

# The Professional Education Ecosystem of Industrial Design at Georgia Institute of Technology Based on SECI Model

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**Abstract.** The changes in international competitive environment and the adjustment of national industrial development strategy have put forward new requirements for the education of industrial design. Industrial design is the research on design knowledge. It includes systematic explicit knowledge and empirical tacit knowledge. The education of design is about the transfer and accumulation of this specialized knowledge. By using SECI model of knowledge transformation and creation proposed by Ikujiro Nonaka and others, this article analyzes four processes of knowledge transformation, the platform of knowledge transformation (“Ba”) and knowledge assets. It studies the educational mode of the School of Industrial Design at Georgia Institute of Technology. From basic professional education, to department-level studio courses and university-level laboratory research, to the completion of industrial design education, professional knowledge is built up through the whole process, thus a virtuous cycle of professional education ecosystem is established. It is hoped this will bring useful experience to the education of industrial design in China.

## 1 Introduction

Technological innovation has brought social transformation and changes in international competitive environment. China's industrial development strategy about intelligent manufacturing, internet plus and cultural revitalization has proposed new requirements for the content and pedagogy of the education of industrial design.

## 2 The education of design is the transmission of design knowledge

### 2.1. The education of industrial design is the transfer of design knowledge

The core feature of modern design is the acquisition of new knowledge. The competitiveness of a new product lies in the existence of new knowledge in product design [1]. At the same time, product manufacturing has changed from mass production to flexible production [2]. Modern design features multiple processes, overlapping needs and multiple objectives. It is also knowledge intensive and multi-disciplinary. Industrial design has become a comprehensive interdisciplinary subject which consists of informatics, computer science, engineering, design art and other disciplines. The acquisition and

representation of new design knowledge and the integration and sharing of design knowledge have become the focus of design education.

Education is based on knowledge transfer. Ken Wallace pointed out that design is essentially a process of knowledge acquisition, storage and use. Modern design is also centred on the acquisition of knowledge. Industrial design is the materialization of knowledge, and innovative design is the materialization of new knowledge. The acquisition and expression of design knowledge, the automation of design process and the inheritance and sharing of design information have become the key scientific issues in modern design [3]. Since the Design Thinking Research Symposia held in Australia in 2003, design expertise has become a hot spot of design research. According to the famous psychologist Ericsson, it needs a long time and a lot of practice to accumulate expertise; it is a kind of knowledge of how to achieve the best performance [4]. Expertise is the result of knowledge that focuses on a certain field, which is reflected as empirical knowledge [5]. The transformation of design knowledge in the design process is of great significance to the research of design knowledge. Design knowledge can be regarded as the combination of design experience, value, product manufacturing, user experience and other background knowledge [6, 7].

The work of industrial design is a kind of knowledge "externalization". It is the transformation process of design knowledge through the designer's work. As shown

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in Figure 1, designers can transform design knowledge into specific and external product characteristics through design.

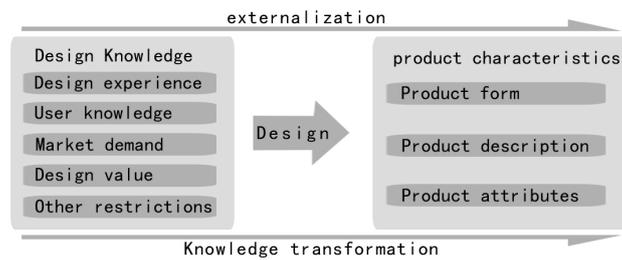


Figure 1. Externalization of Design Knowledge

The knowledge of industrial design has several basic characteristics: empirical, this kind of knowledge needs to be accumulated through a large number of design practices; effective, it must be proved by practice that it can effectively solve design problems; structural, it is a thinking framework based on structural methods and personal intuition. Design education is not only the transfer of a standard, but also a thinking process.

## 2.2. Industrial design knowledge includes explicit knowledge and tacit knowledge

Explicit knowledge is the knowledge that can be represented in a systematic way and stored in a structural form such as words, which can be expressed as commands, reports, formulas, theorems, documents, databases, instructions, applications, etc. Tacit knowledge is difficult to express in a formal system. It is more reflected in personal experience, feelings, impressions, values, tacit understanding, and cultural customs and so on inside the community. Compared with explicit knowledge, tacit knowledge has more far-reaching influences in terms of scope and depth.

The domain knowledge of industrial design includes: colour, shape, emotion and environment which need designers to express through visual means in the design process with potential experience and feelings, which belong to the tacit knowledge that features intuition and image. At the same time, it also contains a large number of analytical and logical explicit knowledge, such as product function, structure, process, costs and ergonomics.

## 2.3. Tacit knowledge and explicit knowledge can be conversed

Tacit knowledge can be conversed into explicit knowledge through socialization, and new knowledge will be expanded and created in this process. Ikujiro Nonaka and Hirotaka Takeuchi called it "knowledge conversion"[8].

The process of making tacit knowledge explicit is the one in which tacit knowledge is put into practice to create value. The expression means of tacit knowledge are declarative representation and situated representation [9]. For example, design tools such as story board and image

scale are used for quantitative expression of emotional preferences.

## 3 SECI model of knowledge management and innovation

Knowledge acquisition of industrial design is not mere accumulation of information, nor simple input, storage and extraction of knowledge. It is a process in which students communicate and discuss with others to build up new knowledge under the guidance of teachers [10].

In the basic theoretical research of knowledge management and innovation, Ikujiro Nonaka and others put forward SECI model of knowledge transformation and creation, and gradually improved it [11]. The model consists of three parts: SECI, the process of knowledge creation through the transformation of tacit and explicit knowledge; "ba", a shared place for knowledge creation; and knowledge assets, input, output and regulation of knowledge creation process [12].

### 3.1. Knowledge creation process of SECI

According to Ikujiro Nonaka, an organization creates and uses knowledge through the interaction between tacit knowledge and explicit knowledge, i.e. the process of knowledge transformation. Knowledge transformation includes four processes (or four forms): socialization, externalization, combination and internalization. As shown in Figure 2, this is the well known SECI knowledge spiral model.

Socialization is the process of knowledge dissemination (the tacit knowledge from one to another) through observation and learning. Externalization is the conversion from tacit knowledge to explicit knowledge to express tacit knowledge usually in the way of "dialogue or collective thinking", in order to help team members express tacit knowledge that is difficult to communicate. Combination is the transition from discrete explicit knowledge to systematic explicit knowledge, to systematize structure, create and serve new knowledge and solve new problems. Internalization is the process from explicit knowledge to tacit knowledge. It is individuals' digestion, absorption and integration of knowledge within an organization, thus promoting the progress of individuals and the community.

According to SECI model, through these four processes, knowledge presents a state of spiral

development in the community, promoting the generation and application of new knowledge [13].

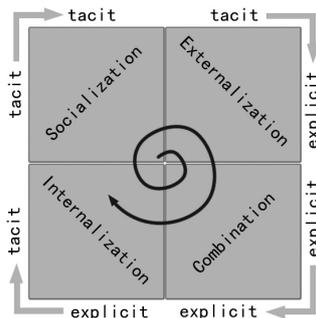


Figure2.The SECI Process

**3.2. “Ba” is the platform of knowledge creation.**

The creation of knowledge depends on a certain platform and situation. Knowledge does not only exist at the cognitive level; it is also the result of purposeful action [14]. According to the existing environment, “Ba” can be

not only a regular classroom or laboratory, but also an email or an app. According to different stages of SECI process, “Ba” is also divided into four categories: originating Ba, interacting Ba, cyber Ba and exercising Ba, as shown in Figure 3.

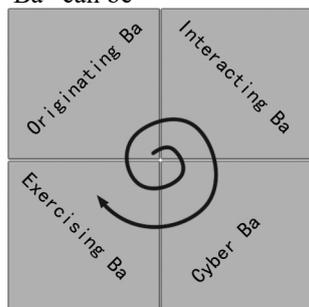


Figure3. Ba

**3.3. Knowledge assets are high quality resources in the process of knowledge creation**

Knowledge assets which originate from the process of knowledge creation are high-quality resources that can bring effective value to the team. In order to analyze how knowledge assets are created and utilized more effectively, Ikujiro Nonaka divided them into four types: experiential knowledge assets, mainly the tacit knowledge formed by the exchange of experience among team members; conceptual knowledge assets, which mainly includes the knowledge recorded by images, symbols and languages; systemic knowledge assets, i.e. systematic knowledge, such as product manuals that contain specifications; and routine knowledge assets, i.e. the tacit understanding and practices formed within the team [15].

development. During 2019, the author visited the School of Industrial Design at Georgia Institute of Technology and had a deeper understanding of its professional training. The SECI model is used for analysis.

**4 Analysis of the Professional Education Model SECI of Industry Design at Georgia Institute of Technology**

As an educational institution, Georgia Institute of Technology is also a knowledge management team dedicated to design knowledge inheritance and

**4.1. The first year basic course of industrial design at Georgia Institute of Technology is the process of knowledge socialization**

Undergraduate students of industrial design at Georgia Institute of Technology’s attend the foundation program in the first year. According to SECI model, this is the transition stage from tacit knowledge to tacit knowledge, which is in the originating Ba.

As can be seen from the undergraduate curriculum of the School of Industrial Design at Georgia Institute of Technology in Figure 4, like many universities in China, first year students start to learn basic design history and theories and basic graphic design courses, understand design concepts, methods and other knowledge, and acquire design thinking and basic design abilities. The difference is, in Georgia Tech’s curriculum, the conventional courses about comprehensive formation, i.e. plane formation, colour formation and three dimensional composition are not there. Instead, students learn sketching and modelling and other design techniques and software directly, to describe, create and display their

concepts. At the same time, students are encouraged to take interdisciplinary elective courses.

Taking classrooms as the main platform through face-to-face communication and guidance, this stage of theoretical study realizes the socialization of professional

design knowledge. It contains a lot of design experience and the comprehension of such tacit knowledge. But students are not able to fully understand it, let alone its application from classroom lectures.

First Year - Fall	Hrs	First Year - Spring	Hrs
ID 1011 Industrial Design Fundamentals 1	2	ID 1012 Industrial Design Fundamentals 2	2
ID 1101 Intro to Industrial Design 1	1	ID 1102 Intro to Industrial Design 2	1
ID 1401 Intro to Graphic Communications 1	1	ID 1402 Intro to Graphic Communications 2	1
ID 1418 Intro to Sketching & Modeling 1	1	ID 1419 Intro to Sketching & Modeling 2	1
HIST 2111 or 2112 or	3	CS 1301 or	3
POL 1101 or		CS 1315 or	
PUBP 3000 or		CS 1331 or	
INTA 1200		CS 1371 Computer Science	
ENGL 1101 English Composition 1	3	ENGL 1102 English Composition 2	3
MATH 1551 Differential Calculus	2	MATH 1552 Integral Calculus	4
ID 2202 History of Modern Industrial Design	3	APPH 1040 / APPH 1050 Health & Wellness	2
Second Year - Fall	Hrs	Second Year - Spring	Hrs
ID 2023 Industrial Design Studio 1	3	ID 2024 Industrial Design Studio 2	3
ID 2101 Digital Design Methods	3	ID 2102 3D Modeling	2
ID 2325 User-Centered Design Methods	3	COA 2242 Art History II	3
MATH 1553 Linear Algebra	2	ID 2320 Human Factors In Design	3
Phys 2211 Physics I	4	Lab Science	4
Third Year - Fall	Hrs	Third Year - Spring	Hrs
ID 3031 Health Design Studio 1 or	4	ID 3032 Health Design Studio 2 or	4
ID 3041 Product Development Studio 1 or		ID 3042 Product Development Studio 2 or	
ID 3051 Interactive Product Design Studio 1		ID 3052 Interactive Product Design Studio 2	
ID 3301 Materials/Processes I	3	ID 3302 Materials/Processes II	3
ID 3320 Design Methods	3	ID 4206 Culture Of Objects	3
Industrial Design Elective	3	Industrial Design Elective	3
Social Science Elective	3	Free Elective	3
Fourth Year - Fall	Hrs	Fourth Year - Spring	Hrs
ID 4061 ID Capstone Design Studio 1 or	4	ID 4062 ID Capstone Design Studio 2 or	4
ID 4071 Invention Studio 1 or		ID 4072 Invention Studio 2 or	
ID 4081 ID/ME Collaborative Studio 1		ID 4082 ID/ME Collaborative Studio 2	
Social Science Elective	3	Industrial Design Elective	3
Industrial Design Elective (specialization)	3	Social Science Elective	3
Free Elective	3	Humanities Elective	3
Free Elective	3	Free Elective	3

Figure4. Curriculum of undergraduate study of industry design at Georgia Institute of Technology

#### 4.2. The studio course in the second year of industrial design at Georgia Institute of Technology is the process of knowledge externalization

Based on its strong engineering background, the School of Industrial Design at Georgia Institute of Technology advocates the studio culture of solving practical problems. The second year of study is mainly working at college level studios to participate in design practices under the guidance of professional teaching teams. There are metalworking, woodworking, plastic fabrication and other studios where students can learn the characteristics of metal, wood, plastic and other materials and processing techniques. Rapid prototyping studio provides the guidance of 3D printing and other rapid prototyping equipment and processes. Digital fabrication studio provides large professional equipment such as laboratory large-format machines, 3-axis and 5-axis milling machines, CNC water jet cutting machines, KUKA Robot for students to use for their courses and to complete design prototype production. Guided by their tutors, junior students are able to participate in cooperative education under the partnership with enterprises to finish the complete process of product development and design.

Through these basic design practices, the theories which were taught in the first year and tacit knowledge such as design experience were transformed into explicit knowledge in specific design projects. For example, the famous "golden ratio" is the transformation from the perceptions of beauty into a reference standard in practice.

#### 4.3. The advanced studio course in the third year of industrial design at Georgia Institute of Technology is the combination of design knowledge

American colleges and universities have always attached great importance to practical abilities of students and the cooperation between enterprises and colleges and universities. Through the projects supported by or cooperated with enterprises as the carrier, the complete process of product development and design is carried out in the studio course of the whole semester. For example, during the author's visit, a clothing company cooperated with studio course to explore the design trend of future clothing with the application of 3D printing technology. Figure 5 is a three-dimensional lace dress designed by students and made by 3D printing technology.



Figure5. Three dimensional lace dress made by 3D printing technology

These courses integrate the decentralized and targeted design training in the previous stage, and train students to be qualified designers with the complete process of product design and development. This is a process of systematization and combination of discrete explicit knowledge.

#### 4.4. It is the internalization of knowledge that senior students of industrial design at Georgia Institute of Technology participate in laboratory research

Georgia Institute of Technology is a well-known research-based institute. At the School of Industrial Design, there are Interactive Product Design Lab, which specialty focuses on intelligence hardware, wearable equipment, etc., for the research of lifestyles in the future; Body Scan Lab, a human body scanning laboratory which studies the equipment that is more suitable for individual characteristics through human body 3D scanning technology; GM Human Machine Interface Lab

which studies the vehicle design and interaction mode in the future, and carries out relevant verification and testing, which requires the cooperation of engineering, technology, computer, machinery and other disciplines.

The laboratory is in the charge of professional professors, with the assistance of postgraduates in management. It conducts research on major scientific research topics for teachers and students of the whole school. Senior students and graduate students of industrial design are able to join the laboratory for in-depth study and research according to their own interests and specialties. Design knowledge is fermented through in-depth project research, digested and absorbed in the laboratory internalization, and became the knowledge assets of the team, with new knowledge experience accumulated in the process. Figure 6 shows the cooperation and exchange of future automobile design between GM Human Machine Interface Lab members and GAC Design & Research Institute during the author's visit.



Figure6. GM Human Machine Interface Lab

## 5 The innovation and training ecosystem of industrial design at Georgia Institute of Technology based on SECI model

Freshmen learn the basic design theory and performance skills in the classroom, sophomores and juniors join the studios for design practice under the guidance of their tutors, and seniors and postgraduates enter the laboratory for special research. These platforms are all “Ba”, which

are necessary for knowledge transformation in SECI model. Figure 7 is the training ecosystem in the School of Industrial Design at Georgia Institute of Technology summarized by the author. Professional designers are trained via these platforms step by step by knowledge transmission. The conversion of tacit knowledge and explicit knowledge is realized in four “Ba”, thus increasing the knowledge assets. After internalization, new knowledge assets will be fed back to a new round of teaching and research activities, so as to realize the healthy development of discipline ecology.

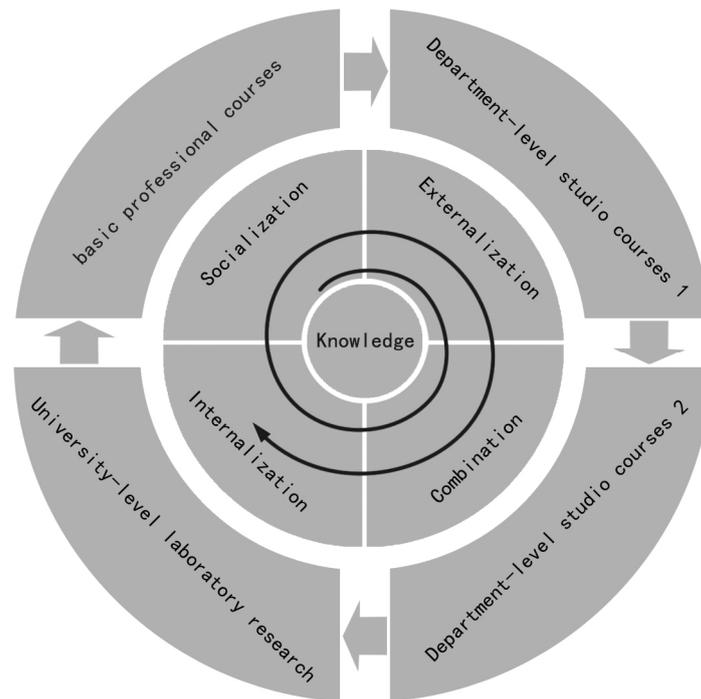


Figure7. The innovation and training ecosystem in the School of Industrial Design at Georgia Institute of Technology

## 6 Inspiration from the training ecosphere in the School of Industrial Design at Georgia Institute of Technology based on SECI model

- To increase the transmission efficiency of knowledge, the conversion of tacit knowledge and explicit knowledge needs to be improved. Explicit knowledge and tacit knowledge in design knowledge alternate in the process of learning and practice. The more conversion there is, the more obvious the improvement of design ability will be. In China, the curriculum of industrial design is long-hours study of basic aesthetic theories, such as comprehensive formation in the first two years, then design practice in the third and fourth year. At Georgia Institute of Technology, it advocates the combination of theories study and project practice with the latter as the core, to enhance the efficiency and effect of learning.
- Provide more “Ba” for knowledge transformation and enhance the opportunities for students to design and practice. First of all, progressive studio courses and laboratory research from the second year provide students with practice opportunities at different levels. Secondly, the School of Industrial Design at Georgia Institute of Technology encourages students to take interdisciplinary elective courses, while studio courses and laboratory research are also open to all the students. The collision of different disciplines is the fertile ground for knowledge generation. During the

visit to GM Human Machine Interface Lab, the author participated in several research meetings. Each topic was announced in advance, attracting teachers and students from different departments to participate, which promoted the collision of ideas, knowledge innovation and accumulation.

- Market-oriented education and enhanced communication and cooperation between universities and enterprises are the biggest “Ba” for the development of design education. Enterprises are the main body of the market, and students are the future of enterprises. The times and market are changing, the content and methods of design education should be adjusted accordingly. Enterprises are important partners of higher education. In the design practice of students, it is not only necessary for enterprises to provide real design projects, but also to strengthen the cooperation from the perspective of thinking and design process.

## 7 conclusion

Based on SECI model, the professional education model in the School of Industrial Design at Georgia Institute of Technology is very effective. Not only students can get good professional training, the discipline itself is also thriving. This is worth learning from.

The inheritance and development of knowledge is the foundation of human civilization, but the way of education is not unchangeable. We should actively explore the most effective methods of knowledge transfer and accumulation in different historical stages and organizational structures. As important players of higher

education, teachers should not only do well in knowledge research, but also try to explore more effective teaching methods to promote the positive development of discipline.

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