

A Quantitative T-Shaping Method for Planning and Measuring Learning Outcomes in Interdisciplinary Engineering Courses

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Abstract: Interdisciplinary Engineering Education (IEE) empowers students to combine knowledge and skills from multiple disciplines within a cohesive, competence- and systems-oriented structure. The conceptual framework, grounded in modern industry requirements, emphasizes the importance of T-shaped engineers who possess both vertical and horizontal skills, forming the essential elements of the 'T' model. The vertical stroke in this blueprint represents the traditional technical disciplinary learning path that gets deeper with training, while the horizontal stroke represents interdisciplinary and multidisciplinary competencies that become broader with learning. Significant challenges exist in transforming traditionally mono-disciplinary learning environments in engineering courses to IEE. We develop a quantitative method based on experience to address the problem of maintaining a balanced, quality and benefit-oriented learning environment under the IEE precept without overtaxing the diverse student cohort. Graphical illustrations target synthesis of complex concepts into familiar representations for science and engineering audience. Bloom's taxonomy presents the foundation for evaluating the learning outcomes at each educational level through the categorization of cognitive skills, upon which the T-shaping concept is superimposed and elevated to a quantified form. The method is tagged iso-load and iso-cognition T-shaping (IIT) of learning outcomes. Sample case studies are utilized to reflect on the merits of the IIT approach.

Keywords:

Engineering Education, Learning Outcomes, Interdisciplinary, Bloom's Taxonomy, T-Shaping, Iso-load, Workload-neutral, Iso-cognition, Cognition levels, Study levels

1 Introduction

In 2006, the U.S. National Academy of Engineering identified fourteen grand challenges for the 21st century, emphasizing interdisciplinarity (upper Figure 1) [1]. Unlike the well-defined achievements of the 20th century (lower Figure 1) [2], modern challenges, such as making solar energy economical, require multidisciplinary contributions, reflecting the evolving nature of engineering education and research. Traditional engineering problems persist, but modern challenges require interdisciplinary expertise. Interdisciplinary Engineering Education (IEE) trains socially engaged engineers who work across disciplines, analyze, evaluate, and innovate [3, 4, 5]. Universities are incorporating interdisciplinary courses to prepare students for complex, collaborative projects [6], though challenges in delivering the associated competences remain.

Interdisciplinary learning integrates knowledge across fields, enhancing collaboration and critical thinking [7, 8]. It provides deeper understanding compared to multidisciplinary approaches, which combine fields without synthesis [9, 10]. Transdisciplinarity applies integrated knowledge to real-world problems, involving external stakeholders. IEE fosters innovation and solutions beyond single-discipline approaches [11, 12], despite resource constraints and unclear guidelines. The challenge of IEE is integrating expertise from multiple disciplines while emphasizing metacognitive skills like systems thinking and T-shaped competencies [3]. Systems thinking manages dynamic components, while T-shaped approach combines deep technical expertise with cross-disciplinary competences in critical thinking and communication [13, 14]. The authors have created interdisciplinary, project-based courses but faced challenges in balancing activities for meaningful learning. Planning IEE in terms of course outcomes remain underexplored and lacks optimization approaches in the literature.

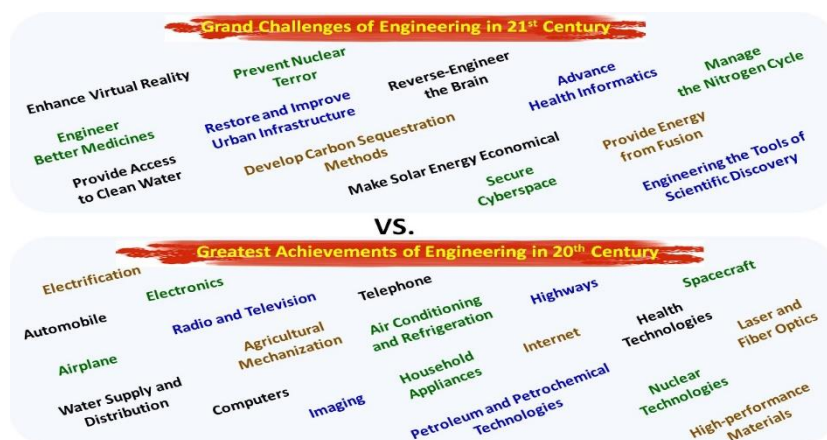


Figure 1 Grand challenges of engineering in the 21st century vs. greatest achievements of engineering in the 20th century – these are indicative of the higher-level drivers for engineering education.

This paper presents a quantitative approach to planning learning outcomes for interdisciplinary engineering courses, ensuring comparable workloads and cognition levels to traditional courses. Section 2 covers learning objectives, challenges, and Bloom's Taxonomy in IEE, including T-shaped competences. Section 3 introduces the Iso-load and Iso-cognition T-shaping (IIT) method with case examples. Section 4 summarizes the method, discusses outcome planning prerequisites, and offers recommendations for further development.

2 Background

2.1 Adaptation of Bloom's Taxonomy domains to engineering learning outcomes

Bloom's Taxonomy is a framework for developing learning outcomes with emphasis on subject expertise and cognitive depth [15]. It helps educators structure objectives and design assessments [16]. The taxonomy classifies learning into three domains — cognitive, affective, and psychomotor — each with increasing complexity, as shown in Figure 2. In engineering education, learning outcomes vary by course, often emphasizing higher cognitive skills. The taxonomy's levels are flexibly applied across educational stages (bachelor's, master's, PhD) based on discipline, with general trends shown in Table S1. Figure 2 illustrates these levels, highlighting shifts in emphasis at different stages.

Bloom's Taxonomy categorizes cognitive learning levels, but application varies across disciplines. Recognizing learning progression is essential in engineering education. As students advance, their cognitive, affective, and psychomotor abilities increase, promoting higher-order thinking. Historically, engineering education has emphasized 'hard' skills (Figure 2), with 'soft' skills integrated more recently to accreditation requirements [17]. However, affective and psychomotor outcomes receive less emphasis due to dense technical curricula, as represented by the illustrative distributions in Figure 3. Implementing complex cognitive skills in interdisciplinary courses is challenging due to diverse student backgrounds and learning styles.

2.2 Cases in point: challenges with diverse academic backgrounds in common interdisciplinary courses

This section explores challenges associated with the rise of interdisciplinary courses enrolled by students from diverse programmes, based on examples from our experience.

2.2.1 *What happens when electronics, programming, and motors converge in a single course?*

Embedded systems enhance everyday devices like cars, appliances, robots, and health devices. With IoT and smart technologies, expertise in embedded systems is crucial across engineering fields, including electrical, electronics, computer,

mechanical, biomedical, and robotics. These systems integrate hardware and software, typically around a microcontroller or microprocessor. As embedded systems courses, traditionally for electrical and electronics engineers, start including computer scientists and mechanical engineers, how should learning outcomes evolve?

2.2.2 What do engineers and health scientists have in common?

Modern rehabilitation and assistive technologies, like prosthetics and robotic exoskeletons, have revolutionized healthcare. Understanding their design, operation, and safety is essential. OsloMet’s ACIT Master’s programme now includes a course on these technologies, attracting students from engineering and health sciences. Given the diverse cohort, should learning outcomes focus solely on project-based teamwork, or are further adaptations needed?

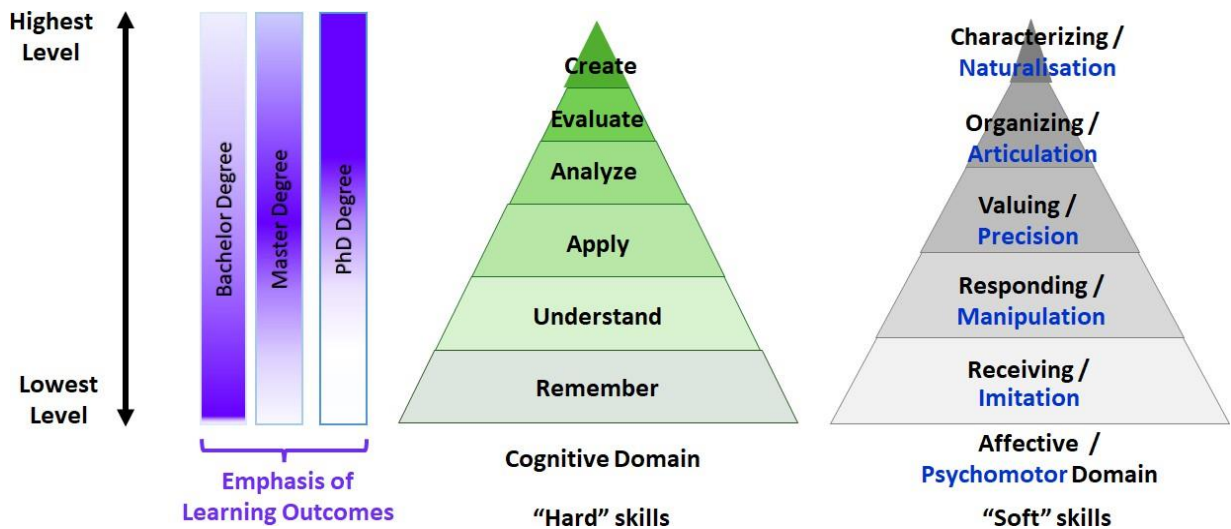


Figure 3 Bloom’s Taxonomy domains and learning outcomes – the purple-shaded area in the vertical bar illustrates the expected levels of learning outcomes typically observed in an engineering course with a uniform academic background, as is common in conventional mono-disciplinary programmes. Darker shades represent areas of greater emphasis, while lighter shades denote areas of lesser focus.

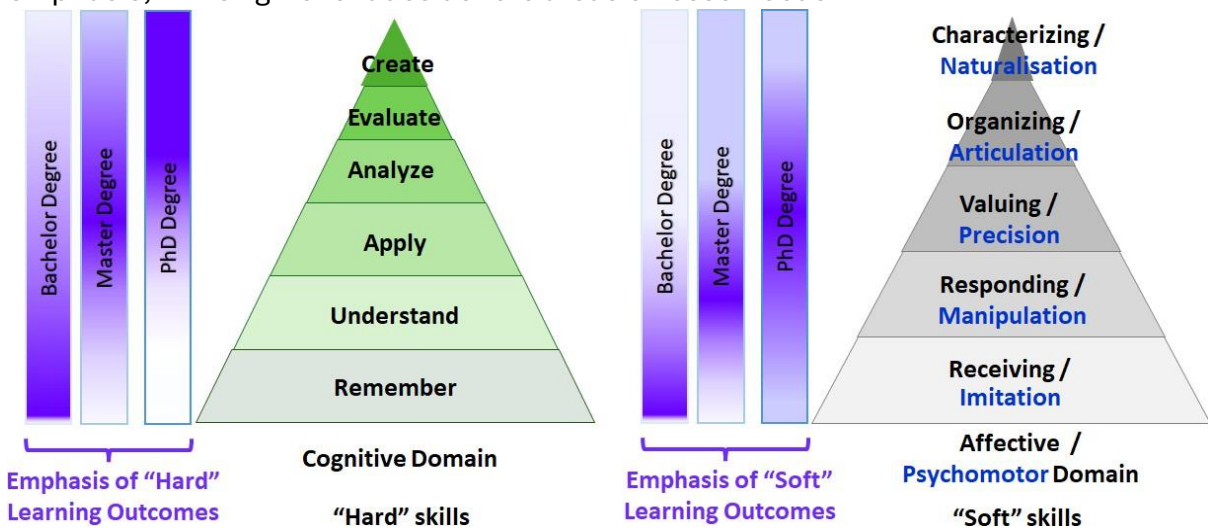


Figure 2 Differences in the emphasized levels of Bloom’s Taxonomy domains in traditional mono-discipline engineering learning outcomes – the emphasis on “soft” skills is typically significantly lower compared to the emphasis on “hard” skills.

2.2.3 How advanced can an “Advanced Topics in Biomedical Engineering” PhD course be with students from diverse backgrounds?

Biomedical engineering covers medical electronics, imaging, biological modeling, and medical devices. OsloMet’s Advanced Topics in Biomedical Engineering PhD course offers insights into diagnostics, organ modeling, and advanced medical equipment. Students from diverse engineering backgrounds often lack formal biomedical training. How should learning outcomes be structured to ensure all students attain advanced competences?

2.3 Factors influencing achievement at different levels of Bloom’s Taxonomy

Common factors for achieving cognitive skill development at different academic levels are:

- Prior knowledge: Students with stronger backgrounds in a subject progress faster but may need support in interdisciplinary integration.
- Interdisciplinary exposure: Familiarity with multiple disciplines enhances students’ ability to synthesize and evaluate concepts at higher cognitive levels.
- Teaching strategies: Active learning and project-based approaches involving multidisciplinary facilitate progression through Bloom’s Taxonomy, fostering interdisciplinary problem-solving [9].
- Collaboration and peer learning: Diverse academic backgrounds enable students to bridge knowledge gaps through teamwork.
- Course complexity and scope: Higher study levels (PhD) demand greater interdisciplinary depth compared to Bachelor level, making it challenging to balance foundational knowledge with advanced innovation.

2.4 T-shaped competency model

The T-shaped competency model in IEE balances depth and breadth, equipping engineers to tackle multidisciplinary challenges. An AACU survey highlighted a gap in ‘soft’ skills on the horizontal bar of the ‘T’ (Figure 4) [18], since delivering comprehensive competences in IEE is challenging. Programs like Business Engineering Technology and Engineering Leadership have been reported to support T-shaped engineers [17]. Rogers and Freuler proposed a general professional model for T-shape (Figure 5(a)), while Delicado et al. created a T-shaped competency model for the Spanish aircraft sector (Figure 5(b)) [19].

2.5 Revising an interdisciplinary engineering course for a cohort with different academic backgrounds

Teaching an engineering course requires foundational knowledge, typically ensured through prerequisites. In an interdisciplinary course for Discipline A (Students AA), students from Discipline B (Students BB) may lack this background, requiring a redesign of learning outcomes. Applying Bloom’s Taxonomy and interdisciplinary strategies

(Section S1.1) can help. The T-shaped competency model (Section 2.4) offers guidance, but two major difficulties arise:

Problem 1 - Overtaxing students: Failing to balance workload within credit constraints can overwhelm students.

Problem 2 - Failing quality targets: Overemphasizing fundamentals may disengage experienced students, while a fast-paced approach may hinder comprehension for others.

To address these issues, the next section proposes a quantitative method for designing course learning outcomes based on the presented challenges and framework.

Employers give college graduates low scores for preparedness across learning outcomes; students think they are better prepared.

*Proportions saying they/recent college graduates are well prepared in each area**

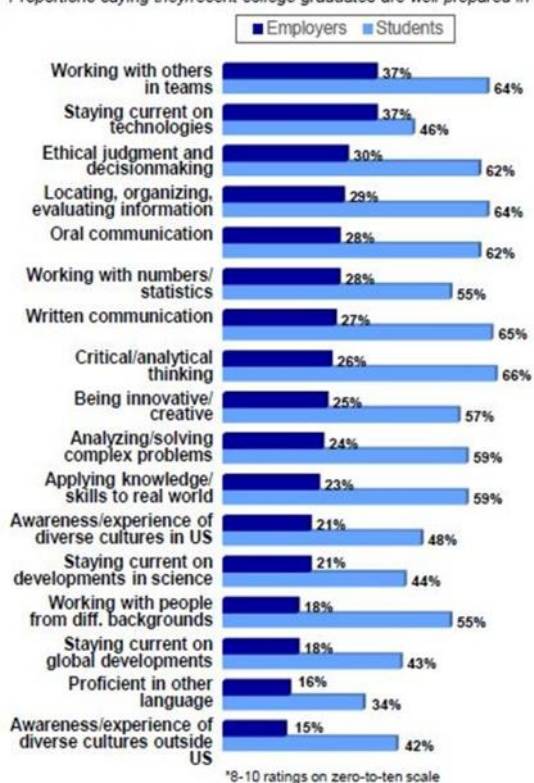
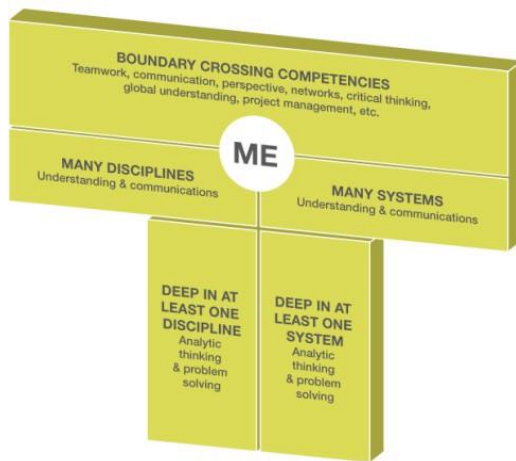
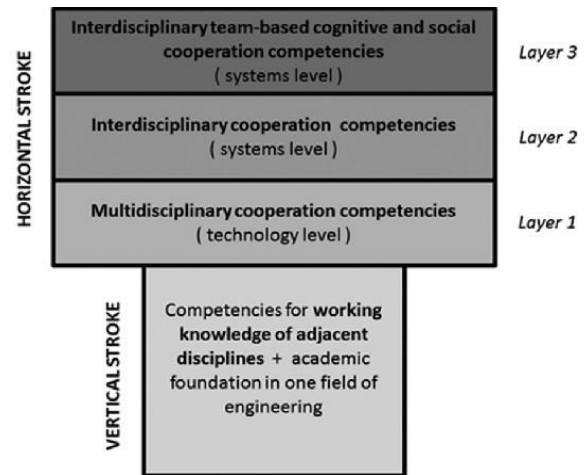


Figure 4 AACU survey of student career preparedness [18].



(a)



(b)

Figure 5 (a) A T-shaped professional model [17], (b) A T-shaped engineers competency model [19].

3 Iso-load and iso-cognition T-shaping (IIT) method

Key terms, “iso-load” and “iso-cognition”, are introduced to support a balanced method as part of a broader IEE strategy, using quantitative terminology and pictorial representations familiar to science and engineering community. The approach is then applied to different study levels, with challenging cases from Section 2.2 revisited to illustrate the concept through examples.

3.1 Inverted T-shape

The horizontal stroke of the T-shape represents introductory interdisciplinary knowledge and ‘soft’ skills with no prerequisites, while the vertical stroke involves deeper disciplinary expertise. Integrating Bloom’s taxonomy with T-shaped competencies, the ‘T’ aligns inversely with Bloom’s prism (Figure 6).

3.2 Iso-load optimization

Course workload is planned based on credits (ECTS in Europe or credit points in the USA), with each ECTS credit typically corresponding to 25-30 hours of work. For a 10 ECTS course, this results in about 13-16 hours of weekly workload, including lectures, reading, assignments, and assessments. When designing or redesigning interdisciplinary courses, maintaining a consistent workload is crucial. Increasing team project work or other skills should reduce individual assignments to avoid overtaxing students (Problem 1 in Section 2.5). The iso-load principle ensures a balanced workload, keeping the total hours constant as shown in Figure 7. The purple ‘T’ in the figure represents a fixed surface area based on the course’s credit assignment.

3.3 Iso-cognition optimization

The average cognition level in a course, based on Bloom's taxonomy, indicates learning quality and student satisfaction that aligns with educational objectives. Setting lower learning outcomes in interdisciplinary courses can reduce quality, as discussed in Section 2.5. While some concepts may not be covered deeply due to diverse backgrounds, other concepts without prerequisites can be targeted at higher Bloom's levels. Figure 8 illustrates iso-cognition optimization: maintaining average cognition (horizontal purple line) by adding a strong learning outcome (rightmost bar) while reducing depth in some topics. This keeps the center of mass (red dot) stable as the T-shape changes.

3.4 IIT concept applied across study levels

The method of T-shaping interdisciplinary course learning outcomes using iso-load and iso-cognition principles is shown in Figure 9. Unlike the I-shaped outcomes of mono-discipline courses, T-shaped outcomes reflect the cognitive, affective, and psychomotor domains. Darker purple shades in the figure indicate greater emphasis. The T-shape combines the cognitive and affective/psychomotor domains, balancing the total course load against I-shaped courses with the same credits. Any reduction in cognitive competency is compensated by higher expectations in the other two domains, maintaining overall learning quality.

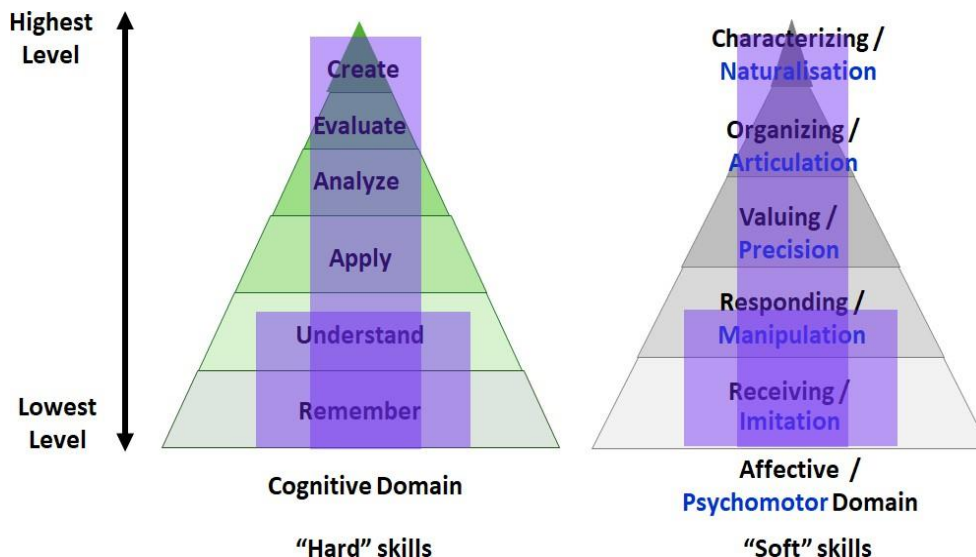


Figure 6 Inverted T-shape superimposed on Bloom's prism to indicate simultaneous consideration of both in optimizing course learning outcomes

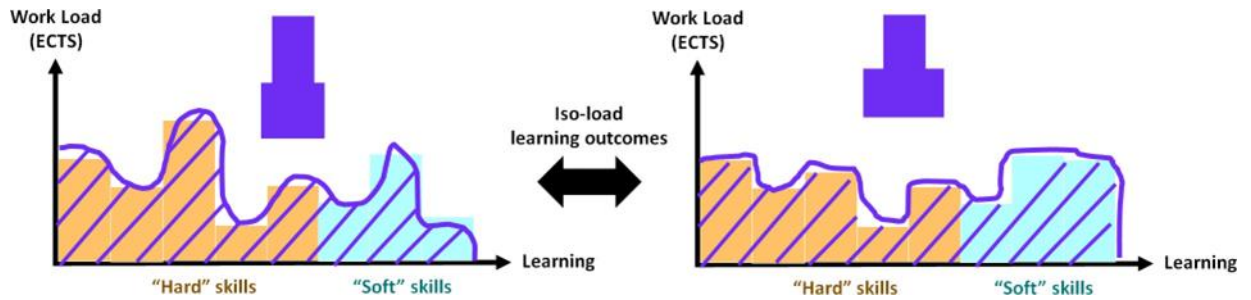


Figure 7 Illustration of two different course plans with iso-load optimization principle - shaded area under each curve is maintained the same.

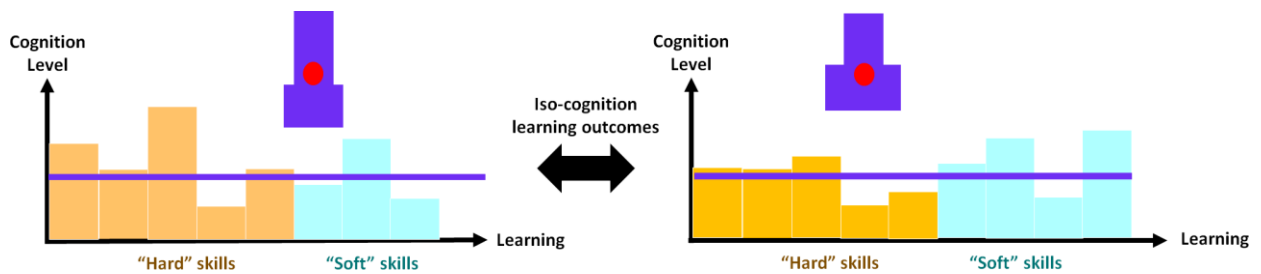


Figure 8 Illustration of two different course plans with iso-cognition optimization principle - the average target cognition level, represented by the dark purple horizontal line, is the same

3.5 Case Studies

This section addresses challenges from Section 2.2 by applying the IIT method to redesign interdisciplinary courses originally for Electronics Engineering students. Table 1 shows that diverse participants require adjusted learning outcomes and activities. Depth in disciplinary topics may be balanced with broader systems-oriented topics at a fundamental level, satisfying iso-load but not iso-cognition requirements. Thus, higher study levels must also adjust learning outcomes to include advanced affective and psychomotor skills, leveraging the multidisciplinary cohort.

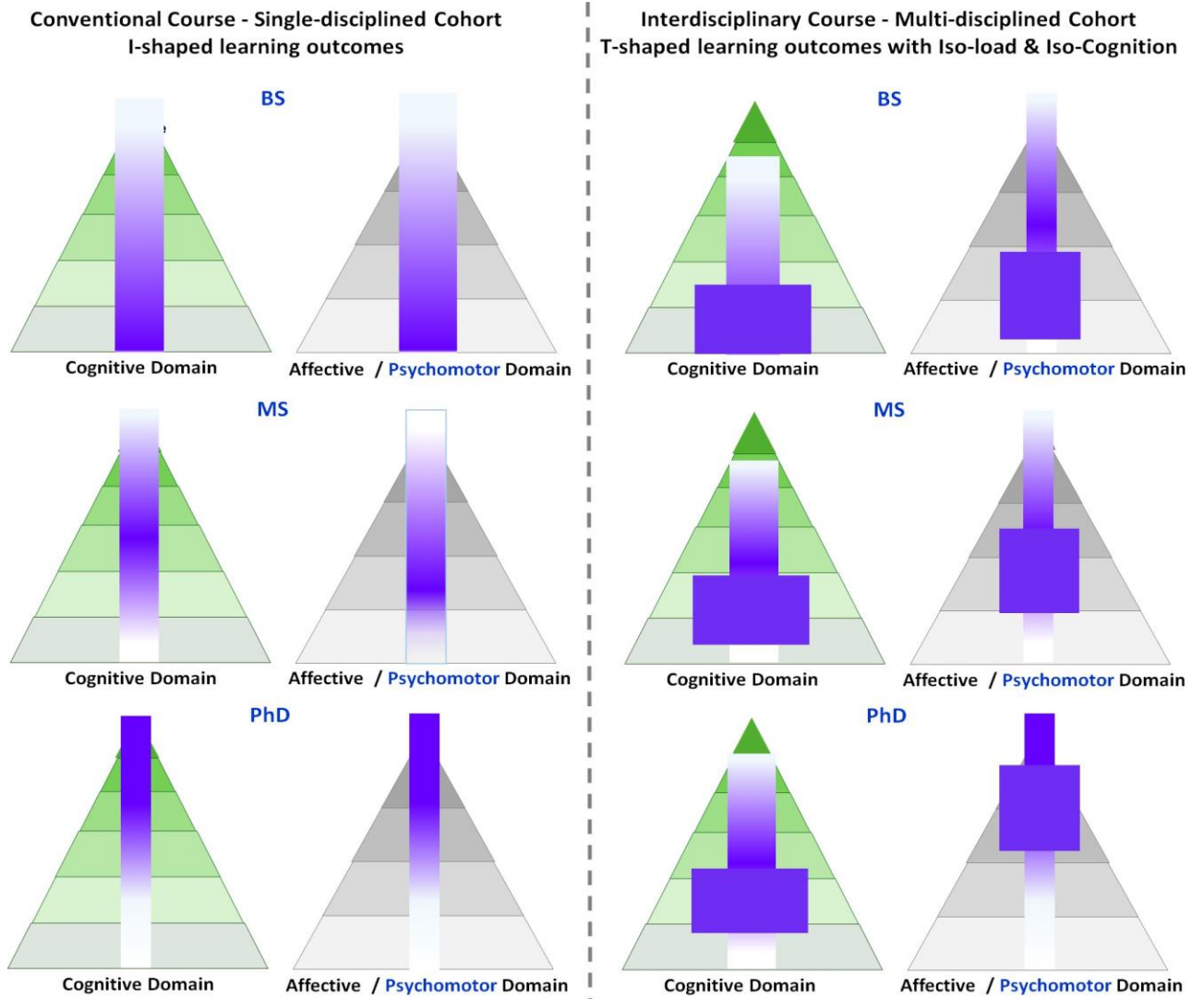


Figure 9 : Illustration of T-shaping Bloom’s Taxonomy-based learning outcomes using iso-load and iso- cognition principles in an interdisciplinary course with a diverse background of participants, in contrast to a conventional single-discipline I-shaped course.

Table 1 Applying IIT to sample OsloMet case studies originally introduced in 2.2 - a subset of the course outcomes is provided for clarity (significant differences between I-shaped and IIT outcomes are bolded).

Course	I-shaped Learning Outcomes	IIT Learning Outcomes	Comments
Embedded Systems (Bachelor's level)	Cognitive Domain: Understand fundamentals of microcontrollers Apply knowledge of electronics for advanced analysis of embedded hardware electricals Evaluate and design complex multi-tasked systems Affective / Psychomotor Domain: Receive, respond, value and articulate Teamwork	Cognitive Domain: Understand fundamentals of microcontrollers Apply knowledge for basic analysis of embedded hardware and software (electricals, thermodynamics, simple data structures) Evaluate and design simple multi-tasked systems Affective / Psychomotor Domain: Receive, respond, value and articulate using terms from multiple disciplines Cross-disciplinary organization and teamwork	IIT is applied to accommodate a student cohort with three distinct disciplinary backgrounds in electronics, computer and mechanical engineering (right) vs. electronics engineering only (left)
Rehabilitation and Assistive Devices (Master's level)	Cognitive Domain: Evaluate and characterize in detail complex mixed signal electronic components for a rehabilitation system Analyze and design electronic subsystems as part of an assistive device Affective / Psychomotor Domain: Clearly communicate precise specifications and functions Teamwork in a project lab setting	Cognitive Domain: Evaluate and characterize different aspects of a rehabilitation system Analyze an assistive system and its effectiveness in a patient care environment Affective / Psychomotor Domain: Articulate functions and usage models along with full system comparisons Cross-disciplinary team organization in engineering and health lab- oratories	IIT is applied to accommodate a student cohort with background in both engineering and health (right) vs. electronics engineering only (left)
Advanced Topics in Biomedical Engineering (PhD level)	Cognitive Domain: Apply advanced knowledge for critically analyzing and designing complex biomedical electronic circuits Affective / Psychomotor Domain: Disciplinary valuing, precision, articulation, organizing, naturalization, characterizing e.g. research and generation of a project report on a biomedical electronic subsystem	Cognitive Domain: Apply basic knowledge and new learning to critically analyze fundamental or representative complete biomedical systems Affective / Psychomotor Domain: Interdisciplinary and full system level valuing, precision, articulation, organizing, naturalization, characterizing e.g. research and generation of a fully rounded re- search project proposal on a new type of multi-function biomedical system	IIT is applied to accommodate a student cohort with mixed disciplinary backgrounds in engineering (right) vs. electronics engineering only (left)

4 Discussion and Summary

Engineering relies on quantitative analysis for objective decision-making, resource management, and quality improvement. Many universities use quantified metrics for quality management, aligning with international standards such as the Accreditation Board of Engineering and Technology (ABET). Given this quantitative focus, the authors, with backgrounds in electronics and mechatronics engineering, developed the IIT method to adapt interdisciplinary courses without sacrificing quality or student satisfaction. The method is effective, as shown in Section 3.5, though detailed data is pending. Two factors support continuing this approach:

I. Student Course Evaluations: Students from diverse disciplines appreciated the material and activities.

II. Instructor Reflections: Instructors reported increased satisfaction with learning quality.

Given engineering education trends and future challenges, developing higher-level 'soft' skills is vital to balance any gaps in 'hard' skills to achieve unique and relevant competence levels. However, applying the IIT method requires preparatory work.

4.1 Required prework for applying the IIT method

When designing a course, it is important to consider the ECTS credits, programme goals, and student environment, including educational traditions and priorities. Experience helps estimate the workload for an average student; if lacking, peer communication is vital. Interdisciplinary courses require additional planning before applying methods like IIT:

I. Evaluation of Student Academic Background: Evaluate the backgrounds of enrolled students and the disciplines involved.

II. Identification of Critical Learning Outcomes: Determine cognitive, affective, and psychomotor outcomes that are challenging and appropriate for the students' educational level and competencies.

The above steps improve workload estimation accuracy. Despite thorough preparation, instructors may still need to make assumptions. Therefore, early feedback and student dialogue are recommended to adjust learning activities as needed.

4.2 Summary

This work addresses designing learning outcomes for interdisciplinary engineering courses in today's evolving educational landscape. Diverse student backgrounds converge due to modern engineering challenges, necessitating new course designs. While literature on interdisciplinary education pedagogy exists, guidance on designing course outcomes for diverse students is lacking. A quantitative approach ensures consistent quality and effort from students. The proposed Iso-load and Iso-cognition T-shaping (IIT) method uses Bloom's taxonomy to grade learning outcomes, forming a T-shaped structure representing total student effort, fixed by ECTS credits. This is iso-load

optimization. Iso-cognition optimization maintains average competence across cognitive, affective, and psychomotor domains. Graphical representations are introduced in illustrating the method for science and engineering audience. Case studies from Oslo Metropolitan University illustrate IIT's application, showing re-optimization of learning outcomes for diverse students. The necessary pre-work for applying IIT is also discussed.

4.3 Future Work

The authors see value in further testing this method to gather data on its effectiveness. The goal is to track students from different disciplines through their studies and into their careers. A shorter study could follow senior bachelor's students into the workplace. Additionally, exploring the IIT method in non-engineering disciplines with diverse student backgrounds could be insightful.

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1 Supplementary Data

S1.1 Application of Bloom's Taxonomy across study levels in IEE context

IEE courses are typically structured for students with varied and similar academic backgrounds. The diversity in students' academic backgrounds can significantly impact the course delivery when aiming to achieve different levels of Bloom's Taxonomy as mentioned in Table S1. The interplay between students' previous knowledge and their capacity to reach higher cognitive, affective, and psychomotor levels of Bloom's Taxonomy poses unique challenges and opportunities at each educational level (Bachelor, Master, and PhD), as elaborated in the subsequent sections.

S1.1.1 Bachelor's Level of Education

At the undergraduate level, students are generally expected to master foundational knowledge and basic application of concepts, aligning with the lower-order cognitive skills in Bloom's Taxonomy: Remembering, Understanding, and Applying, which are typically covered by courses from the 1000-3000 levels. When students come from diverse academic backgrounds, they bring different perspectives that can enrich discussions and problem-solving approaches. For example, students from mechanical engineering might offer practical insights, while those from electrical engineering could provide a more theoretical understanding. However, students with varying levels of prior knowledge may struggle to meet baseline competencies in interdisciplinary courses. For instance, students with little exposure to programming may find it challenging to engage with courses that integrate software tools and hardware, thereby limiting their ability to achieve higher-order skills like analyzing or evaluating. Diverse academic backgrounds may also create gaps in the foundational knowledge required to understand more advanced interdisciplinary concepts. This can make it harder for them to grasp the material needed to advance through Bloom's Taxonomy effectively.

S1.1.2 Master's Level of Education

Graduate students are expected to achieve higher-order cognitive skills such as analyzing, evaluating, and creating. At this level, interdisciplinary engineering education becomes increasingly important, as students often need to synthesize knowledge from various domains. Diverse academic backgrounds can be advantageous here, as students are encouraged to combine their specialized knowledge with new interdisciplinary concepts to solve complex, real-world problems. The diversity in thinking allows for richer, more creative solutions and a deeper understanding of the connections between different engineering domains. For example, the master-level course ACIT4035, titled 'Rehabilitation and Assistive Devices,' is open to students not only from engineering but also from other disciplines, making it multidisciplinary. The course focuses on a project related to the design and development of specific assistive technologies. The diverse academic backgrounds of the students foster rich discussions around the project, addressing various aspects due to the variety of perspectives. However, this diversity also presents a challenge in achieving the higher cognitive

abilities expected in a master-level course (3000-4000 level). Students coming from different disciplines may struggle with the higher cognitive demands of interdisciplinary courses. This can slow their ability to achieve mastery in more complex tasks like creating new solutions or conducting independent research. While some aspects of the project create opportunities for certain students to master their previous knowledge in the evaluation and creation of assistive technology, diverse backgrounds can sometimes lead to uneven group contributions, especially in collaborative project-based courses. This can make it harder for all students to reach the evaluating and creating levels of Bloom's Taxonomy equally. Among the many challenges for such a course is the development of a syllabus that accommodates unexpected and highly multidisciplinary student backgrounds, faculty preparedness, assessment methods, and resource allocation, as discussed in Table S2.

S1.1.3 PhD Level of Education

At the doctoral level, students are expected to engage in creating new knowledge through independent research, involving synthesis, analysis, and evaluation at the highest levels of Bloom's Taxonomy. In an interdisciplinary context, PhD students can draw upon their backgrounds and merge knowledge from multiple disciplines to address novel research problems. The challenge of integrating concepts from different engineering fields pushes students to think critically, and exposure to diverse approaches can help them develop innovative solutions and contribute significantly to their field. At the PhD level, students are often expected to engage in complex, independent research that requires a high degree of interdisciplinary integration. Students from diverse academic backgrounds may struggle to fully integrate knowledge from areas outside their primary discipline. For example, a PhD student in electrical engineering might face challenges when working on a project that requires advanced knowledge of mechanical or biological systems. The need for both depth (specialization) and breadth (integration) can create difficulties in achieving the highest levels of Bloom's Taxonomy, particularly in evaluating and creating knowledge across disciplines.

Some of the previously studied general challenges in the delivery of IEE courses are summarized in Table S2, along with noted implications for learning and proposed solutions or strategies. To overcome these challenges, innovative teaching methods such as problem-based learning, project-based learning, and inquiry-based learning are employed to foster critical thinking, creativity, and problem-solving abilities. However, the literature does not discuss how to manage the total student workload and learning quality in such settings to optimize learning outcomes.

Table S 1 Mapping Bloom Taxonomy domains to academic study levels

Academic Level	Cognitive Domain	Affective Domain	Psychomotor Domain
Bachelor's Level 1000-3000-Level Courses	Focus on foundational levels: <i>Remembering</i> , <i>Understanding</i> , and <i>Applying</i> . Advanced courses may include <i>Analyzing</i> and <i>Evaluating</i> .	Emphasis on <i>Receiving</i> and <i>Responding</i> , with some development in <i>Valuing</i> .	Development of basic and intermediate skills, such as operating tools and conducting experiments.

Master's Level 3000-4000-Level Courses	Higher-order thinking: <i>Analyzing, Evaluating, and Creating</i> . Critical assessment and problem-solving are emphasized.	Focus on <i>Valuing</i> and <i>Organizing</i> , integrating professional and academic values.	Advanced technical skills, such as designing systems and conducting complex experiments.
PhD Level 5000-6000-Level Courses	Operates at the highest levels: <i>Creating</i> and <i>Evaluating</i> . Original research and new knowledge generation are key.	Emphasis on <i>Characterizing</i> — internalizing and exemplifying professional and academic values.	Mastery of specialized techniques, including developing new methodologies or tools.

Table S 2 Summary of challenges in teaching interdisciplinary subjects in engineering education [9] [20].

Challenge Category	Specific Challenge	Implications for Learning	Proposed Solutions / Strategies
Curriculum Design	Lack of cohesive content integration Misalignment with traditional engineering concepts	Reduced coherence for students Difficulty in applying knowledge across disciplines	Develop flexible modules Regular curriculum reviews for alignment
Faculty Preparedness	Limited interdisciplinary expertise Resistance to non-traditional topics	Reduced enthusiasm in teaching Potential knowledge gaps for students	Cross-department training Faculty collaborations
Student Role	Variability in student backgrounds Low initial interest in non-core subjects Lack of interdisciplinary understanding	Disparities in skill acquisition Potential drop in motivation	Interactive sessions Problem-based learning activities Developing student competencies to navigate interdisciplinary problems through specially designed activities
Assessment Methods	Difficulty assessing interdisciplinary knowledge Lack of standardized grading criteria	Inconsistent student feedback Complications in grading fairness	Rubrics for interdisciplinary tasks Mixed qualitative and quantitative evaluations
Resource Allocation	Limited funding for interdisciplinary tools Lack of lab space for non-traditional projects	Restricted hands-on learning Potential disengagement in practical skills	Prioritize resource sharing agreements Virtual labs and simulations