Journal of Engineering Education Transformations,
Volume No. 37, January 2024 Special Issue, eISSN 2394-1707

Augmenting Engineering Pedagogy - Fusion of Practical and Theoretical Dimensions: Exploring Onsite Immersions

Harshavardhana [1], Dr.Jagdish. H. Godihal[2,*]
[1]Research Scholar, [2]Professor Civil Engineering, Presidency University, Bengaluru, Karnataka, India
[1]harshavardhana.20223civ0005@presidencyuniversity.in
[2]drjagdishgodihal@presidencyuniversity.in

***Abstract*—Contemporary engineering education faces multifaceted challenges, stemming from the dynamic essence of the discipline, the expanse of knowledge acquisition demanded of students, and the inundation of information availability. Nurturing well-rounded graduates necessitates not only a profound grasp of their chosen domain but also adeptness in troubleshooting complex issues. Synthesizing theoretical erudition, hands-on proficiencies, and computerized applications tailored to bolster diverse facets of projects—encompassing drafting, designing, tridimensional visualization, and analysis—constitutes a pivotal facet of the engineering curriculum. Noteworthy achievements have been recorded by individuals irrespective of their formal educational background, underscoring the potentiality of knowledge garnered from conventional schooling or alternative avenues. While the knowledge drawn from textbooks and didactic sessions falls under the aegis of theoretical comprehension, practical acumen is honed through immersive engagement with real-world predicaments. Both realms of knowledge bear significance, necessitating holistic appreciation. The principal objective herein resides in fortifying engineering students' grasp of their specialized subjects, achieved through hands-on pedagogical interventions. This endeavor probes the import of infusing interactive classroom engagements and pragmatic on-site sojourns into engineering training regimens, synergistically empowered by software aids. The vantage point embraced is that of the students, examining the perceived value of such integrated approaches.**

Keywords **- Cognizance; Graduates; Pragmatic; Problem-Solving and Theoretical Competence**
***JEET Category*—Pedagogy of Teaching and Learning**

I. INTRODUCTION

Innovations in engineering pedagogy involve seamlessly blending theoretical knowledge with practical applications. This fusion is exemplified through on-site immersions, creating an educational environment where students can bridge the gap between classroom concepts and real-world scenarios. This introduction sets the stage for a comprehensive exploration of how immersive experiences enhance the learning journey in engineering education. In the realm of engineering pedagogy, the traditional dichotomy between theoretical concepts taught in classrooms and practical applications in the field is being transcended. The augmentation of this pedagogical approach involves a deliberate fusion of theoretical knowledge and hands-on experiences, with on-site immersions playing a pivotal role. On-site immersions bring engineering education to life by providing students with the opportunity to apply theoretical concepts in real-world settings. Whether it's through internships, site visits, or collaborative projects with industry partners, these experiences immerse students in the practical dimensions of engineering.

This approach serves several purposes. Firstly, it enhances students' understanding of theoretical concepts by illustrating how they manifest in actual engineering practices. Secondly, it fosters a deeper appreciation for the interdisciplinary nature of engineering, as students navigate the complexities and challenges of real-world projects. Additionally, on-site immersions cultivate essential skills such as problem-solving, teamwork, and adaptability attributes crucial for success in the professional engineering landscape. As we delve into the exploration of this augmented pedagogy, we will unravel the impact of on-site immersions on student engagement, retention of knowledge, and the overall effectiveness of engineering education in preparing the next generation of engineers for the dynamic challenges of the modern world.

Engineering involves a methodical approach to satisfactorily fulfilling human requirements using resources and individuals. Science used to solely attract those with a passion for it, whereas engineering has traditionally been centered around meeting people's requirements. In engineering, art and practice are commonly employed. Throughout the last 200 years, there has been a growing dependency on science to comprehend the functionality of nature. Engineering has been a profession since ancient times and has been practiced for a significant duration. Engineers were the individuals recognized for constructing

[*]Corresponding author: **Dr. Jagdish. H. Godihal,** [2]Professor Civil Engineering, Deputy Dean-Academic Research, Presidency University, Bengaluru, Karnataka, India
Address: Department of Civil Engineering, Presidency University, Bengaluru-560064, Karnataka, India
(drjagdishgodihal@presidencyuniversity.in).

structures such as canals, dams, palaces, temples, roads, and other beneficial items. They provided aid and fulfilled the requirements of the people surrounding them. In previous eras, engineers commenced their participation in military affairs. They were responsible for constructing forts and war equipment. Since ancient times, people have been engaged in engineering, making it a longstanding profession.

For India to advance as a nation, engineering education is crucial and cannot be overlooked. This contributes to strengthening the industry and economy, ultimately resulting in an improved quality of life for the people. India's economy has experienced substantial growth due to this assistance. The nation's various educational initiatives have contributed to its advancement following the acquisition of independence. This development entails varying and enhancing its manufacturing output. Thanks to the skilled workers trained by the country's technological institutions, this becomes achievable. The presence of Indian engineers is required to cater to the expanding needs of IT, industrialization, and globalization. To cater to the growing demand for engineers, there has been a heightened emphasis on delivering comprehensive technology education to ensure a greater number of graduates in this field each year.

There are varying levels of engineering education provided in India. Engineering education is diversified, encompassing different tiers and levels. The areas emphasized within these encompass craftsmanship, diploma programs, various degrees, post-graduate studies, and research in specific domains. Nowadays, engineering graduates require additional qualifications beyond technical knowledge and problem-solving capabilities. This is achievable only if they integrate the theoretical module along with the regular practical exposure visits/ along as they offer hands-on experience, fostering a deeper understanding of concepts, enhancing skills, critical thinking, and problem-solving abilities, making learning more engaging and applicable to real-world situations. While knowledge is not tangible, its significance becomes more evident when we employ it in real-world contexts (Valencia, A., et.al, 2021). When you acquire theoretical knowledge without the application of practicality, you understand only the concepts without putting them into practice (Zhao Xinyan and Lai Meijian, 2020). The superiority of practical education lies in its ability to teach individuals about the practical applications and operations of various aspects and recent developmental trends in the engineering domain (Zhang Yan and Lu Rong, 2020). Currently, our education system is more inclined towards promoting theoretical classes along with practical learning. Many people are convinced that students benefit greatly from acquiring knowledge through practical application. The most effective way to learn is through the application of practical knowledge (Sghari, A. and Bouaziz, F., 2021). By engaging in practical activities and experiencing them firsthand, one can acquire vast knowledge and skills that cannot be learned through passive means. Throughout history, the trend of adopting this learning approach has been progressively on the rise. As we frequently emulate Western culture in all aspects, it was high time for us to replicate their schooling techniques as well. It can be argued that practical learning is beneficial since it empowers students to utilize their acquired knowledge in real-life settings. The significance of this can be likened to the two parts of a coin, and it is essential to grasp the perspectives from both sides of the spectrum. For mastering this blend, devoting time is needed to grasp how this technique is applied in a broader context and their operational mechanisms. (Yuan Zhang, 2021).

The professor's assistance is also vital in ensuring that the graduate is well-prepared for their future endeavors with a scientific approach. Familiarizing oneself with the present trends and progressions in engineering is an essential part of this preparation. Acquiring this knowledge will equip the graduates with the necessary tools to kickstart their professional careers in an intensely competitive society (Warhuus, J.P et. al., 2021). This article intends to examine and recommend a new teaching technique applicable to the current situation. Applying this method can equip engineering graduates with the ability to effectively address the practical issues they may come across in their professional paths.

II. METHODOLOGY

In this section, the integration of the newly proposed enquiry wheel framework into the engineering curriculum along with the vintage conventional methodology is recommended as a new technique applicable to the current situation with an inclusion of a case study.

a) Conventional Framework: The type is the current vintage methodology that has been followed in the engineering community. The framework is a one-man thought with the inclusion of theoretical and laboratory-oriented classes with the aid of textbooks/concepts. This type is only restricted to classroom sessions with no practical exposure to the development of recent trends across the globe. Fig.1 summarizes the one thought existing framework. The outcome of this framework is Exam-based where students are only results-specific.

b) Enquiry wheel Framework: Enquiry-based learning entails the amalgamation of practical and theoretical learning approaches. The process commences with creating the curriculum content for each semester and scheduling the classroom sessions. Further, the practical visits will be scheduled for the students to gain more insights, practical knowledge, recent trends and developments. Here, post visit, the encountered observations/ findings can be reflected on the scientific society in a positive way leading to wellbeing of the mankind and habitat. This framework equips & enables the students practically to accompany with the experts or industry professionals to visit a site after finishing each chapter or content. The Fig.2. represents the Enquiry wheel mechanism. Additionally, this approach incorporates both in-person learning and the acquisition of practical knowledge which the students can benefit from a flexible learning environment that promotes the development of thinking skills, as they are allowed to share their perspectives and engage in site visits for a more immersive learning experience.

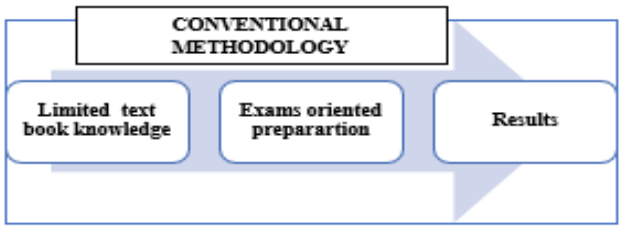

Fig. 1. Conventional Framework

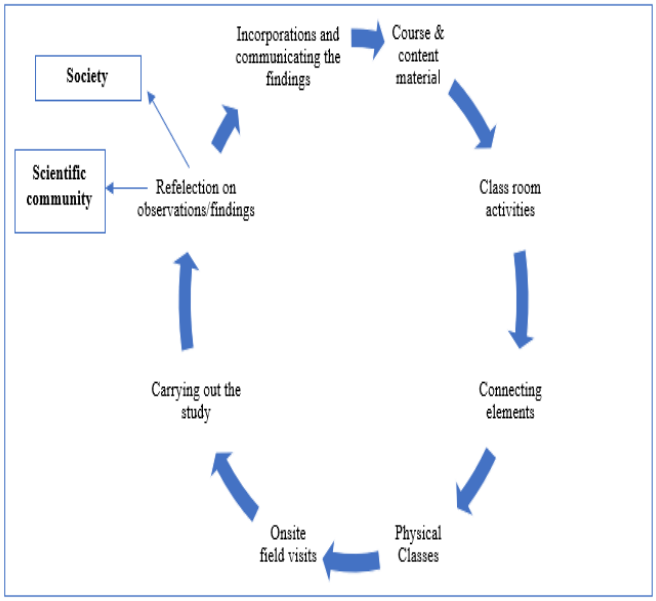

Fig. 2. Enquiry Wheel Framework

A. Facets de Enquiry learnedness

The consensus is that careful planning plays a vital role in connecting the knowledge acquired in the classroom with the practical aspects of learning outside of school. Enhancing student learning and understanding is achievable by implementing a combination of teaching methods, encompassing both traditional classroom teaching and teaching in different environments.

Below you will find a case study that how graduates can effectively enhance their teaching and learning by incorporating the enquiry wheel framework. At any time, they can come together and share their ideas, as well as engage in discussions, in a unified space.

B. Case study: "Approaches to integrating enquiry wheel learning into engineering curriculum".

The study was undertaken at the University, Department of Civil Engineering. This study has been carried out for 45 students, who undergone two courses, namely, Wastewater Technology with conventional approach and Solid Waste Management with enquiry wheel approach in 2022.The subject with enquiry wheel methodology was determined to be the more effective approach in both subjects after evaluating the results and the significance. The grades received by the students who decided to pursue Solid waste management for the semester amounted to 93% (Fig.3.). These students took part in both classroom sessions and field trips to a solid waste processing facility, Chikkaballapur. The people in charge and experts imparted practical knowledge to them, utilizing the machinery already available. Within this setting, students were taught the significance of observing things meticulously and the potential issues faced during treatment. The results marked 67% for the students who decided to specialize in Wastewater Technology. These students solely participated in classes and refrained from visiting the site. The outcomes we witnessed fell far short of our expectations as per the investigation wheel structure, referring to Fig.4. The comparison of the grades secured via applying both methodologies are depicted in Fig.5.

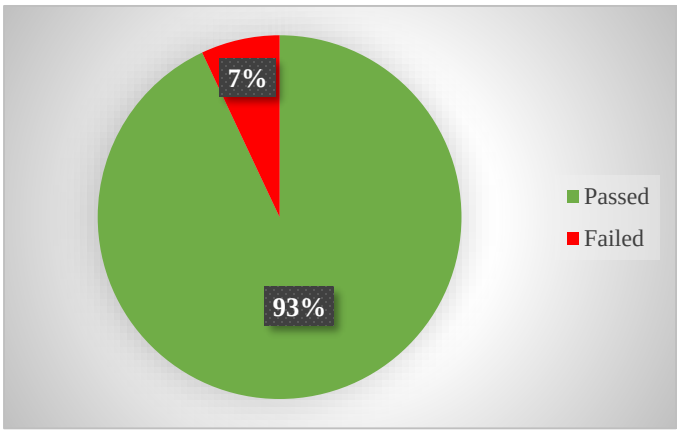

Fig. 3. Results of the students who opted for Solid Waste Management

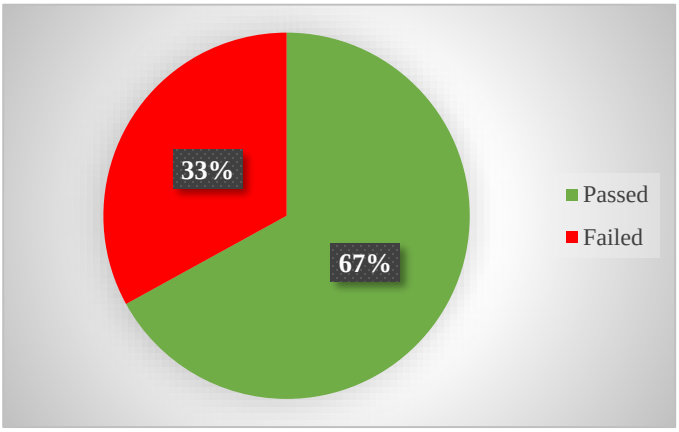

Fig. 4. Results of the students who opted for Wastewater Technology

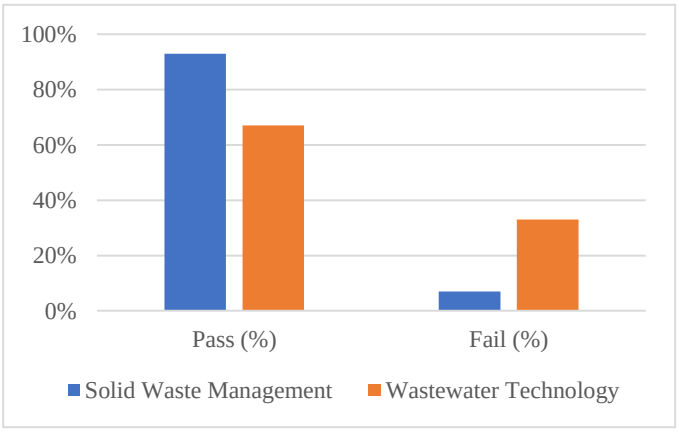

Fig. 5. Enquiry Wheel vs. Conventional Methodology

Interference: From the above study it was noticed that the students with enquiry wheel approach performed well with the following outcomes. The application of practical education enabled the students to better comprehend and engage with subjects that are challenging or uninteresting to them when approached solely through theoretical study.

• The importance of practical knowledge was deeply interconnected with the way real-life functions

• It supported them in getting prepared for the myriad challenges that life might present to them

• Moreover, it aided in the practical aspect of life and enabled them to exercise their decision-making skills.

III. Enquiry Wheel Approach to the Solid waste Processing facility

In this section, the detailed site visit approach has been explained, that how this led to such promising securing of grades by the students

A. Objectives of the Visit

1. To comprehend and effectively handle waste, specifically produced by households, and abide by waste management regulations and regulations about plastic waste management
2. Developing improved approaches in garbage collection, route planning for garbage trucks, and waste management strategies with an aid of math, science, and engineering.
3. To build compost systems and carry out the operations that facilitate the decomposition of organic waste and produce beneficial compost
4. Dealing with the establishment and maintenance of landfills, implementing waste-to-energy mechanisms, and supervising liquid waste management from trash.

B. Field assessment

1. General Information: A questionnaire was developed, and it is a useful tool for gathering information on solid waste management services. The survey was conducted to comprehend the existing methods employed for managing solid waste at the specific site. To achieve an accurately measured assessment, students were informed to complete the questionnaire by supplying all necessary information in the most comprehensive and precise way possible. The below-mentioned questionnaire and the tables were referred to and taken from the solid waste management Manual. The population scenarios along with the demographics were collected in the below depicted Table I.

TABLE I
NO OF INHABITANTS

CATEGORY	2011	PROJECTED 2022	PROJECTED 2028
URBAN POPULATION			
RURAL POPULATION			
TOTAL			

1.1 Who is overseeing the handling of the garbage? What is their preferred method of communication?

1.2 The size/area of land where rules/authority applies, measured in square kilometers:

1.3 No of Inhabitants:

1.4 Department responsible for solid waste management: Here basically the job roles of various verticals in the department are recorded.

(a) To get in touch with the Department, note down its name, address, and phone number.

(b) The individual in charge of the department can be reached at the given name and phone number.

(c) Name and details of the officer responsible for solid waste management:

(d) Function carried out by the Department

2. Blue Printing and Enhancement:

2.1 Physical characteristics of solid waste: The characteristics of solid waste that can be seen and felt are referred to as its physical attributes. It includes things like size, shape, weight, and texture. These qualities contribute to the distinguishing and organizing of different waste varieties. The varieties of characteristics can be noted in Table II.

TABLE II
PHYSICAL CHARACTERISTICS

Component	% By Weight
Varieties of components	

2.2 Archiving:

The waste stored in designated bins can be included in the below-mentioned Table III.

(1) Are there any rules stipulated by the Department regarding the appropriate way storage bins ought to be utilized? If it does, please give a short overview of the rule:

(2) Assorted sorts of bins for storing belongings:

TABLE III
TYPES OF CONTAINERS

Type of Containers	Domestic establishment	Commercial Premise
Individual Containers		
Communal Containers		

2.3 Collection: Whether collection service for households is available year-round. The coverage for collection services for businesses or shops for the year is collected in this section.

2.4 Disposal: The different approaches to eliminating solid waste are depicted in Table IV.

3.0 Operation: The Automobile Components and the Fundamental information are as follows and these will be collected by the students on site and depicted in Table V.

- Are there any plans in place to uniformize the vehicles and equipment utilized by the Department? If there is such a plan, can you provide details on how it is being executed?
- Do they have a dedicated space within the Department to fix their vehicles and equipment? In the event of an affirmative response, what is the procedure they follow in obtaining the components needed to rectify the issues? Generally, how long does it take for them to procure these parts? What methods do they use to monitor and control their inventory?
- The equipment for primary collection pertains to the instruments and appliances utilized in the collection of solid waste from residences and its transfer to a communal bin or depot. Subsequently, different vehicles are

responsible for gathering the waste

- **Landfill Management:** The Moving equipment employed in the solid waste management value chain is depicted in Table VI.
- **Procurement:** The materials required for the procurement for maintaining sustainable solid waste management are depicted in Table VII.
- **Additional Information (If any):** Problems encountered in solid waste management service. Please tick the appropriate spaces depicted in Table VIII.

TABLE IV
DISPOSAL

	Disposal Site		
	Site 1	**Site 2**	**Site 3**
Name of site			
Total area (ha)			
The year when disposal started			
Estimated life span remaining (year)			
Waste disposed (tonne/day)			
Distance from the collection area to the site (km)			
Disposal method (See notes below)			
Existence of animals on site	Yes / No	Yes / No	Yes / No
The existence of waste pickers or scavengers on site	Yes / No	Yes / No	Yes / No
The existence of open burning on-site	Yes / No	Yes / No	Yes / No

TABLE V
VEHICLES /LOGISTICS

Vehicle type	**No.**	**Av. Cap. cu.m**	**No. of vehicle by condition (See note below)**			**No. of vehicle by age (year)**			
Vehicle type									

TABLE VI
EQUIPMENT USED FOR LANDFILL MANAGEMENT

Type	**Numbers**	**Condition of the Machine**			**Age of the machine (years)**			
Bucket loaders								
If any								

TABLE VII
PROCUREMENT

Type	**Quotations**	**Model/year**

TABLE VIII
ISSUES ENCOUNTERED ON-SITE

Problem	**VS**	**S**	**NSS**	**NP**

4. Stake

(1) The revenue earned by the entity in charge of handling and disposing of garbage in a specific zone is depicted in Table IX
(2) The expenditure on the disposal and upkeep of garbage and waste in the nearby vicinity is depicted in Table X
(3) The human resource requirements are depicted in Table XI

TABLE IX
FINANCE

Revenue source	**Year before last**		**Last year**	
	Budgeted	**Actual**	**Budgeted**	**Actual**

TABLE X
OVERHEADS

Expenditure items	**Year before last**		**Last year**	
	Budgeted	**Actual**	**Budgeted**	**Actual**

TABLE XI
HUMAN RESOURCES

Officers	**Area**						
Total							

C. Outcomes of the visit

Here the students who attended the exposure visit were able to:

• Describe the distinct aspects involved in managing and eliminating garbage, as well as the corresponding guidelines that regulate this process
• Identifying optimal routes for waste trucks and the processes involved in treating solid waste
• Elaborate on the design, operation, and upkeep of distinct treatments
• Illustrate the procedure and practices involved in running and sustaining a sanitary dumpsite
• Identify methods for operating and maintaining an Incineration facility
• Provide an overview of the existing trends in solid waste recycling and repurposing
• Meeting and connecting with people in the field of expertise

IV. DISCUSSIONS

Theoretical and practical approaches reinforce each other. Practical education complements theoretical learning by enabling students to gain practical experience in the field. The acquisition of knowledge assists in grasping our existing knowledge, recognizing our gaps in understanding, and determining the necessary measures to reach our goals.

Both practical and theoretical approaches have their advantages and disadvantages. Knowing when to utilize each approach based on the specific situation holds great significance. Whether you should opt for a practical or a theoretical approach is contingent upon your goals and the specific characteristics of the problem at hand. By pondering over these disparities, we can decide on the most advantageous approach.

Here when we compare the approaches it can be easily observed that the practical approach with an inclusion of a theoretical approach yielded a better result. The key outcomes from assignment of the waste management study with and without site visit were as follows:

- **With Site Visits:**
  - ✓ *Practical Application:* Students gained hands-on experience in waste handling, disposal, and recycling through site visits

- ✓ *Understanding Local Context:* Site visits offered insights into the specific waste management challenges and solutions within a given community or region
- ✓ *Networking:* Participants were able to establish connections with industry professionals, fostering potential collaborations and job opportunities

- **Without Site Visits:**
- ✓ *Theoretical Knowledge:* Emphasis on theoretical aspects of waste management, covering principles, policies, and best practices
- ✓ *Limited Practical Exposure:* Lack of site visits resulted in a limited understanding of real-world challenges and practical solutions with which the percentile was on the lower end when compared to the enquiry wheel approach
- ✓ *Theoretical Framework:* Though the students developed a strong theoretical foundation but might struggle to translate this knowledge into practical applications

V. Conclusions

- Theoretical approaches were utilized by the students only to make sense of and provide rationale for the mechanisms governing phenomena and only for the exam purposes. The pass percentile was only 67%
- Practical approach generally placed a greater emphasis on site-specific circumstances in contrast to theoretical knowledge and was typically customized to suit specific situations or conditions. The pass percentile was 93%
- Upon evaluation, students have shown a preference and heightened engagement in a strategy focused on practical application rather than just theoretical learning
- It was observed that through practical approach, students were able to enhance their ability to think critically, analyze problems in depth, and generate viable solutions
- The acquisition of practical knowledge and skills enabled students to tackle challenges effectively in both their personal and professional spheres, fostering personal development and growth

Overall, the adoption of practical teaching has resulted in more positive outcomes compared to the traditional approach. Students have embraced it with enthusiasm, experiencing better results. While our research project has made strides in encouraging students to adopt a practical engineering mindset, it's still too early to definitively conclude its effectiveness. Continuing to implement and evaluate this technique is crucial to accurately determine its true impact.

VI. Scope for future:

The challenge of finding an effective teaching method adds complexity to the educational process. Schools and universities worldwide are embracing a variety of approaches to educate their students. There's a consistent need to discover and apply efficient teaching methods in the field of education. By blending theoretical lectures with hands-on activities, students on campus can gain from real-life experiences as part of their learning journey. Through consistent practice of problem-solving and active participation in practical education, students can enhance their learning experience, grasp new ideas, and nurture a deeper understanding of concepts. Teachers must give a great attention to translating their lessons into action while ensuring that students grasp both the theory and its practical implications. Practical activities and real-life situations serve as useful tools for students to put their lecture-based learning into practice. The purpose of these activities is to support students in gaining a deeper understanding of concepts, enhancing their proficiency in applying theories to real-life situations, and fostering discipline.

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