attributes education, training and hands on practices at the engineering institutes.

Rather than evaluating the students' cognitive knowledge, employers express concern about the graduates' lack of essential key skills. Among these required skills, problem-solving stands out as the most crucial (IET 2008).

Absolutely, engineering education aims to equip students with a diverse set of skills, including acquisition of knowledge, synthesis and reasoning, problem analysis ability for analysis of real-world problems. Through this comprehensive skill set, students would be well-prepared to tackle and resolve complex problems effectively. By combining their theoretical understanding with practical application, they can apply their expertise to real-world challenges and contribute to innovative solutions within their chosen engineering disciplines . These skills play a crucial role in shaping competent and resourceful engineers who can address the evolving needs of society and make a positive impact in the world. Let's see what we do in the classrooms where a well-structured problem is provided to students. Students use their learned skills: i) to known unknown parameter, ii) the unknown relations are converted to equations, iii) the equations are solved, jv) validate the values obtained to give appropriate solution to the CEPs. In the actual world, problems are not well structured, rather they are ill-structured, ill-defined, confusing and presenting conflicting scenarios. In fact, the problems are completely unexpected. Hence, classroom competence does not guarantee the capability of an engineering student in solving real-world problems (Jonassen et al. 2006).

Success in explaining real-world engineering problems depends on a combination of factors, including:

i. Practical Experience: Applying classroom knowledge to real-life situations and gaining hands-on experience through internships, projects, and industry collaborations is essential for developing problem-solving abilities.
ii. Adaptability: Multifaceted and dynamic real-world problems require engineers to be adaptive and flexible to new approaches.
iii. Collaboration: Engineers are meant to work in multi-disciplined teams, thereby their ability to collaborate and communicate ideas effectively is very critical for solving CEPs.
iv. Critical Thinking: Real-world challenges require creative and critical thinking to produce innovative and sustainable solutions.
v. Professionalism: Understanding of ethical considerations by adhering to the code of conduct is essential for successful engineering practices.
vi. Lifelong Learning: Since engineering fields are continually evolving fields, and a willingness to stay updated and continue learning is critical for continued success.

When classroom learning is combined with practical exposure and fostering these added attributes can produce well-rounded professionals with the capability of addressing real-world challenges and hence will contribute meaningfully for their field and society at large.

1.2. Ill-structured problems

The classroom problems apply some selected fundamental principles that are methodically prognostic (Jonassen 1997). Exactly, ill-structured problems are characterized by their vague and loosely defined nature, with unclear objectives and constraints. Unlike well-structured problems that have a clear path to a single solution, ill-structured problems offer multiple possible solutions and solution paths. In this situation, it is difficult to deduce a methodology for proper actions or development of interrelations among scientific principles used. For the purpose of assessment, the students have to cross check the problems against the principles of science and engineering. Another thinking is that the contemporary engineering curriculum scheme would never enable engineers to solve ill-structured, complex engineering problems. The second component in transfer of knowledge from the content of courses to students is the lecturer (Teacher). In a study the lecturers' perception of CEPs was identified; it was observed that the concepts of around 59% of teachers lacked clarity about the CEPs regarding the traits of graduates as mentioned by the WA (IEA 2015). The lack of clarity may have resulted in students not fully grasping the intricacies and significance of these attributes in the context of real-world engineering challenges. It is essential for educators to provide clear and comprehensive explanations to help students understand the relevance and application of these attributes in tackling complex engineering problems effectively.

2. Methodology

The author visited five (5) public sector and private universities to search for the understanding of complex engineering problems. The purpose of this qualitative research was to explore how teachers and students comprehend their world. The adapted research methodologies were case study, interviewing, literature survey observation, document analysis and so on.

Interviews were conducted to assess understanding of respondents. Sometimes researchers need to explain the questions what information is required. The interviews were time consuming, therefore, focus groups were selected for interview as the approach for this kind of study. The focus groups interviews were conducted among civil engineering, electrical engineering and chemical engineering educators and students who agreed to become part of the current study. The focus of discussion was their understanding about CEPs and how do they attempt to solve the problems. Their teaching experience varied from 4 to 12 years. Table 3 shows some details of the teachers involved in this study. The data was analyzed quantitatively by using the method as introduced by Mills and Huberman, (1994). The data was processed in three stages.

Table 3

Details of the research respondents

Participant	Department	Teaching Experience years
A	Chemical Engineering	4
B	Chemical Engineering	4
C	Chemical Engineering	12
D	Civil Engineering	4
E	Civil Engineering	4
F	Civil Engineering	12
G	Electrical Engineering	4
H	Electrical Engineering	4
I	Electrical Engineering	12

i. Data reduction. The data is reduced by discarding irrelevant points. However, it was ensured that the original raw data to be available when required.

ii. Data display. To draw conclusions, the data was tabulated, and other graphical formats were used to identify patterns.

iii. Conclusion, After the conclusion was drawn, it was verified from the data collected.

In this study, the responses were displayed in a table for their understanding of CEPs and the results were evaluated through data.

2.1 Results Demonstrations

Table 4 displays the results of understanding of complex engineering problems among teachers. The attribute stated the maximum times is that in-depth engineering knowledge is required to solve the complex engineering problems.

Table 4

Responses of teachers

Participant	Response
B	No single solution, requires depth of knowledge
C	To solve the CEPs, we need to have a basic, deep root knowledge.
D	Required to utilize all the technical knowledge learned, not just from a specified course.
E	Multi solution due to complex activities involved
H	Various problems are integrated with environmental local conditions

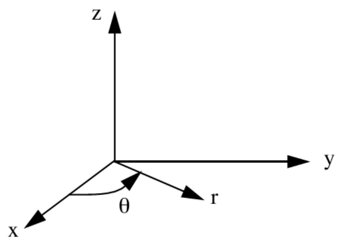
Table 5

Few examples of CEPs with the attributes present in the given CEPs

Sr. No.	Complex Engineering Problems	Complexity Level	Comments / Discussion
1	An incompressible fluid is flowing through a control element of lengths dx, dy, dz with the inlet velocity components u, v, w in x, y, z direction respectively. By the law of mass conservation, it is found that the rate of change of field variable as recorded by an observer moving with the flow is [$D\rho/ Dt = -\rho\ (\nabla\cdot v)$] (i.e.,	(Level 4) Depth of Knowledge Required	This is the simple example of a complex engineering problem from the Fluid Mechanics course. This requires the depth of knowledge of fluid mechanics

Equation of motion/Navier-Stokes Equation). You are required to Solve the Continuity equation and equation of Motion in Cylindrical and Spherical Coordinates.

CYLINDRICAL COORDINATES



$$x = rCos\theta$$
$$y = rSin\theta$$
$$z = z$$
$$r = (x^2 + y^2)^{1/2}$$
$$\theta = Tan^{-1}(y/x)$$

and mathematics to find its solution.

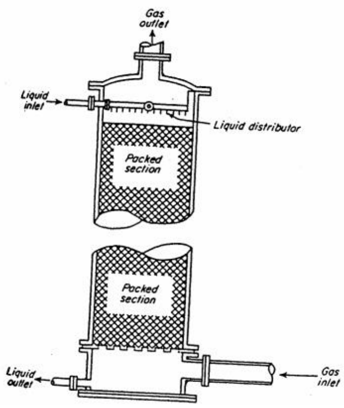
It is usually mis-concepts by most of the instructors that CEP must be a open ended type question (which don't have a single solution), but this is not always true for every situation because how can you expect a solution of open ended type CEP from the junior semester students because he/she do not have the knowledge of the core engineering courses. And this problem is an example of simple type of CEP which aims at the evaluation of depth of the knowledge of students from respective course. It will enable the students to solve (model) any problem in the different coordinate systems like in spherical coordinates etc.

2

The absorption towers are constructed with a vertically positioned cylindrical shell that contains packing material. In this setup, liquid is introduced from the top of the tower and moves downward, while gas is introduced from the bottom and moves upward through the packing. Two critical factors influence the absorption process within the tower:

i) The interfacial surface area per unit volume, which refers to the available surface area for interaction between the liquid and gas phases. The packing material increases this surface area, facilitating the mass transfer of components between the two phases.

ii) The mass-transfer coefficient, which represents the rate at which the mass transfer occurs between the liquid and gas phases. This coefficient varies based on two factors: physical geometry of the tower (i.e., the design) and the flow rates of the gas and liquid streams.



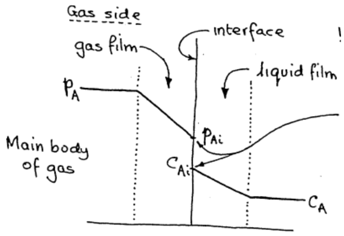
Say, the interfacial surface area per unit volume is 'a'. The interfacial surface area, and the mass-transfer coefficient

(Level 3)
Depth of analysis required

(Level 4)
Depth of Knowledge Required

This is another type of the CEP (open ended type) which we were talking about, it does not have a single solution. The solution of this problem will largely depend on the assumptions taken. Of course, every student will try to solve these problems as per his/her own depth of knowledge (concepts) of the course (it is related to Mass Transfer course). Its solution also depends on the analysis of the given situation. The values of the different parameters like mass transfer coefficients, hydrodynamics of the packed bed, type of packing, flow of fluids (solvent and gas) will determine the solution. Every student will take these variable as per his on thinking/analysis e.g., some students may take random packing and counter current flow of fluids etc., and selection of these parameters will make the solution different for every student.

are generally correlated as the volumetric mass transfer coefficient, $k_{C}a$. From the figure you may note that in packing materials of different types employed in the industrial towers, it is practically not possible to measure.



To solve this problem, students must possess the knowledge of different courses like fluid mechanics, mass transfer, mathematics etc.

A group of researchers found the correlation as given below for the (liquid-film) mass transfer coefficient in packed absorption towers:

$$\frac{k_L a}{D_{AB}} = \alpha\left[\frac{G_x}{\mu}\right]^{1-n}\left[\frac{\mu}{\rho D_{AB}}\right]^{0.5}$$

Following table will provide you the values of a and n required for above equation for various industrial packing materials.

Packing	α	n
50-mm Raschig ring	341	0.22
38-mm ring	384	0.22
25-mm ring	426	0.22
13-mm ring	1391	0.35
9.5-mm ring	3116	0.46
38-mm Berl saddle	731	0.28
25-mm saddle	777	0.28
13-mm saddle	686	0.28
76-mm spiral tiles	502	0.28

Considering the absorption of the sulfur dioxide with water at 294 K in a tower packed with 25-mm Raschig rings with liquid mass velocity G, = 2.04 kg/m^2- Sec, Determine the liquid film mass transfer coefficient. The diffusivity value of sulfur dioxide in water at 294 K is 1.7 x 10^{-9} m^2/sec

Another group of researchers found the absorption rate of sulfur dioxide (SO_2) in water,and it is found that at room temperature, 1 mL of water could dissolve 76 mL sulfur dioxide The solubility of sulfur dioxide in water is highly temperature dependent and is about 400 times more soluble at 273 K (228 g/L) than it is at 363 K (5.8 g/L). the following expression for 25-mm Raschig rings at 294 K

$$k_x a = 0.152\left(G_x\right)^{0.82}$$

where k_Ca is in kmol/m^3 - Sec and G, is in kg/m^2-Sec. For the conditions described in part (a), Estimate the liquid-film mass-transfer coefficient using equation B. Do you think there will be variation in the results obtained.

For knowledge's sake, it is good to know that the experimental work has be done to estimate the mass-transfer coefficient for their fluidized bed and a possible correlation is;

$$\varepsilon j_D = 0.333\left[\frac{\text{Re}}{\varepsilon(1-\varepsilon)}\right]^{-0.364}$$

$$j_D = \frac{k_L}{v_s}\text{Sc}^{2/3}$$

where Re is based on the empty tube velocity.

3

In the laboratory mixed flow reactor, when testing at a specific enzyme concentration (C_E), a harmful organic compound A found in industrial wastewater undergoes degradation into harmless chemicals due to the presence of a homogeneous catalyst, the enzyme E. The obtained results are as follows:

C_{Ao} (mmol/m^3)	C_A (mmol/m^3)	τ (min)
2	0.5	30
5	3	1
6	1	50
6	2	8
11	6	4
14	10	20
16	8	20
24	4	4

It is required to treat 0.2 m^3/min of the wastewater having C_{Ao}= 8.5 mmol/m^3 to 85% conversion with the same enzyme at C_E concentration.

a) One of the possibilities is to choose a tubular reactor (assuming ideal plug flow) with possible recycling of the outlet fluid. What do you recommend about the given design? Determine the size of the reactor, also find if it is feasible/advantageous to use with recycle, if so then determine the recycle flow rate in (m^3/min). Also draw your suggested design.

b) Alternative possibility is to opt one or two stirred tanks. What design of two-tank arrangement do you suggest, and how much better is it compared with the one-tank configuration?

c) To minimize the total volume of reactors required, which combination of plug flow and mixed flow reactors would you employ? Please provide a sketch of your recommended design, indicating the chosen unit sizes. It is essential to note that separating and recycling a portion of the product stream is not permitted.

(Level 3)
Depth of analysis required

(Level 4)
Depth of Knowledge Required

This CEP is of another type (it is related to the design of a reactor for a given reaction with given operating condition). It is also a open ended type question, because different options are given in the question and it is inquired to design an appropriate system which largely depends on the depth of knowledge about the respective course and analysis capability of the student. Every solution given by the students will be considered as feasible solution but the excellent solutions will be those which optimize the reactor volume with optimum operating conditions and maximum yield of the desired product. The analysis skill of the students requires that he/she has the knowledge of various other courses like fluid mechanics, reactor design, mathematics, thermodynamics and mass transfer (for heterogeneous systems only).

From our experience we can say that the CEPs are not simple and easy to understand. To solve, in fact, some searching skills to get compulsory info are required. As these are not simple problems, therefore, there is no specific way to solve them, and no specific course can help. CEPs are real life problems, the solution must comprise of technical, ethical, approaches to reach conclusions. There is no single solution possible. In real life sometime, an engineer has to work on a problem knowingly that early attempts have not been successful.

2.2 Students Perception About CEPs

The most important skill which engineering students should have is Complex Problem-Solving skill [World Economic Forum, 2016]. Therefore, it is required that the students understand and practice using recent tools. The habits of critical, creative out of the box thinking, will lead students to solve complex engineering problems at the tertiary level of education and further after that. The engineering students are obligatory to have problem analysis, operation and evaluation skills to deal with complex problems [Funke and Frensch. 2007]. Therefore, students are put to face and practice open-ended learning, goal-based scenarios, and problem-based learning [Helmi et al, 2016]. These are all ‘should be’ things, practically, to evaluate what students perceive about CEPs, a survey was conducted among the engineering students of a higher education institute. The participant students were from 6th and 8th semesters of various departments as given in table 4.

Table 6

Participants in the survey

Department	Participants
Electrical	16
Civil	28
Chemical	38

The understanding of students is given in Fig. 1. The students from chemical, civil and electrical engineering from 6th and 8th semesters were asked to participate in the survey. 71% of the students from 6th semester were afraid of CEPs. The results were verified through the data and learned that the fear of students was due to less awareness about the problems and the approaches which could be made to solve these problems.

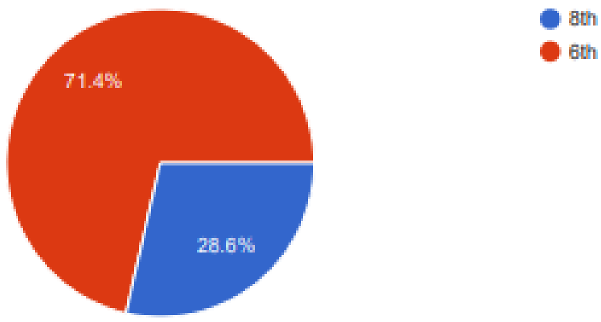


Fig. 1. Awareness of Students About CEPs

Three questions asked in the survey are given in Table 7. The student's response to the questions were various to keep this article simple and concise, the simple and appropriate level responses were selected and given below against every question.

Table 7

Responses to the questions in the survey

Questions	Response	
	Simplest	Appropriate
What is Complex Engineering Problem (CEP), Your views?	CEP is the high-level engineering problem. It includes all the topics covered in that specific course and need high knowledge to solve it.	A complex engineering problem is a challenging issue that involves many interconnected parts and requires advanced knowledge and skills to solve. These problems can't be easily solved with straightforward solutions and often require deep analysis, creative thinking, and expertise from multiple fields. They can include things like designing large structures, optimizing energy systems, or creating advanced technologies
How do you attempt it or what parameter you should consider to attempt it?	First, I understand the problem and I solve it in step by step	Understand the problem: Gain a comprehensive understanding of the CEP, identifying key variables, constraints, and objectives. Break it down: Decompose the problem into manageable sub-problems to analyze individually while considering their interdependencies. Collaborate and research: Engage with experts, gather knowledge, and review existing solutions through research and collaboration. Iterate and innovate: Embrace an iterative approach, refining strategies based on feedback, and exploring creative and innovative solutions.
How could you have a better approach in solving CEPs or what can facilitate you in solving CEPs?	CEPs cannot be understood.	The better approach to solve the complex engineering problem is to read it first several times. Clearly define the problem at hand, generate a list of potential solutions to address the problem, evaluate and prioritize the various possible solutions, create a comprehensive and detailed plan for the most promising solution(s), re-assess the plan's desirability and effectiveness, proceed with implementing the chosen plan, verify and evaluate the results achieved from the implementation. To have a better approach in solving Complex Engineering Problems (CEPs), several factors can

	facilitate the process: Access to resources: Adequate access to data, information, research papers, simulation tools, Class slides, textbook, research different books related to the given problem

2.3 CEPs Cannot Be Understood

The better approach to solve the complex engineering problem is to read it first several times. Clearly define the problem at hand, generate a list of potential solutions to address the problem, evaluate and prioritize the various possible solutions, create a comprehensive and detailed plan for the most promising solution(s), re-assess the plan's desirability and effectiveness, proceed with implementing the chosen plan, verify and evaluate the results achieved from the implementation [7, 10] .

To have a better approach in solving Complex Engineering Problems (CEPs), several factors can facilitate the process: Access to resources: Adequate access to data, information, research papers, simulation tools, Class slides, textbook, research different books related to the given problem.

What happens when students see a CEP, they assume the problem is hard to solve and they give up. The problem can be solved (or can have a right approach to be solved) if students show a little bit of confidence and a little bit of persistence. It has been observed that reading a well-designed curriculum and mathematics will provide confidence that things given are not out of his/her domain. We also know that the more one struggles the more one comes to understand, so, persistence will lead to success.

3. Conclusion

A professional engineer should have the competence to work in complex and uncertain situations. The analysis of our classroom observations uncovered that assignments and projects are the most favorite assessment methods, but actual-world projects and assignments are not the same as we do in our classrooms. The goal of this article is to establish an understanding of the student’s level of perceiving a complex engineering problem with respect to the learning domain and to analyze significant factors to solve such a problem.

The instructions from course teachers can lead and facilitate students to develop the right approach to solve the CEPs. It was realized that educators need training to make complex engineering problems and then transfer the knowledge and technique to students so that they can develop the right approach to solve the CEPs. Industrial training (like apprenticeships), laboratory practices and final year design project are good tools for the complex engineering activities/ exercises. The approach used in this study contains limited quantitative measurements i.e. survey of three departments from an engineering institution. It is recommended to extend this study by using various engineering institutions to ascertain a framework on CEPs solving. skills.

This study shows a substantial difference in the perception level of CEPs between instructors and students. To reduce this gap, following steps should be taken:

i. Increase in practical problem-solving activities and project-based learning opportunities in the engineering curricula.
ii. Revamp the teacher training programs that should focus on developing strategies to enhance students' critical thinking and problem-solving skills.

4. Declaration of Interest Statement

4.1 No Conflict of Interest

The authors declare that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

4.2 No Funding

No funding was received for this work.

4.3 Intellectual Property

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

4. Research Ethics

We further confirm that any aspect of the work covered in this manuscript does not involve human patients. The authors declare that the data supporting the findings of this study are available within the paper, or data is available from the corresponding author on reasonable request.

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