

JIGSAW OR SPIRAL? INDUSTRIAL/PRODUCT DESIGN COURSES COMPARED

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ABSTRACT

Industrial and Product Design programmes vary widely across national contexts, shaped by different educational traditions and institutional frameworks. However opportunities for systematic comparison remain limited, making it difficult to understand how students' learning experiences are structured internationally. This paper compares four undergraduate programmes from China, Türkiye, and the UK using a common course overview template. Two illustrative models are proposed: the *Jigsaw* and the *Spiral*. The jigsaw model, common in China, represents a stepwise acquisition of discrete skills in the early years, with integration only in later stages. The spiral model, typical in the UK, introduces core skills early on and develops them iteratively in subsequent years. Programmes in Türkiye demonstrate a hybrid structure, combining jigsaw-like electives with spiral-like iterations of compulsory design modules. The analogy provides a clear and accessible way to visualise programme structures. Feedback from educators indicates that the models help to clarify the distribution of learning outcomes and the realities of students' workloads, supporting reflection and the exchange of good practice in design education.

Keywords: Design Education, Industrial Design, Product Design

1 INTRODUCTION

Industrial Design and Product Design courses have matured through the last fifty years. For example, variants of the discipline most known as 'Product Design' are taught in over 80 undergraduate degrees at over 50 universities in the UK[1]. Industrial Design and Product Design are often used interchangeably in casual conversation or in specific contexts. Russell and Buck [1] find that in the UK it is possible to undertake a degree in 'Product Design' in no less than four designations: in Art (BA), in Design (BDes), in Science (BSc), and in Engineering (BEng). They made a diagram (Figure 1) to illustrate 'Industrial Design' and 'Product Design' on a scale of disciplines between art and engineering, and proposed to use 'Product Design' as a discipline to cover sub-disciplines Design Crafts, Industrial Design, Design Engineering, and Engineering Design. In recent years, some UK universities have replaced their 'Product Design' course with the title of 'Design', for example, Loughborough University offers Design BA; Brunel University of London offers Design BSc.

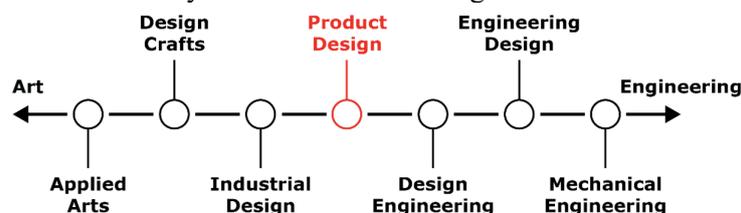


Figure 1. Typical understanding of 'Product Design' in the UK[1]

However, in China, Industrial Design courses are under 'Engineering Subject' and Product Design courses are under 'Art Subject'. Industrial Design courses in China require students to learn mathematics

and engineering; they lead to Bachelor of Engineering (BEng) degrees. Product Design courses in China often recruit students with an art background, and they lead to Bachelor of Art (BA) degrees.

In Türkiye, Industrial Design departments are mostly located under the faculties of architecture or fine arts at universities. Student are accepted through the central university entrance exam of Student Selecting and Placement Centre of Türkiye, and all industrial design departments admit students based on numerical scores, regardless of their subjects. Although there is no Product Design department in Türkiye, there are Industrial Design Engineering departments under the faculties of engineering/technology at three universities. The curricula under Industrial Design departments vary between universities, but generally they put design project modules at the centre. Additionally, depending on each university’s own tradition, the curricula may integrate art-focused courses (e.g., Mimar Sinan Fine Arts University and Marmara University) or technical courses (e.g., Middle East Technical University and Istanbul Technical University) in their four-year programmes. Although there is no clear requirement for the graduation certificates to state BA or BSc, it can be assumed that departments under the faculty of architecture award BSc equivalent and those under the faculty of fine arts award BA equivalent degrees.

In this paper, we consider both Industrial Design and Product Design (or Design) programmes, focusing on their shared modules and specifying distinctive modules wherever possible, in order to build a shared understanding of programme design and to compare patterns of teaching and learning.

2 FOUR UNIVERISTIES’ DESIGN COURSES COMPARED

Four universities (two in China, one in Türkiye, and one in the UK) are compared. The methodology of comparison is through using a common template to map out design undergraduate modules of each university. The mapping was conducted by the first four authors, all with more than 10 years of teaching experiences and significant teaching management responsibilities (e.g. as Head/Deputy Head or Deputy Dean), so they understand the course detail (including credits, teaching and projects) very well. After the mapping, the patterns were discussed and synthesised as models.

2.1 Xi’an University of Technology

Xi’an University of Technology has two undergraduate design programmes: Industrial Design (BEng), established in 1999, and Product Design (BA), launched in 2012; both with a four-year curriculum. The faculty of the Industrial Design Department is composed of 20+ full-time academics with engineering backgrounds (around 60%) and design backgrounds (around 40%). The department emphasises the integration of art, engineering, and technology in its teaching practices, fostering deep collaboration with industry, with three focuses: intelligent equipment, smart healthcare, and digital culture innovation. The BEng programme places a greater importance on skills relevant to intelligent equipment and smart healthcare, while the BA programme focuses more on smart healthcare and digital culture innovation. The educational objective of the department is to cultivate outstanding designers who possess modern technological proficiency alongside humanistic qualities. Its design curriculum is structured into four parts: general, design methods, skills, and design project modules. Both design programmes were recognised as Chinese National First-Class Courses in 2021 and 2022.

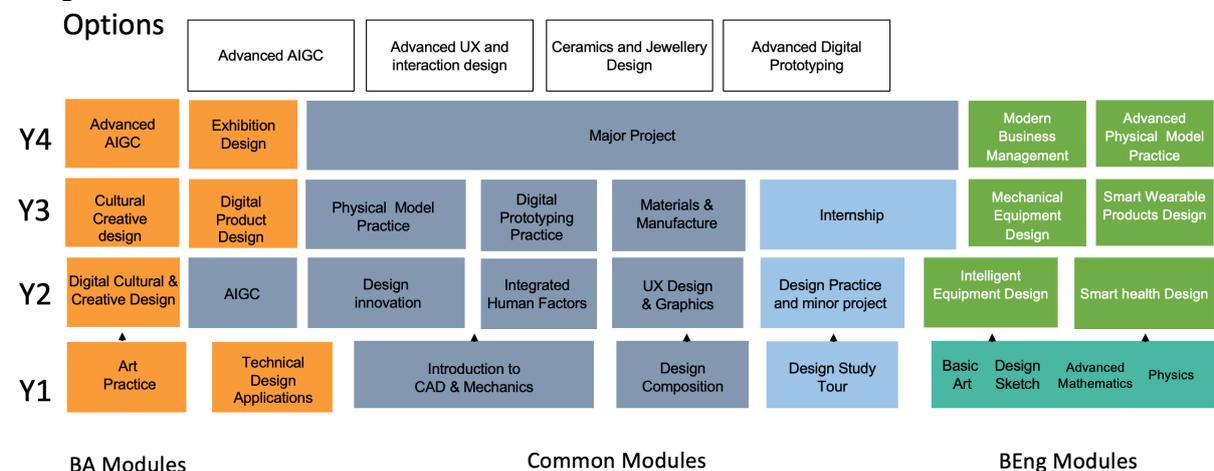


Figure 2. The overall structure of the Xi’an University of Technology’s design courses

Figure 2 gives an overview of its design courses. They aim to develop students' competencies in engineering technology, aesthetic appreciation, artificial intelligence, prototyping, and practical skills. Different knowledge and skills are prioritised in different years: Year 1 focuses on general/elementary art and design knowledge, Year 2 emphasises design methods and skills, Year 3 introduces prototyping, internship and design projects, Year 4 concentrates on graduation project (major project), and some students also conduct industry placement in this year.

The cultivation of practical design skills is achieved through a progressive participation model. In Year 1, a design study tour is offered, involving visits to relevant industries, manufacturing facilities, and design exhibitions to provide students with a first-hand understanding of the design profession. In Year 2, simple skill-based projects are introduced (e.g., Digital, Cultural & Creative Design), allowing students to integrate engineering and technical skills through design practice. In Year 3, students engage in design projects by working on industry-specific topics offered by academics, and participate in 1-3 month internships where they complete enterprise-assigned tasks on-site. In Year 4, students undertake their final year major project, independently completing it from research to prototyping, culminating in a public exhibition.

2.2 Wuhan University of Technology

Industrial Design teaching started at Wuhan University of Technology in 1987. Its Design School offers BEng Industrial Design, BA Product Design, and BA Interaction Design programmes. The Design School comprises 20+ full-time faculty members, with backgrounds in engineering (around one quarter), design (around half), humanities and social science (less than a quarter) and other backgrounds.

Figure 3 shows the overview of the Product Design and Interaction Design courses at the University. Its Product Design course focuses more on the study of tangible product design, e.g., knowledge related to product forms and hardware design, ergonomics and materials technology. The Interaction Design course emphasises more on the study of Advanced UX and interaction design, e.g., digital media software applications, user experience design, Augmented Reality (AR)/Virtual Reality (VR) technology and interactive animation. The two programmes share several common modules, including Design Aesthetics and Scientific Foundation in Year 1, Design Methodology in Year 2, and Service Design in Year 3 (see Figure 3).

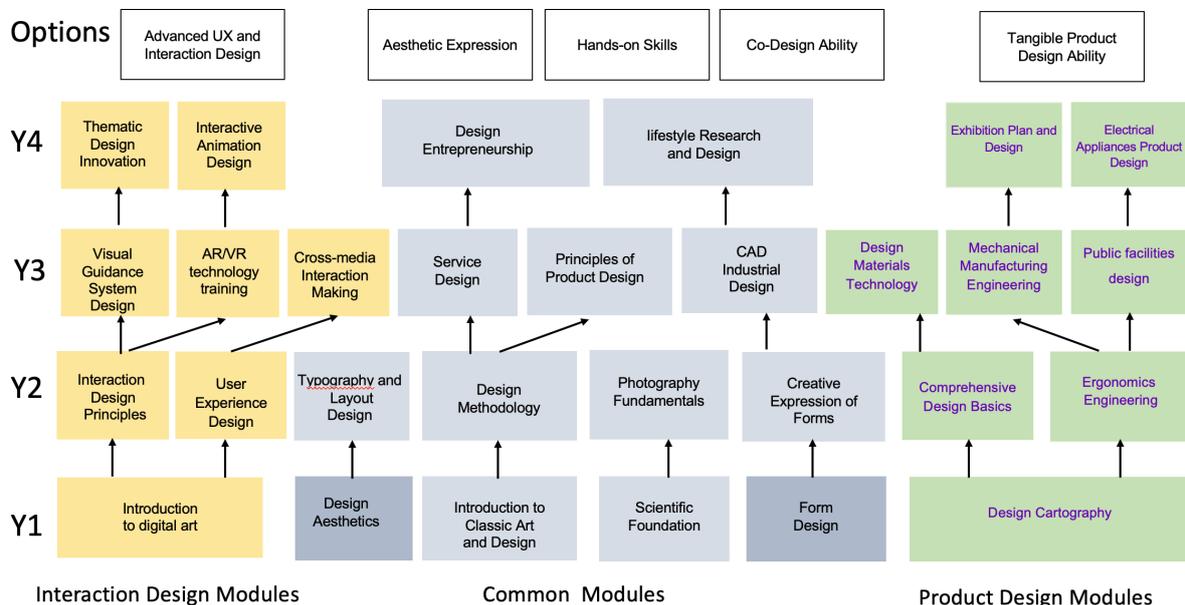


Figure 3. The overall structure of Wuhan University of Technology's Design courses

Its undergraduate design education mainly focuses on three aspects:

- Aesthetics: understanding how to perceive, express, and create forms.
- Design: theoretical knowledge and hands-on practice in product design (hardware and software).
- Teamwork: interdisciplinary collaboration to foster knowledge integration and innovation abilities.

Over the years, the design school has cultivated a large number of excellent design graduates, well received and widely recognised by industry.

2.3 Brunel University of London

Design undergraduate degree-level teaching formally started at Brunel University of London in 1985. The university offers BSc and BA design programmes. A major design course revision took place in 2020-2021, with a new BSc Design programme replacing the past BSc Product Design programme, and a brand new Master of Design (MDes) programme. The revised design programmes emphasise four aspects: technology, human-centred design, business and strategy, and sustainability.

Brunel's undergraduate design courses are accredited by the Institution of Engineering Designers (IED). These courses are taught by faculty members (with diverse backgrounds ranging from design, engineering, to physics, and computer science) and hourly-paid lecturers who are professional practitioners.

The overview of the design courses at Brunel University of London is shown in Figure 4. The 3-year courses offer a one-year placement/international exchange option, and the students choosing this option are recognised by their degree certificates (i.e., 'with professional development').

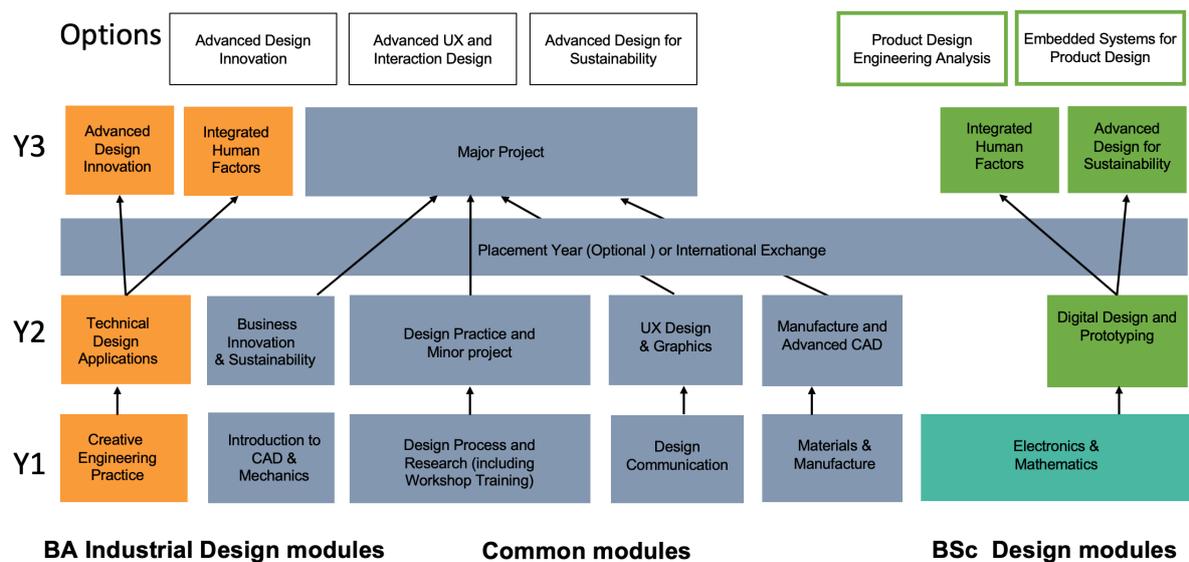


Figure 4. The overall structure of the Brunel University of London's Design courses

Students at Brunel learn Design Process and Design Communication modules (both are project-based) in Year 1, together with Introduction to CAD and Mechanics, and Materials and Manufacture modules. In Year 2, they study common modules Design Practice and Minor Project, and UX Design and Graphics (both are project-based), Manufacture and Advanced CAD, and Business Innovation and Sustainability. In Year 3, the students apply all the skills learned to their Major Projects, in addition to studying 3-4 more modules (some are project-based). Each year is like a cycle with a similar structure, featuring several projects – some involve industry or end users[2].

2.4 Mimar Sinan Fine Art University

Industrial Design teaching started in 1971 at the ISFA which became Mimar Sinan Fine Art University in 2004. Its Department of Industrial Design, part of the Faculty of Architecture, offers a four-year programme in Industrial Design. The department is composed of 10 faculty members and 5 research assistants with backgrounds in art, design and engineering, where the academics with an industrial design background account for 87%. Hourly-paid lecturers from industry also contribute to teaching. The industrial design curriculum comprises 75% compulsory modules (i.e. industrial design project modules, theoretical modules, and technical modules) and 25% of elective modules – these are industry sector-based modules (e.g., automotive design, display design and smart industrial products), CAD modules and other complementary modules (e.g., portfolio design and UX/UI design).

Figure 5 gives an overview of the Industrial Design course structure. The modules in the first year are for students to gain basic design competencies. In the second year, the educational approach centres around project modules, where industry partnerships are valued. Project briefs vary at levels from simple product requirements to product/service systems. 51% of the compulsory modules are taught in the first year, and elective modules are introduced in the second to the fourth year. Students can get help from

the academic advisor assigned to them in choosing their elective modules. In addition to the taught modules, students must complete two internships before graduation. Its Industrial Design curriculum is accredited by ENTAK (Industrial Design Accreditation Board) in Türkiye.

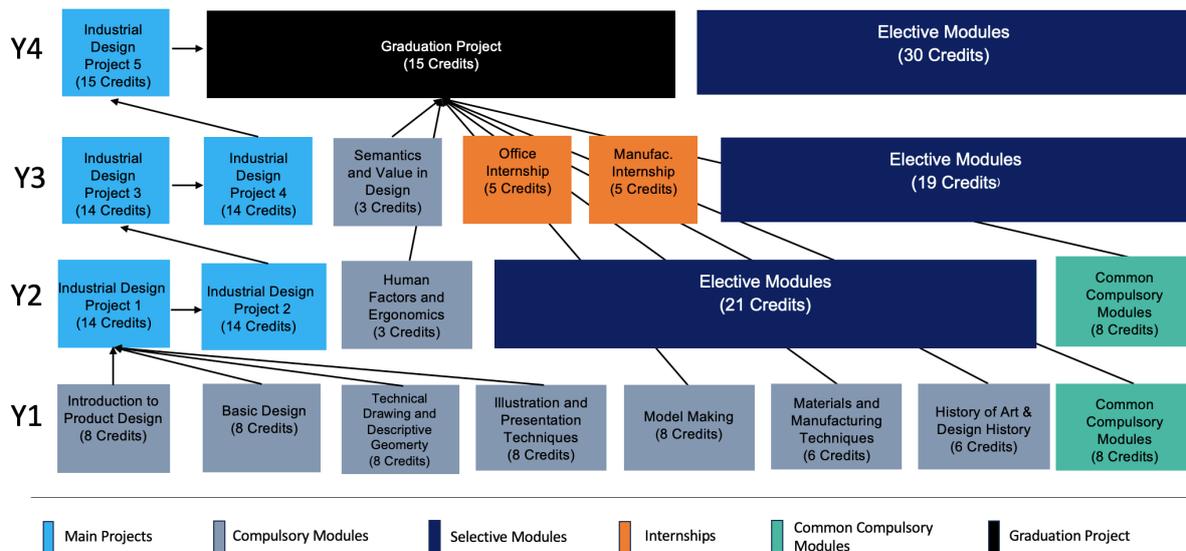


Figure 5. The structure of the Mimar Sinan Fine Arts University's Industrial Design course

3 MODELS: JIGSAW AND SPIRAL

Although Figures 2-5 appear to have a similar structure at the first sight, different learning patterns have been identified through comparison and discussion: the Jigsaw model and the Spiral model (Figure 6). The Jigsaw model describes the pattern of developing knowledge and skills piece by piece (from incomplete to complete, only see the big picture at the end), and the Spiral model illustrates the pattern of advancing knowledge and skills step-by-step (from lower level to higher level; each level itself is complete).



Figure 6. The Jigsaw Model and the Spiral Model

The design courses in Xi'an University of Technology and Wuhan University of Technology can be referred to as a Jigsaw model: students learn different skills (like 'jigsaw pieces') in each year, and they start to see the entire picture and acquire comprehensive design skills towards the final year. Students do not have design projects in the first year when they study theories and design fundamentals; they only do simple design projects (if any) in the second year. In the third and fourth year, the students are introduced to around 4-5 design projects (including the major project).

The design courses in Brunel University of London can be referred to as a Spiral model: students learn design skills in each year through a variety of design and technical module combinations, and they practise these skills through design projects. They have workshop training (in wood, metal, plastics, and digital fabrication) in the first year and use these skills throughout the three/four years. Each year their design skills are advanced through conducting multiple design projects (typically 2-4 projects per year), i.e., they develop their skills in a Spiral manner, iteratively advanced each year.

The design courses in Mimar Sinan Fine Art University can be seen as a combination of the Spiral model and the Jigsaw model. It is a Spiral as the students learn design knowledge and skills (75%, including model making) from Year 1, and advance their design skills year on year, mainly through Industrial Design Project modules, which become more complex as the student progresses. The elective modules

(25%) are more like a Jigsaw model, and they are pieced together one by one based on students' individual choices and the guidance of their academic advisor. Therefore, each student's individual competencies at graduation may vary.

4 MODELS COMPARED

The courses and the proposed Jigsaw and Spiral models are descriptive rather than prescriptive. Course design in each university has its own tradition, requirements, and restrictions. These models are not intended to suggest which design is superior; rather, they provide a framework to analyse course structures and to compare patterns of teaching and learning.

A semi-structured interview was conducted with six educators (lecturers and programme directors) from the UK and China to compare the two models. The results centre on the strengths and drawbacks of these models in relation to learning experience and learning outcomes.

4.1 Learning experience

Learning experience focuses on the process of learning. In the Jigsaw model, it was found that this more structured approach holds the potential to promote inclusive learning by supporting students who are less able to initiate self-learning; they will only need to follow the very clear guidance to complete the learning outcomes progressively. While the drawbacks can emerge at early stages, where a jigsaw module layout may lead to the risk of disconnecting theory from practice. Students may also find it difficult to locate the relevance of what they have been taught to design practice, which can further lead to demotivation.

The core strength of the Spiral model lies in that it can enhance learning by seamlessly connecting learning and application. The immediate application of knowledge can help students find the relevance to real-world challenges, which in turn enhance theory learning. Moreover, with learning complexity gradually increases, this model can also promote engagement by enabling immediate and tangible feedback (e.g., physical prototypes from course projects). However, the Spiral model introduces challenges at the early stages: students may struggle with design ideas and techniques before they have sufficient theoretical grounding, leading to potential confusion. With emphasis on project and practice based learning, it may also impose higher demand on students' abilities of transferring what they have been taught to application. Students might feel overwhelmed due to the breadth and integration required early on. Meanwhile, it can also challenge students' time-management and energy allocation.

In addition, from a teaching perspective, the Jigsaw model is considered easier to manage and adapt, as modules can be updated independently. Its structured nature provides educators with clear parameters, easing administration. In contrast, it was acknowledged that the Spiral model requires significantly more effort in teaching and coordination. It demands higher levels of expertise and responsiveness from teachers, as well as intensive programme-level coordination.

4.2 Learning outcomes

The Jigsaw model is deemed well suited to students who lack practical skills or who have weaker self-learning abilities. Its clear and modular learning structure help students build a solid theoretical base and professional literacy, supporting depth of knowledge acquisition. This can also benefit students with clear learning goals and support the cultivation of specialist expertise. However, the outcome might become narrower: students may have less awareness of transferable skills and lack exposure to a broader perspective, which can constrain their career development and leave them under-prepared if they move beyond design.

The Spiral model was highlighted for producing students with stronger competencies for real-world challenges. With the provision of all-rounded knowledge and skills, even at fundamental levels, it holds the potential of supporting students in developing a comprehensive 'big picture' understanding of design competencies, fostering professional awareness from the early stages of their educational journey. Early and continuous engagement in projects supports the timely application of theoretical knowledge, leading to improved problem-solving skills and practical ability. In comparison with the Jigsaw model, the breadth of integration of the Spiral can come at the expense of specialised depth; students may not always achieve strong technical mastery or focused expertise.

5 DISCUSSION

The Jigsaw model is common in Chinese product design programmes, while the Spiral model is common in English product design programmes, why? The cultural and education-historical contexts in China and the UK might have an impact on these. For example, design education in China started relatively late, and 1980s-2000s saw a rapid expansion of design schools. The early design courses in China were influenced by Soviet art and engineering models, and they were formalised after the 1978 economic reforms. Although some design courses also had influence from Germany or Japan, early Chinese design education was mainly influenced by the Soviet educational philosophies, the Bauhaus education system, and China's own crafts and arts education traditions. Today's curriculum structure (e.g., Figure 3) still has traces of the Soviet influence, i.e., the curriculum comprises general education modules, foundational modules, and specialised modules (from simple to difficult ones). Course design in each university follows a national guidance.

The Jigsaw model seems to be systematic and logical from the course design perspective. The advantage is that students will accumulate fundamental knowledge and different skills required for their future design work. However, from the learners' perspective, as it is difficult for them to see the whole picture in earlier years, they may encounter fragmented learning experiences. In addition, each module is generally taught independently by different lecturers who may not be aware of the connections with other modules. Therefore, a pressing challenge today of design course design in China is how to effectively strengthen the connections between foundational and specialised modules and provide a more integrated learning experience for students.

UK has been leading in design education. Its pre-1950 design education was rooted in the Arts and Crafts Movement and industrialisation, focussing on craftsmanship, material understanding, and bridging art and utility. Design education is offered in both art schools and technical colleges. In the 1980s, industrial design began to be taught in polytechnics (many later became universities). Universities have relatively good autonomy in designing their courses, and they generally use external and internal references (such as the Quality Assurance Agency for Higher Education – QAA and their own university's senate regulations) in designing courses. Courses are designed and revised with industry input.

The Spiral model allows students to develop industry-relevant skills step-by-step. Students are introduced to projects from Year 1, and they iteratively develop and advance design knowledge and skills in further years. The intense three-year programmes at Brunel University of London leave little space for elective modules in the first two years. With in this structure, the capability of planning and integration is often given stronger emphasis over other modular dimensions such as design expression and ergonomics knowledge, tendency noted in previous studies [4]. The students tend to have heavy workloads, and they often manage multiple projects – similar to a real-world situation. The Spiral approach therefore aligns effectively with programme restructuring initiatives that advocate for improving students' competencies to address real-world challenges [3]. As the learning outcomes are pre-defined (e.g., by the quality assurance bodies such as QAA, accreditation bodies such as IED, and university strategies and policies), they cannot be changed by lecturers individually. Most lecturers are aware of the learning outcomes of the programme and the connections between different modules. The common template used for comparison was initially developed at Brunel, and it illustrates the links of modules at different levels.

The four-year course in Mimar Sinan Fine Arts University seems to balance compulsory and elective modules well, offering space for students to choose modules and develop their unique knowledge and skills. Since the university has its roots as an art academy dating back to 1883, the teaching approach supports project-based design learning [5] which is mainly practical and one-to-one. However, because of the increasing complexity of the project briefs as the student progresses and the limitations of the realisation facilities/opportunities, the students generally stop their project work as a detailed conceptual design, which means that the course mainly focus on the first three phases of the double diamond design process [6], i.e., discover, define, and develop, without deliver. The curriculum is based on a large number of elective courses; this flexibility necessitates informed decision making, which the students may lack if they do not seek support from their academic advisors.

In summary, the Jigsaw model describes the pattern of developing knowledge and skills piece by piece (from incomplete to complete). Courses based on the Jigsaw model offers the student sufficient time (first year) to adapt to design, but students will only see the big picture in their final year. The Spiral model illustrates the pattern of advancing knowledge and skills step-by-step, and students learn design

from Year 1, developing their design knowledge and skills to higher levels year on year, but may struggle with heavy workload. The mixed jigsaw and spiral model as seen in Mimar Sinan Fine Arts University requires personalised guidance from advisors to students.

With the analysis of the strengths and weaknesses of different models, for future course design, we propose:

- Encourage exchange among different universities – the template we used in this paper may help facilitate visualisation and comparison.
- Balance compulsory modules and elective modules; provide students advice when needed.
- Monitor students’ learning experience and feedback to improve course design – the Jigsaw and Spiral models may help predict students’ learning experience but this needs to be verified by the learners.

6 CONCLUSIONS

In this paper, we compared four Industrial/Product Design undergraduate programmes from China, Türkiye, and the UK using a common template. Our original contribution is the proposal of the Jigsaw and Spiral models for analysing and synthesising product design course patterns. These descriptive models help explain how courses may be experienced by students and highlight their potential strengths and weaknesses. The conclusions are informed by the first four authors’ combined 40+ years of teaching experience, observation, and reflection. Future work should involve testing the models with students to explore how design knowledge and skills are acquired in practice.

The template can also be adopted by other universities to illustrate their course structures, facilitating comparison across institutions and cultures, and enabling knowledge sharing and the exchange of good practice. The Jigsaw and Spiral models may be further adapted to analyse course design, anticipate students’ learning experiences, or inspire educators to propose new approaches. Together, the template and models provide practical tools for comparing course design, sharing insights, and fostering learning from good practice.

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