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THE INFLUENCE OF TECHNOLOGICAL ADVANCEMENT IN FOUNDATIONAL STUDIES OF UNDERGRADUATE INDUSTRIAL DESIGN IN JAPANESE UNIVERSITIES

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ABSTRACT
This study aims to clarify how technological advancements have influenced the foundational studies of Japanese undergraduate industrial design education. Design is often seen as a bridge between technology and human needs, with human-centred design adding emotional and cultural significance to technological applications. However, while much research exists on the history and current state of design education, there is limited discussion on future trends, particularly regarding the impact of artificial intelligence. Most existing studies focus on single institutions, making it difficult to generalise conclusions about the evolution of Japanese industrial design education. Therefore, identifying trends and changes in education due to technological development is necessary for forecasting future needs.

Keywords: Industrial design curriculum, industrial design education concept, curriculum structure, technological development

1 INTRODUCTION
In recent years, the technological innovation of artificial intelligence (AI) has made significant progress. With its further development, the industrial structure and social structure are likely to undergo tremendous changes [1]. Industrial design (ID) has a deep connection with life culture. It is a mirror that reflects the society of that era and reflects people's values and industrial structure. As society changes, the content of ID education is expected to change. Therefore, the development of AI will inevitably have an impact on the field of ID. Education and industry development are interrelated. The disconnection between education and industry will cause "skill lag" [2]. Due to AI developments, Japanese university education has begun to integrate AI with engineering, design and other related field to develop programmes. Therefore, ID education will also be subjected to change. In any curriculum planning, it is important to identify the key fundamental knowledge and skills students required to study in a university programme. Some scholars proposed that the purpose of studying fundamental knowledge and skills in ID is not to learn design itself, but to master the basic skills necessary for design learning. What are fundamental knowledge and skills for studying ID? Will these fundamental knowledge and skills change according to technological advancements? Current available studies mainly focus on studying the ID education by focusing on a single university programme. Comparative studies to understand the general trend are few. The purpose of this study addresses that gap by examining how the study of fundamental knowledge and skills in Japanese undergraduate ID programmes evolved between 1970 and 2000. The findings will offer historical insights for future curriculum development of ID in the age of AI.

2 LITERATURE REVIEW
Education develops gradually, and historical exploration deepens our understanding of ID education theory. This section thus traces the historical development of the study of foundational knowledge in ID education. ID education can be traced its roots to the Bauhaus. When Bauhaus was founded in 1919, the first basic design course was initiated by Johannes Itten. Itten's basic course drew on contemporary educational reforms and integrated perception, and design ability [3]. He designated a six-month compulsory training period for all students, covering perception training, form and colour basics, texture, breathing, creative stimulation, and personality development [4]. Later, Moholy-Nagy and Albers evolved the course toward rational structures such as space, materials, and technology-expanding

foundational design education to encompass material exploration, spatial cognition, social awareness, and integrative thinking [5]. Developed through time, in 2006, Christian reaffirmed that basic design education remained central, covering elements like point-line-plane, space, rhythm, deformation, and ergonomics [6]. He later proposed a three-stage model-individuality development, knowledge acquisition, and planning capacity-emphasising creativity, expression, and technical tool use, aiming to build systematic thinking and project management [7]. In the digital era, traditional art-based training has been challenged. Norman argued for a new ID foundational studies should include behavioural science, experimental design, technical literacy, and business insight [8].

In Japan, Japanese design education after the second world war evolved under traditional craft influences and Western ideas, especially Bauhaus and Constructivism [9]. From the research related to "Kosei" published between 1932 and 1935, it was found that "Kosei" means a basic construction method of visual language, including organisational training of form, proportion, rhythm, and colour. [10]. However, postwar Japanese education often emphasised knowledge division and technical training while neglecting perceptual psychology and systematic composition [11]. As time goes by, the foundations of design education has gradually developed from emphasising the awakening of sensory language and the awareness of form creation to a teaching system with a progressive structure of "sensory awakening - sense of order cultivation - skill expression" [12]. Hino further proposed that the foundation of design education should focus on the comprehensive training process of creativity cultivation, expression technique acquisition and form sense cultivation [13]. In Loh's survey, it was found that the basic knowledge of design education in Japanese ID programmes is usually reflected in compulsory courses, and the contents of these compulsory courses can be divided into three categories: soft skill development, compulsory course content with the times, and courses that are constantly updated with changes in technology and industry [14]. Based on this section, it is assumed that the foundation of ID education is the knowledge and skills that all students must study as compulsory subject in the curriculum.

3 RESEARCH METHODOLOGY

3.1 Research Questions

1. How do the Japanese ID undergraduate programmes respond to the impact of technological change?
2. Have foundational studies in ID been redefined due to technological development?

3.2 Research Scope and Implementation

This study selected five representative Japanese undergraduate ID programmes in the University of Tsukuba, Kyushu University, Chiba University, Kyoto Institute of Technology and Tokyo University of the Arts as the research objects. When selecting these five schools, the key consideration is that the five schools show obvious differences in basic course settings, professional goals, curriculum structure and technology integration rhythm, which can provide a comparative perspective for the technology impact model under the coexistence of multiple paths.

This study uses a qualitative comparative case analysis approach to analyse curriculum plans and subject descriptions recorded in curriculum manuals and related literature between 1970 and 2000. First, the compulsory subjects in each ID programme, offered between 1970 and 2000 were systematically sorted out. The content of each compulsory subject was reviewed. Changes to the subject content due to technological influenced were identified. Based on the study of subject content, comparing key developments in the society at that time, the trends and characteristics of compulsory studies for ID can be clarified and hypothesised.

First, the documents of each university were sorted in chronological order according to available data, and then the compulsory subjects in the documents were extracted and the content of the compulsory subjects were recorded by year. Then, the composition of the compulsory subjects of the five universities at different time periods was compared. In addition, the total number of compulsory subjects offered in each year and the establishment, discontinuation and content change in each subject was also analysed.

4 FINDINGS AND DISCUSSIONS

In the data analysis, all courses were first categorised by technology absorption patterns: 1) Subjects that did not seem to be subjected technological influences based on subject content (NO); 2) Subjects whose content was not explicitly related to technological studies but content certain study of

technological development and techniques (Indirect); and 3) Subjects that are directly related to studying technological related techniques and theories (Direct).
The undergraduate ID programmes in this study may be categorised into three categories based on the history and educational objectives of the universities. The ID programmes in Tokyo University of the Arts and Kyoto Institute of Technology may be categorised as ID programmes in art-oriented universities. The ID programmes in University of Tsukuda and Chiba University may be categorised as ID programmes in comprehensive universities. Kyushu University's School of Design, formerly known Kyushu Institute of Design, started off as a university focusing on Design. The curriculum for ID on mechanical engineering, human factors, and engineering principles, showing a typical industry-oriented programme.

(1) Art-Oriented Universities

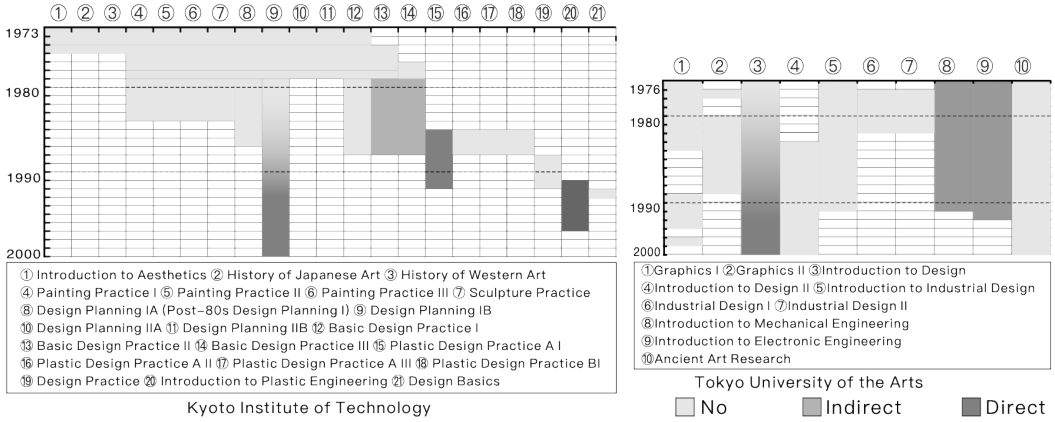

Figure 1.Kyoto Institute of Technology and Tokyo University of the Arts Compulsory Subject

As shown in Figure 1, in the 1970s, the compulsory subjects in Kyoto Institute of Technology and Tokyo University of the Arts were centred on perceptual training and artistic composition. The former emphasised visual expression and aesthetic understanding, and set up courses such as "Painting Practice", "Sculpture Practice", and "Art History", but had not yet introduced obvious technology related content; the latter focused on spatial perception and social function understanding. Although digital tools were not introduced, technical cognition was initially embedded through subjects such as "Introduction to Mechanical Engineering". In the 1980s, with the development of industry and electronic products, the compulsory subjects in these two ID programmes gradually infused technological elements. Kyoto Institute of Technology added courses such as "Design Planning" and "Form Practice" to strengthen system composition and spatial organisation. Tokyo University of the Arts introduced material and structure training on the basis of the original theoretical courses. In the 1990s, the compulsory subjects of Kyoto Institute of Technology became more flexible, adding system expression and task-oriented design capabilities. While Tokyo University of the Arts continued the gradual integration path of "culture-form-function", technology integration was still mediated by artistry, and the course structure was not completely reconstructed.
From the analysis, between 1970 and 2000, the compulsory studies in Kyoto Institute of Technology showed a trend of transition from art-oriented composition education to integrated training combining industrial functions and technical literacy, while the compulsory studies in Tokyo University of the Arts gradually evolved from "form-oriented" to "system understanding". These two ID programmes displayed a transition from the perceptual perspective to the multi-dimensional system of material exploration, spatial understanding and social awareness. These characteristics further showed that the foundation of ID needs to develop towards "knowledge construction and cognitive ability".

(2) Comprehensive Universities

As can be seen from Figure 2, in the 1970s, the University of Tsukuba introduced courses such as "Generative Methodology" in structural training, emphasising the combination of sensory cognition and theoretical construction. In the 1980s, with the rise of digitalisation, the University of Tsukuba added courses such as "Computer Art", "CAD Practice", and "Ergonomics", and compulsory studies shifted to the cognitive dimensions of algorithm expression, dynamic graphics training, and the relationship between the organism and the environment. In Chiba University, compulsory studies also incorporated

"Drawing" and "Drawing Practice" into structural education at the same stage, integrating scientific measurement and understanding of physical properties. In the 1990s, the compulsory studies of the University of Tsukuba were further systematised, adding courses such as "CAD Programming" and "Structural Mechanics", incorporating engineering knowledge and user data analysis, and cultivating critical thinking and historical judgment through "Design History Practice" and "Design Theory Practice". During the same period, Chiba University strengthened courses such as "Human Engineering" and "Spatial Design Theory" and promoted the integrated training structure of "digital tools, cognitive composition and product expression".

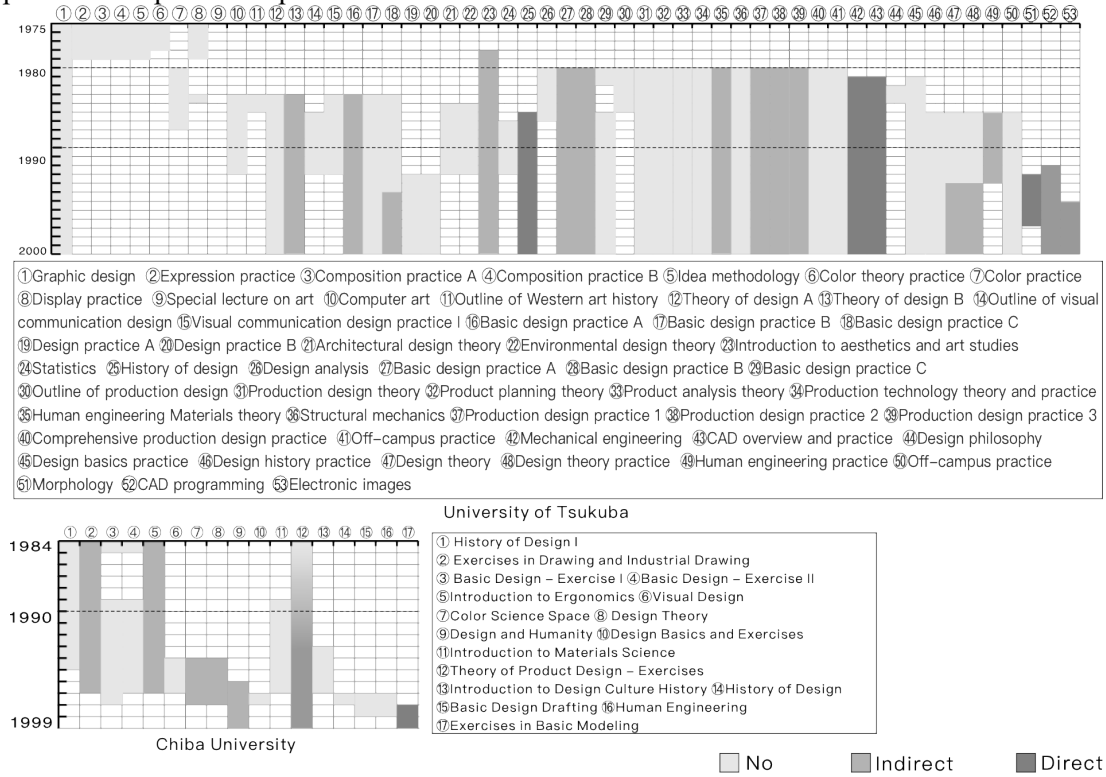

Figure 2. University of Tsukuba and Chiba University Compulsory Subject

While inheriting its sensory training, the University of Tsukuba actively introduced digital tools, ergonomics and system thinking, and promoted basic education from artistic expression to scientific construction. From the analysis, the study of compulsory subjects was only offered from around 1984 onward in the ID programme of Chiba University. Since 1984, the overall trend in the study of compulsory subjects has shifted from early composition and expression to later multi-dimensional integration. The developments in these two ID programmes displayed an emphasis on the coordinated understanding of the human-technology-behavior system in design. Furthermore, is also in line with the educational concept of the three-stage model of "creativity-tools-system capabilities" described in the literature review.

(3) Industry-Oriented Universities

Kyushu University's Study of Compulsory subjects present a distinctive feature of highly interdisciplinary integration and engineering science orientation, and at the same time demonstrate the transformation trajectory of the curriculum system from "Focus on function and structure" to "integration of system engineering and information technology". Compared with other universities, Kyushu University's compulsory studies responded to the pulse of the times of technological development earlier and reflected the gradual evolution of the three dimensions of engineering thinking, information tools, and interaction between people and technology, as shown in Figure 3.

In the early 1970s, the compulsory studies of Kyushu University were centred on "structural theory", "product design theory", "introduction to ergonomics", etc., emphasising the adaptive relationship between structural logic and human body data, reflecting the emphasis on "manufacturability" and "operational safety". This was responding to the actual needs of Japan's industrial development at that time. In the 1980s, with the development of automation and mechatronics, compulsory studies deepened

the education of information and intelligent technology and established a design cognitive system supported by algorithmic thinking and digital tools. In the 1990s, with the improvement of living standards, while paying attention to the technical foundation, the focus on sensory experience was strengthened. For example, "sensory engineering" and "public design theory" reflected that the basic ability of design has been redefined as the underlying ability construction of technology-system-life behavior integration.

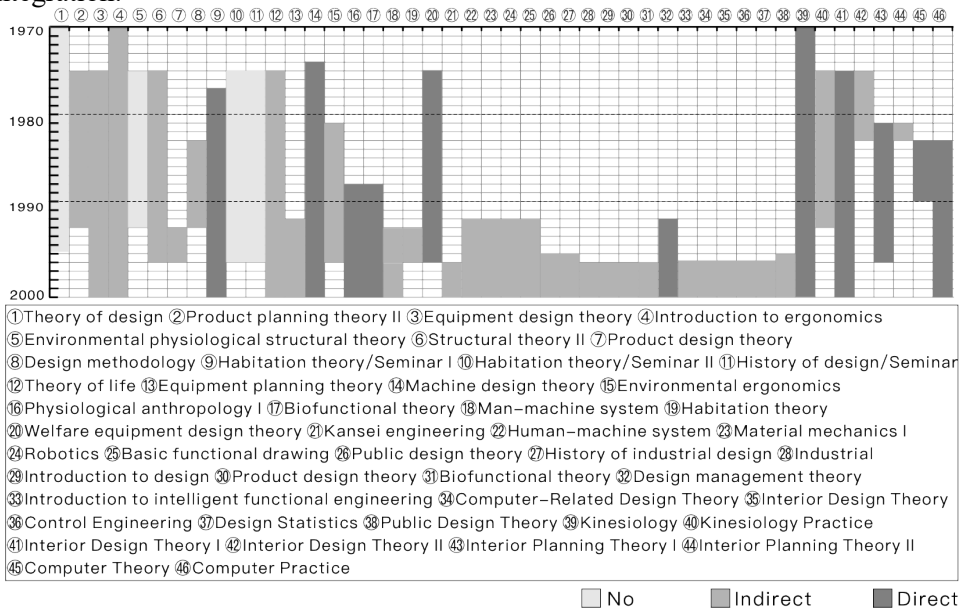

Figure 3. Kyushu University Compulsory Subject

Kyushu University's compulsory studies present a distinctive feature of highly interdisciplinary integration and engineering science orientation. Furthermore, it demonstrated the transformation trajectory of the curriculum system from "focus on function and structure" to "integration of system engineering and information technology". This teaching orientation was moving towards the direction in using "design thinking as a tool for coping with complex system problems". It provided a glimpse where design education expanded from tool mastery to system understanding and behavioural insight.

5 DISCUSSIONS

The table above shows that art-oriented institutions are slow to integrate technology in compulsory studies for ID programmes. In addition, comprehensive institutions have a wider use of technology in their courses. Moreover, industrial institutions have a deep and wide use of technology, reflecting the varying degrees of introduction of technology in different types of institutions within the same context. The observation in the findings reflects how technological developments are driving a shift in compulsory studies and redefining the learning of core competencies in ID programmes. Based on the findings, several educational logic and developmental implications behind curriculum evolution can be hypothesised.

1) Core Competency Shift: From Perceptual Expression to Systematic Cognition

Findings indicate that core competencies have evolved beyond form, colour, and spatial expression, expanding to systematic thinking, tool application, and behavioural understanding. This aligns with Findeli's view that design education should become a cognitive structure for systematic social intervention [15]. As a result, mandatory courses are now seen as an entry point for design cognition and interdisciplinary thinking, rather than just traditional training.

2). Technological Development and Educational Structural Change

The impact of technology is not limited to the introduction of tools as it has also reshaped course content and cognitive logic. Kyushu University integrates ergonomics, structural systems and mechanics at the basic level. In Tsukuba and Chiba Universities, a systematic approach that cover conceptualisation, human-computer interaction and visualisation tools. While Kyoto Institute of Technology and Tokyo University of the Arts progressively assimilate technological content through projects or design studios. These differences reflect different institutional traditions and disciplinary attributes and illustrate the adaptive interaction of design education with technological developments.

Overall, developments in curricula suggests that compulsory studies have transitioned from a focus on sensory expression to a cognitive platform that integrates tools, methods, and problem solving. The compulsory studies now focus less about preparatory instruction and more about the critical starting point for developing systemic cognition. This has important implications for curriculum reform in the age of smart technology and provides theoretical support for reconfiguring the foundational studies.

6 CONCLUSIONS

The purpose of this study is to clarify the key changes in the study of compulsory subjects in the ID programmes of Japanese universities amid technological developments between 1970 and 2000. Using ID programmes from 5 representative Japanese universities, the following key points can be concluded. Firstly, there were notable differences in curriculum structures and technology integration strategies among school types: Art-oriented organisations progressively integrate technology by focusing on both art and culture; Comprehensive universities achieve parallel development of tools and cognition through extensive integration; industry-focused schools develop systems emphasising control and engineering adaptation. These reflect diverse modernisation paths and educational philosophies in ID design education. Moreover, technological progress has reshaped the "core abilities" in ID Education Foundation—from perceptual and expressive skills to composite competence in technical understanding, system cognition, human logic, and tool use. Basic courses now serve as cognitive entry points to "system design thinking and problem-solving," rather than mere pre-art preparation.

Nonetheless, the study has limitations: incomplete data in some years may affect continuity analysis, and the focus on curriculum structure overlooks teaching methods, faculty composition, and student feedback. Future research should include teaching practices and effectiveness assessments to build a more holistic evaluation framework. Ultimately, the study shows that the study of design foundations is not static technical training, but a dynamic cognitive platform shaped by technology, society, and culture. Understanding its evolution helps address current educational challenges and informs future curriculum and capability model reforms.

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