Using AHP method to construct the capacity index in industrial design courses

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ABSTRACT: In the current era of information technology and creative thinking, industrial technology and design is no longer a simple manufacturing technology. If social culture, living standards, lifestyle, technology and aesthetics are considered, industrial design has become a very important task. Industrial design has become a multi-disciplinary and interdisciplinary subject. However, in the past, few have applied the scientific method to develop a model curriculum in the industrial design curriculum planning process. Hence, industrial design curricula are inadequate to cope with the current rapid social changes brought about by demand, resulting in a gap between the expertise of many industrial design graduates and the professional needs of business. In this study, the literature was reviewed, and the needs of industry were investigated. Further, a capacity index (AHP) was constructed, after triangular verification was performed by three experts, and 15 academic experts and practitioners were invited to test the AHP. The results of this study should be useful for universities, enterprises and vocational training institutions.

INTRODUCTION

In recent years, industry has been forced into rapid changes. This has been due to the continuous escalation and maturity of the design industry, the rapid development of information technology, and improvements in people's quality of life and taste. The demand for corporate design talent has changed because of the changes of the whole social environment. Industrial design, which is an interdisciplinary academic discipline, contains technology, science, aesthetics and daily life application, etc.

In other words, it requires professional manufacturing technology, aesthetics and a sense of beauty in addition to continuous innovation. Hence, it is important to consider social and enterprises' needs, and to adjust curricula and course content accordingly in a university's industrial design curriculum, in order to assist industrial design students, so that their training can meet the needs of enterprises. Moreover, it is desirable for students to have the ability to integrate new elements of innovative ideas into their new design.

Quality innovative talent has become the core of the competiveness of current industries. Its ability is cultivated mainly from school education. Zang pointed out that a large number of industrial design students graduate each year, but the industry has generally agreed that there is a shortage of people possessing design talent for fashion, aesthetics and originality [1].

Many studies have shown that a significant gap exists between the graduates from design departments and the professional expertise required by business [2]. These studies show that the current curriculum cannot meet and fulfil business needs and expectations.

In just five short years, Shiao-Mi Smart Phone has become the world's third largest smart phone company. Its Chairman Jun Lei said …*In the world of martial arts, only fast speed resists breaking*. To a successful business, speed and innovation are two important elements of the business. He even predicts that in five to ten years, Shiao-Mi Smart Phone will surpass Apple and Samsung to become the global leader in smart phones [3].

In summary, in the era of information technology, originality, creativity, aesthetics and speed seem to be important factors in the current business development. How to shape university students into the desired business talent is of utmost importance.

The main purpose of this study was to convert the ability required to be an industrial design expert, and apply it to university education and curriculum planning, as well as vocational training, so that businesses get the right graduate. The results of this study should be useful and applicable for universities, enterprises, and vocational training institutions.

THE CONTENT OF INDUSTRIAL DESIGN

The general public's understanding of industrial design is typically limited to the adjustment or correction made to the exterior, and its design of the product during manufacturing. However, with the progress and evolution over time, the scope of industrial design has been adjusted and expanded. In addition, more and more scholars will be needed to infuse business, aesthetics, arts and crafts and other elements into industrial design to further shape industrial design.

Researchers, summarising various domestic and international scholars' opinions on *industrial design*, define it as follows:

> *Explore the needs and behaviour of man, integrate environmental factors and production technology, ultimately infuse beauty through the creative method, to come out with the shape and function of a product, also enrich and beautify the community's workers* [4].

Creative thinking is the core focus of industrial design. Human *use* behaviour is the concept basis for developing, innovating, and creating new best usage through visual and reified process [5].

Design is a creative activity. It is a key factor contributing to cultural and economic interaction [6]. Industrial design is the creative behaviour in response for the demand of the industrial product. The goal is to unify and harmonise a product's appearance, internal functional structure and the quality of the product in order to meet the needs of the users [7]. Further, industrial design refers to a series of action from idea, to establishing a practical implementation mean in order to achieve a particular purpose. It contains the design process using all the modern means for production and service [8].

Industrial design is an act of creation, which is designed to determine the true quality of industrial products. The so-called true quality does not mean the appearance of the product. Rather, it emphasises the relationship between the structure and the function of the product in order to best serve and satisfy both the producers and the users [9]. And, it must take into account the interests of users and producers, engage in creating and developing concepts and specifications of products and systems, to enhance the value of products and system due to its function, value and appearance [10]. Moreover, industrial design includes two processes: asking questions and solving problems [11].

In summary, the industrial designer in practice should possess many aspects of knowledge, from marketing strategy, which is the front-end of product development, requirements in development process, creativity, design, research and development, to development of the back-end production expertise; and have the ability to integrate, manage and communicate. Many studies have proposed the use of ability indexes; some of these indexes of different industrial designers are described as follows:

Yeh proposed a set of parameters relating to the professional capacity needed for industrial designers: 1) the ability to use a computer-aided tool; 2) problem-solving ability; 3) the ability to set up marketing strategy; 4) creativity; 5) positive attitude; 6) integration of communication and coordination; 7) foreign language communication skill; 8) market research and analysis skill; 9) international outlook; 10) exterior design capability; 11) the capacity to undertake structural design; 12) the capacity of design creativity; and 13) product planning capabilities [12].

Takesue considered that industrial designers should develop the following professional capacity: 1) perception; 2) imagination; 3) creativity; 4) visualisation; and 5) coordination [13]. Whereas, Lippincott pointed out that industrial designers must possess certain basic elements in the training process: 1) humanities; 2) engineering; 3) economics; and 4) the arts [14].

Lu et al pointed out that from the view of the needs of industry talent, the abilities that industrial designers require are as follows, according to the degree of importance in descending order: 1) professional design knowledge; 2) problem-solving ability; 3) teamwork ability; and 4) technical expertise [15].

Yan et al emphasised that when enterprises recruit new industrial designers, the most important of the five selected traits in order are: 1) creativity; 2) the ability to shape the product; 3) quality of work; 4) observation; and 5) aesthetic qualities [16].

Design Republic pointed out the ten principles of good design: 1) creative and innovative (not repeating the familiar style, but would not deliberately present a new, novel, unusual product either); 2) valuable and useful products (as practical as possible, there is a specific and clear usage for the principal function and auxiliary function); 3) aesthetic charm and fashion; 4) clarity at a glance; 5) natural and restrained, to provide users with a space for self-expression (both decorative and artistic); 6) timeless; 7) detailing (better reflects the respect to the users); 8) environment friendly (rational use of raw materials); 9) to be as simple as possible; and 10) focus on a key part of the product [17].

Industrial Design Education

Researchers indicated that industrial design students should have the ability to cover the following ten aspects:

1) Excellent ability to hand-draw sketches;
2) Modelling capabilities;
3) The ability to use graphics software sketch;
4) The ability to use advanced three-dimensional modelling software;
5) The ability to use two-dimensional graphics;
6) Possess excellent, independent communication skills and interpersonal skills and the ability to present a real design report;
7) Have good product appreciation and have a keen ability to feel the space architecture;
8) Can finely depict in three-dimensional design;
9) The ability to sufficiently understand the product from design, manufacturing to marketing;
10) To be very precise on the timing of the design process [18].

In summary, the authors found that industrial design really covers a widespread territory. By integrating the various researchers' connotations of industrial design and, then, through the scientific method, the required professional skills of industrial designers can be synthesised and presented. It is believed that this information will help greatly in nurturing industrial design talent.

RESEARCH METHOD

Through this study, a literature review was undertaken to collect information from the industrial design literature, followed by the ability to integrate the necessary indicators of industrial design talent and, then, through the triangular test to strengthen the certainty and rigor of these capacity indices. Finally, fifteen scholars and expert practitioners were invited to conduct the AHP method, and to complete the presentation of these index weights [19].

RESEARCH ANALYSIS

After exploring the literature, the indices of industrial design expertise were sorted out by the authors. Three experts in academia and the practice of industrial design were invited to carry out triangular testing, and the industrial design and rigor capacity indices were strengthened. The results were presented as follows:

Eight major indicators of professional competence and ability with twenty nine corresponding facets were assembled by the authors:

1. Engineering technology base capability (ability facets): 1-1 machine design and construction principles, 1-2 process knowledge, 1-3 use of multiple materials (professional competence indicators).
2. Information technology capability (ability facets): 2-1 ability to use computer plane graphics software, 2-2 the ability to use 2D computer graphics software, 2-3 3D computer graphics software skills (professional competence indicators).
3. Culture and technology interactive capability (ability facets): 3-1 knowledge of human-machine interaction, 3-2 sensory perception ability, 3-3 multi-cultural cognitive ability (professional competence indicators).
4. Aesthetics and fashion literacy (ability facets): 4-1 appearance construction capabilities, 4-2 plane and three-dimensional perception ability, 4-3 leadership and mastery of fashion capacity. 4-4 visual sensitivity (professional competence indicators).
5. Creativity and originality (ability facet): 5-1 ability to freely dream, 5-2 ability to have real body corrected and originality added, 5-3 have a positive attitude, 5-4 have teamwork ability (professional competence indicators).
6. Design rendering capabilities (ability facets): 6-1 have transforming abstract idea to specific object capabilities, 6-2 have the ability to visualise three-dimensional perspective (professional competence indicators).
7. The overall product planning capability (ability facet): 7-1 system architecture capabilities, 7-2 system organisational capabilities, 7-3 individual and team communication and interaction capabilities, 7-4 interdisciplinary knowledge and skills (professional competence indicators).
8. Foreign language skills (ability facets): 8-1 English language proficiency, 8-2 Japanese language proficiency, 8-3 Korean language proficiency, 8-4 French language proficiency, 8-5 German language proficiency, 8-6 Russian language proficiency (professional competence indicators).

AHP-LEVEL ANALYSIS RESULTS

Questions of consistency ratio of each facet to the overall facet, CR = 0.03, which complies with CR $\leqq$ 0.1 of the acceptable range, indicating that the experts' questionnaire responses were logical and consistent [20].

Overall facet results: 1) engineering technology base ability (0.239); 2) information technology capabilities (0.080); 3) cultural and technological interaction capabilities (0.131); 4) aesthetic and fashion literacy (0.150); 5) creativity and originality (0.167); 6) design rendering capabilities (0.108); 7) overall product planning capability (0.068); and 8) foreign language skills (0.057).

Among all facets, the experts believed that the first three highest weights should be engineering technology base ability (0.239), creativity and originality (0.167), and aesthetics and fashion literacy (0.150).

In other words, in the field of industrial design, engineering and technical infrastructure capacity is essential, and it is the most important basic skill. Having basic skills and knowledge, industrial designers should further strengthen creativity and originality, development and integration of new products, to facilitate convenience in human life, plus the final aesthetic quality and fashion to enhance the beauty of the product and create a higher quality of life and improved taste of the product, while increasing added value to the product.

The results of analysis of the professional competence index weights were as follows:

1) Among 1-1 machine design and construction principle (0.56), 1-2 process knowledge (0.12), 1-3 multi-material use (0.32).

   The most important, according to the experts, is the machine design and construction principles. For industrial designs, machines structural design and its principle is the most important issue according to the experts. By having basic mechanical knowledge and ability, expansion and integration of other related skills become possible.

2) Among 2-1 ability to use computer plane graphics software (0.14), 2-2 the ability to use 2D computer graphics software, (0.33), 2-3 the ability to use 3D computer graphics software, (0.53).

   The most important is the ability to use 3D computer graphics software as indicated by the experts. From this information, 3D graphics has become a trend. In addition to the ability to use 3D computer graphics, mastery of the 3D graphics software is desirable. Students can then exhibit freely and be unlimited in their design and creativity in the field of industrial design.

3) Among 3-1 knowledge of human-machine interaction (0.12), 3-2 sensory perception ability (0.32), and 3-3 multi-cultural cognitive ability (0.56).

   The experts believe that multi-cultural cognitive ability is the most important, In other words, they believe that technology always comes from human nature. Only by having the ability to learn about different diversified culture can one perceive the needs of different cultures, societies and nations, which ultimately shows that the technology products are manufactured to meet human needs. The needs of people in different regions are different, therefore, it is important to understand multi-culture and to design industrial products to meet the regional public demand.

4) Among 4-1 appearance construction ability (0.22), 4-2 plane and three-dimensional perception capability (0.12), 4-3 leadership and ability to master the trend (0.51), 4-4 visual sensitivity (0.15).

   The experts indicate that the most important is the ability to lead and to master the trend. In other words, industrial designers should possess the ability to grasp the trends, know the design trends in order to be able to design the desired trendy product. Moreover, industrial designers should not only master the trend, but also lead the trend. Brand name designers, such as Steve Jobs created the Apple companies. Their products not only master the iPhone trend, but also lead other trends, such that change human lives in the whole world, directly affected by changes in iPhones.

5) Among 5-1 ability to think and dream freely (0.33), 5-2 ability to amend entity and add creativity (0.35), 5-3 have a positive and pleasant attitude (0.11), 5-4 have the teamwork ability (0.21).

   The experts consider the ability to amend entity and add creativity, and the ability to think and dream freely as the two highest results. In other words, the experts believe that creativity is the most important skill, having the ability to think and dream freely, but also having the ability to add creative ideas to the original product and make improvements.

6) Among 6-1 ability to transform abstract ideas to specific object (0.47) and 6-2 three-dimensional perspective capacity (0.53).

   The experts believe that the ability to transform abstract idea to specific object and having perspective view capability are very important. In other words, to be able to have three-dimensional image perspective reasoning ability, and the ability to transform abstract ideas into specific objects, that is, to transform the idea to a *real* specific product is important.

7) Among 7-1 system architecture capabilities (0.12), 7-2 system organisational capabilities (0.07), 7-3 individual and team communication and interaction skills (0.36) and 7-4 interdisciplinary knowledge and skills (0.45).

   The experts believe that interdisciplinary knowledge and skills, communication skills and the ability to interact with team members are the two highest index weights. In other words, to find the most consistency with the demand and value of people's lives through interdisciplinary knowledge and team interaction and, then, present the product in line with human nature through the system organisation and structure is highly important.

8) Among the 8-1 English language proficiency (0.48), 8-2 Japanese language proficiency (0.29), 8-3 Korean language proficiency (0.09), 8-4 French language proficiency (0.07), 8-5 German language proficiency (0.05), and 8-6 Russian language proficiency (0.02).

The experts' weights for languages place proficiency in English and Japanese as the two highest. In other words, the experts believe that English is the most widely used language around the world; hence, it is placed first, while the second focuses on Japanese, mainly because Japan is the strongest in industry among Asia-Pacific countries. Moreover, the strong Taiwan-Japan bilateral trade and technical interaction make the Japanese language proficiency very important. The experts believe that the other languages are of smaller weight, and can be replaced by English in communication and interaction.

CONCLUSIONS

Through the above process, from literature review, the capacity index of industrial design and a triangular test and, then, eight major indicators of professional competence and the ability with twenty nine corresponding facets have been assembled by the authors.

Using the AHP method to analyse the eight major indicators of professional competence and the ability with twenty nine corresponding facets, the AHP weights were determined. The results not only reveal the required professional competence indicators for the training of current industrial designers, but also determined that these capabilities will form indicators for weight analysis. Furthermore, the obtained results provide a useful curriculum planning reference directly to universities, businesses and vocational training institutions.

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