A PEDAGOGICAL APPROACH TO BRIDGING THE GAP BETWEEN HIGH SCHOOL AND NATIONAL INSTITUTE OF TECHNOLOGY STUDENTS IN ENGINEERING EDUCATION

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At Toyohashi University of Technology (TUT), undergraduate students are admitted either from high schools or Japan's National Institute of Technology (KOSEN). With a majority of students entering from KOSEN at the third-year level and one-fifth from high school starting from the first year, a learning gap is observed when these groups converge in the third year due to their differing educational backgrounds. To address this disparity, TUT introduced elective subjects called Introduction to Liberal Arts and Engineering and Science Literacy during the first and second undergraduate study years. This paper presents the subject's pedagogical design, which emphasize foundational engineering knowledge and skills through a project- and problem-based learning approach, parallel with liberal arts education. In the Introduction to Liberal Arts and Engineering and Science Literacy courses, foundational science or engineering-focused coursework, such as literature surveys, experimental design, teamwork, and scientific presentation, is assigned. Preliminary results indicate that the course enhances student motivation, critical thinking, and readiness, helping with both their integration with KOSEN students' future careers. This highlights the value of targeted pedagogical interventions in bridging educational gaps in engineering education.

Keywords: *engineering education, natural science, liberal arts, education gap, engineering science and literacy*

Introduction

Toyohashi University of Technology (TUT) has been actively collaborating with Japan's National Institutes of Technology (KOSEN) to develop a seamless educational pathway from KOSEN to TUT. In addition, TUT promotes global education initiatives aimed at cultivating adaptive, internationally minded global engineers and scientists (Tan, Lim, Umemoto, & Matsuda, 2015; Tan & Umemoto, 2021). Although most undergraduate students at TUT are admitted from KOSEN institutions, the university also enrolls students directly from high schools into its undergraduate programs.

Approximately 80% of TUT's student enrolments are from KOSEN. These students complete five years of KOSEN vocational education prior to enrolling at TUT as third-year undergraduate students. The other 20% are from high schools and enroll as first-year undergraduate students. Table 1 shows the pre-university education pathways for students from high school and KOSEN backgrounds. By the third year of undergraduate study (typically at age 21, assuming a standard progression), students from both paths converge into the same class. At this point, a gap is observed between those who entered from high school and those from KOSEN. Students entering engineering programs often face significant learning gaps in foundational subjects (mathematics, physics, and chemistry), which negatively impact their academic performance and highlight the need for targeted curricular interventions (Chaves, Moreira, & Camargo, 2016). As education at KOSEN is more focused on practical and specialized subjects, KOSEN students are better prepared for engineering education at higher learning levels compared to those from a high school background. The Model Core Curriculum is specifically designed to ensure that KOSEN graduates possess the specialized knowledge and practical skills required by society. This focus on developing competencies that align with industry needs highlights the specialized nature of KOSEN engineering education (Rashed, 2024). In addition, the KOSEN curriculum is also designed to provide a balanced education, combining specialized courses in engineering with general subjects such as social studies (history, modern society, introduction to philosophy, ethics, and law), music, art, health, and physical education (Araki, 2010). This results in a learning gap between high school and KOSEN students.

Therefore, there is a need to introduce coursework built around a pedagogy that can bridge the gap between high school and KOSEN students prior to their convergence in their third-year undergraduate classes, when they begin to focus on more specialized subjects at a higher intensity.

Table 1: Comparison of educational paths of high school and KOSEN students prior to enrolling in university (source:https://www.kosen-k.go.jp/en/nationwide/features ,accessed May 13th, 2025)

Age	High school	KOSEN
15	Enroll in high school (3 years)	Enroll in KOSEN (5 years)
18	Graduate high school	Continuous education at KOSEN
18-19	Enroll in university (degree; 4 years)	Continuous education at KOSEN
20	2nd year of university	Graduate from KOSEN (with an associate degree)
21	3rd year of university	Enroll in university (directly to 3rd year)
22	Graduate university with an engineering bachelor's degree	

TUT introduced new courses, Introduction to Liberal Arts and Engineering and Science Literacy, for first- and second-year undergraduate students. The aim is to induce awareness, scientific literacy, and soft learning skills that could be helpful not only in diminishing the learning gap between high school and KOSEN students in their third-year of study but also in the development of their future careers. This paper presents preliminary findings on the students' reception of and engagement with a newly implemented pedagogical approach designed to bridge the education gap between high school entrants and KOSEN students in an engineering program.

Materials and Methods or Pedagogy

The pedagogical approach was designed in direct response to an observed learning gap between students entering from high school and those transitioning from KOSEN institutions. While KOSEN students typically possess well-developed competencies in experimental design, problem-solving, and collaborative work, students entering directly from high school often lack the equivalent exposure. As a result, these students tend to demonstrate limited proficiency in core skills essential for engineering education, including research inquiry, critical thinking, teamwork, and scientific communication.

To address this disparity, the course employs a pedagogical framework that integrates liberal arts education with foundational science or engineering skills. This includes specialized modules such as Introduction to Liberal Arts and Engineering and Science Literacy, designed to build foundational skills in scientific reasoning, communication, and collaborative problem-solving. A central feature of the course is the implementation of problem- and project-based learning, which engages students in real-world inquiry requiring active investigation, peer collaboration, and interactive learning.

Through these activities, students develop competencies in conducting literature reviews, technical writing, formulating hypotheses, planning and executing experiments, analyzing data, and presenting their findings in a scientific format. Throughout the course, three lecturers (the authors) facilitate sessions, provide guidance, and monitor student activities and responses. The course was first implemented in fiscal year 2023 with 25 students, followed by 11 students in fiscal year 2024.

Results and Discussion

As part of the Introduction to Liberal Arts course, undergraduate first-year students with a high school background are introduced to familiar chemical compounds to stimulate curiosity about their underlying properties (Figure 1). Although students may have previously learned about carbon chain molecules in high school, engaging in more analytical discussions on the interactions between short- and long-chain carbon compounds facilitates a deeper understanding of their distinct physical properties, such as vaporization rates and boiling points. Through this process, students are encouraged to articulate their perspectives, fostering critical thinking and contributing to their cognitive development.

The aim of this course is to employ interactive learning methods designed to foster inquisitive thinking, with a particular emphasis on exploring the "why" and "how" behind chemical phenomena. This pedagogical approach aims to cultivate proactive learning and encourage independent thought. Notably, when the students recognize the learning gap between them and their KOSEN peers during their third-year undergraduate studies, this realization serves as a motivational factor, prompting increased engagement and active participation in class activities.

Figure 1: Interactive lesson designed for first-year undergraduate students from high school backgrounds to foster proactive learning and develop inquisitive thinking skills.

With an emphasis on problem- and project-based learning, an inquiry-driven teaching approach is used. The primary goal is to connect new concepts with students prior knowledge and familiar experiences, fostering critical thinking skills. This approach aims to

stimulate their natural curiosity and inquiry instincts, which will support their learning and adaptation in higher-level studies in different disciplines (Sánchez-Cambronero et al., 2021).

Meanwhile, in the Engineering and Science Literacy course that is offered to second-year undergraduates, students are given an assignment to design an experiment aimed at verifying the value of gravitational acceleration. The assignment requires students to develop a suitable experimental method, design and prepare the necessary apparatus in advance, and plan the implementation process (based on a method they deem fit and implementable during the class period). Subsequently, experiments are conducted during class under lecturer observation, as shown in Figure 2. After collecting and analyzing the data, they present their findings in a mock academic conference-style presentation (a lecture on the requirements for conference preparation such as literature review, abstract writing, and oral presentation is given beforehand). This hands-on exposure is intended to cultivate and equip them with an experimental mindset and help bridge the gap between them and the KOSEN students, who had prior experience conducting research projects at their respective institutions.

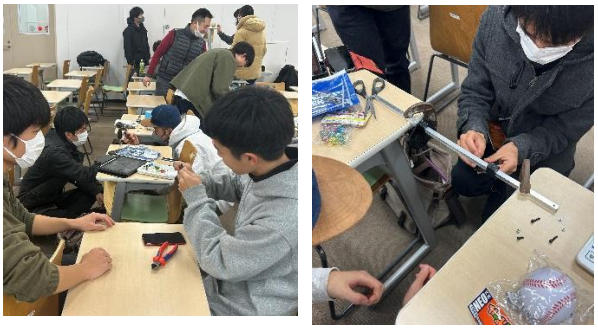

Figure 2: Students in the Engineering and Science Literacy course carrying out experiments to evaluate gravitational acceleration using the pendulum method.

Furthermore, a noticeable disparity exists between students from KOSEN and those from high school, particularly in the development of soft skills. It has been mentioned that the social skills of high school students are in decline, which suggests that they may experience a decline in certain soft skills such as assertiveness and peer relationship-building. This trend underscores the importance of integrating social skills training into the curriculum to address these deficiencies and support students overall development (Nishimura, Fukuzumi, Fujiwara, & Kawamura, 2018). KOSEN students typically engage in extensive hands-on technical training and collaborative experimental work throughout their coursework, which inherently fosters competencies such as open communication, teamwork, and leadership. In contrast, first-year undergraduates with a high school background were observed to possess poorer interpersonal dynamics and group coordination, due to a lack of similar exposure to collaborative learning environments and practical problem-solving contexts. These soft skills, however, are crucial for success in engineering education, especially in project-based learning and group-oriented tasks where effective collaboration directly impacts learning outcomes. Moreover, soft skills such as collaboration, leadership, problem-solving, critical thinking, and interpersonal communication are highly regarded by industry employers and could play crucial roles in students' future careers (Karimi & Pina, 2021; Munir, 2025). As subjects addressing soft skills in engineering courses are limited, their importance has led to their gradual incorporation and implementation in education (Almeida & Morais, 2023).

This gap highlights the need for targeted pedagogical interventions to support undergraduates with a high school background in acquiring these essential non-technical skills. In our pedagogical approach, the emphasis is on interactive learning activities, providing students with structured opportunities to communicate, engage in discussions, and draw direct connections to the subject matter. The participating students are encouraged to freely express their thoughts and perspectives, fostering an inclusive and participatory classroom environment. Therefore, this pedagogical approach not only builds confidence in public speaking and effective communication but also deepens students' understanding through peer exchange and collaborative inquiry (Liao, 2014). As a result, learners become more actively involved in the learning process, which enhances their critical thinking and promotes the retention of concepts, which are useful skills when they enter their third year of study. One study indicated that peer learning, communication and social bonding during team-based learning increase motivation and generate ownership of learning for students (Lysne et al., 2023). The active participation of students through peer-learning was observed to be effective in our class implementation, as shown in Figure 3.

In addition, it is essential to shift the educational paradigm from a solely knowledge-based approach to one that integrates pragmatic wisdom through critical inquiry and experiential learning. This shift can cultivate reflective thinking and interdisciplinary understanding, equipping students to navigate complex challenges both within and beyond the classroom (Spelt, Biemans, Tobi, Luning, & Mulder, 2009; Tan, 2022).

Figure 3: Students actively engage in interactive peer learning, which promotes active participation and fosters the development of social and communication skills.

This study is still on-going and the preliminary findings show that the students who undertook this subject showed high learning motivation and accomplished their assignments with distinction. These findings indicate the importance of integrating a constructive and innovative pedagogy that could bridge the gap between students from different backgrounds.

Conclusions

At TUT, an educational institution that admits undergraduate students from diverse background, such as high schools and KOSEN, there exists a notable gap between these two groups when they merge at a higher level (the third year of study). To address this disparity, this study proposed a pedagogical approach aimed at bridging the gap by supporting and developing students from a high school background.

The strategy includes the Introduction to Liberal Arts education and Engineering and Science Literacy courses introduced during the first and second years of undergraduate study. By implementing these measures, we aim to create awareness and bridge the gap between high school and KOSEN (college-level) engineering education, ensuring students are better prepared for advanced coursework. This awareness encourages proactive class participation and a stronger sense of ownership over their learning. This approach serves to level the academic playing field across diverse student backgrounds, fostering learning and the adoption of soft skills vital not only in students' engineering education, but also in their future careers.

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