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MODERN ENGINEERING EDUCATION IN GRAPHIC TECHNOLOGY AT UNIVERSITIES

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Abstract: *This paper explores the cultivation aims and methods for students majoring in graphic technology at universities in the era of the Internet and Artificial Intelligence. The graphic technology major, with an engineering focus, originated from traditional printing technology. By referencing the Washington Accord—an agreement for engineering degree accreditation, this paper introduces the demands of modern engineering education. Tracing back to its traditional focus on the printing industry, the social demands for the graphic technology major have shifted to include cross-media presentation and the reproduction of graphics and images across various media, not just paper. The new social ecosystem requires talent capable of solving complex technical problems and designing innovative print-related products by applying knowledge from multiple disciplines. The development of related printing technologies and the methodologies that support the cultivation of such talent are described in this paper, including the application of printing theories in cross-media contexts, the design thinking approach, STEAM skills training, and aspects of product innovation. These analyses strengthen the related theories in printing and expand the cross-media content and design thinking components when building the cultivation system for students. When we organized activities that brought together students from different disciplinary backgrounds, aiming to enhance their STEAM skills, their enthusiasm could be observed in their designs and products. While the methods suggested in the paper are still in the conceptual stage, they are continuously being promoted and developed.*

Key words: graphic technology, engineering education, product-centred, design thinking.

1. INTRODUCTION

The Internet and Artificial Intelligence (AI) era shows extremely different from the previous time, which is filled with abundant knowledge and is developing at a very rapid pace. It demands new talents from human beings to adapt to rapid social change. A university takes on the responsibility of cultivating students' abilities to serve society. It must understand the needs of society and the demands of the era, and then design a reasonable training plan for students that incorporates strategies to meet the demand for social talent.

The graphic technology major at universities has an engineering focus and originated from the traditional printing technology major, which concentrated on knowledge, theories, and techniques related to printing on paper substrates (Soyang, 2023). However, it has now expanded to include a wide range of other media substrates. That is why the development trends of the printing industry will be analyzed first. The basic tasks of print manufacturing involve the presentation and reproduction of graphics and images. Traditionally, these tasks are primarily focused on the paper surface using printing method. However, the media used for image and graphics have now expanded to include digital display on computer, network, mobile phone. A question arises: are printing-related technologies still solely focused on paper-based scenarios today? Certainly not. The mature technologies used in the traditional printing industry emphasize microscopic control over the final presentation of colour and details, such as the control over halftone dots, grayscale tones, ink transfer, ink dot formation, colour balance and so on. This approach is sufficient to manage detailed changes on seemingly less complicated displays or other material surfaces. We refer to these application scenarios as cross-media. Many methods or approaches can be transferred from print media to these new media. That means mastering the technology and workflow used in the printing industry is key to adapting colour or details control in other industries for image and graphic presentation.

Given the above cross-media service context, another question arises: what kind of talent is needed for the cross-media graphic technology major in engineering education? The Washington Accord is an international agreement between bodies responsible for accrediting engineering degree programs (IEAS, 2014). It establishes and benchmarks the standards for professional engineering education. The talent standards include the skills, knowledge, and experience necessary to solve complex technical problems, design and develop innovative products, and contribute to engineering projects, among other things. In the traditional education system for printing technology, we usually emphasized skills, knowledge and experience, which are the focus of the first stage of education. In modern society, these aspects can now be acquired and addressed more easily, narrowing the gap between professionals and others. What is professional education in graphic technology at the next stage? Following the Washington Accord, the first aim-solving complex technical problems-has been supported by the traditional training methods. This paper emphasizes expanding knowledge of media beyond just paper. Designing and developing innovative products is the focus of the second aim. The third aim, contributing to engineering projects, can be achieved by integrating the abilities developed in the first two aims and applying knowledge from different disciplines.

The following related works outlines the conditions -such as the printing theories that can be applied in cross-media industry, and Design Thinking, STEAM education-that support the realization of our training plan. Some specific innovative methods used in academic course development are presented. It is noted that the implemented methods are still being promoted, but it is believed that the completed education system will be effective in developing students' talents, preparing them to adapt to the challenges of the future.

2. RELATED WORKS

2.1 Printing theories that can be transferred to cross-media industry

Colour and tone changes are basic factors controlled in graphic presentations.

2.1.1 Colour control theory

No matter the colour presented on a paper surface, display, or any other material, the final result will be perceived and evaluated solely by the human visual system. The colour control process in printing generally focuses on the RGB and CMYK colour modes and their conversion relationship. However, almost all digital media such as display monitors can be colour-controlled using the additive RGB light mode. All pigment-coloured materials can be based on subtractive CMYK colour mode. No other industry encompasses more theories and experience in colour conversion between RGB and CMYK than the printing industry. Nowadays, most colour theories are generalized across different media surfaces, despite the specific requirements of various colour presentation devices. For example, by following the colour theories and rules established in 2D printing, colour control issues in 3D printing, monitor displays, and video displays can be addressed, with additional considerations for the imaging schemas of different system.

2.1.2 Visual tone and detail control theory

Visual tone is another key factor for image or graphics presentation alongside colour. For easier control of colour in the printing process, a grayscale is separated into many fine dots, allowing for a mixture of inked and non-inked regions to create the visual effect of greyness. This is the 1-bit halftoning technology, the simplest method for accurately representing continuous tones on a material surface.

With the advent of digital printing methods, multi-level halftoning technology was developed to address the limitations of low-quality imaging. This technology is also used in some displays and medical imaging to simulates continuous tone changes. Digital printing technology is widely used across various media surfaces today. Industries involved include clothing and textiles, home decoration, advertising and exhibitions, and even flexible electronic devices.

2.2 Design thinking and STEAM education

Knowledge sharing and acquisition have become more convenient and accessible in a short time for humanity, thanks to the popularity of Internet and AI technology. The future society seems more uncertain and challenging. Undergraduate education is responsible for making students capable and adaptable in facing future changes. Design thinking methodology and STEAM skills will become most important for students and their future development.

2.2.1 Design Thinking

Design Thinking is a problem-solving approach that emphasizes understanding users, challenging assumptions, redefining problems, and creating innovative solutions (Shelburn et al., 2020). It is characterized by a human-centred focus, iterative prototyping, and cross-disciplinary collaboration.

During the long history of the publishing industry, considerable experience has been gathered in composing images, text, and graphics on pages for paper-based products, ensuring a comfortable viewing experience for readers. The page design and layout should follow different scenario rules, even taking into account the readers' age. However, cross-media scenarios face many new materials and tools environments without established rules to follow, making the application of User Experience (UX) essential. UX refers to the overall experience and satisfaction that a user has when interacting with a product (Berni & Borgianni, 2021). It encompasses all aspects of the end-user's interaction to use the product, as well as the evoked emotions and perceptions. One of the important aspects is the layout of image and graphics on page. UX process can ensure its user-friendly effectiveness.

UX analysis is the foundation of Design Thinking. Design Thinking can also help create more innovative print-related products beyond traditional printed pages.

2.2.2 STEAM education

With the knowledge gap shortening between professional and others in AI era, STEAM skill will play an important role in effectively integrating and utilizing interdisciplinary knowledge (Razzaq, Townsend & Pisapia, 2013). STEAM skills refer to the specific abilities and competencies developed through the five key education areas: Science, Technology, Engineering, Arts, and Mathematics (Carter& Barnet, 2021). The goal of STEAM education is to foster innovation, creativity, critical thinking, and problem-solving skills by connecting these disciplines in meaningful ways. STEAM skills provide the technical and creative foundation, while Design Thinking offers a methodology to apply these skills effectively in problem-solving and innovation. Together, they empower individuals to tackle complex challenges with both analytical and creative strategies.

2.3 Conditions supporting innovative print-related product design

A product can be described in terms of its shape, material, appearance, and interactive functions with the user. With the development of new materials and the blending of interdisciplinary techniques in recent years, print-related products can now be presented in unique and innovative styles that go beyond conventional books or packaging boxes. The production process involves product shaping, such as pop-up structures created through die cutting; appearance decoration, such as foil stamping; new substrates with textured or patterned elements; and products with lighting and sound controlled by microchips. (Jiong & Huaming, 2021). All the aspects above mentioned support the thinking and design of the education plan for the graphic technology major.

3. OUR METHODS

In the new teaching plan, fundamental courses in printing are prioritized as the core, complemented by cross-media content. A theory course in Design Thinking is introduced, along with activities that promote interdisciplinary communication among student teams, particularly emphasizing collaboration between the arts and engineering disciplines.

3.1 Course design to strengthen print-related theories

The core courses cover the entire printing process, from prepress and press to postpress, including material analysis, process planning and quality control, as illustrated in Figure 1. The prepress phase is expanded into include premedia. Print manufacturing, a process that reveals macroscopic appearance through microscopic control, provides excellent way to train students' systematic thinking skills.

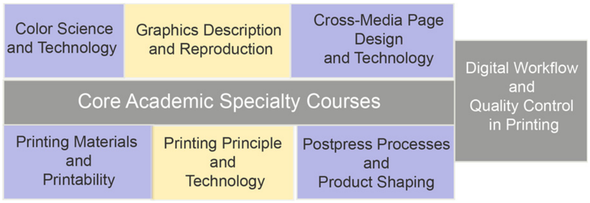


Figure 1: Core academic specialty courses in the curriculum plan

3.2 Cross-media content integration

Course content on web page and database technology is added as a supplement to premedia. This knowledge helps students move beyond the traditional focus on printing media, as illustrated in Figure 2, enabling them to recognize that all media can be unified within a common framework (Drew, 2010).
Visual and optical image-related content can help expand application scenarios in camera imaging field. We invited Colour Space, a Chinese company specializing in camera imaging quality checks, to design a practical course for students. This course helps students understand imaging theory and evaluation methods, as illustrated in Figure 3, similar to how an image engineer would, thereby expanding their knowledge from paper-based imaging to digital media-based imaging.

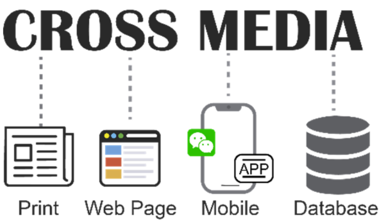


Figure 2: Cross-media technology

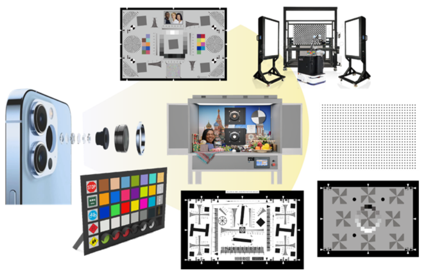


Figure 3: Visual imaging quality checkers

3.3 Training in design thinking methodology

A UX design course is introduced to train students in design engineering skills. After learning the principles and methodology of UX Design, students are asked to explore a specific project, including user demand analysis, persona design, ideation, prototyping and testing, as illustrated in Figure 4. The scientific approach to product development focuses not only on technology but also on the user.

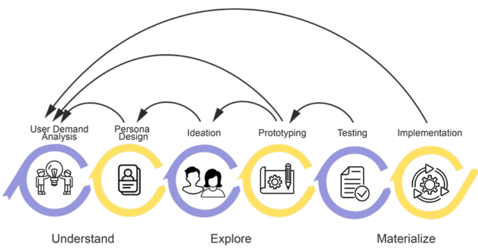


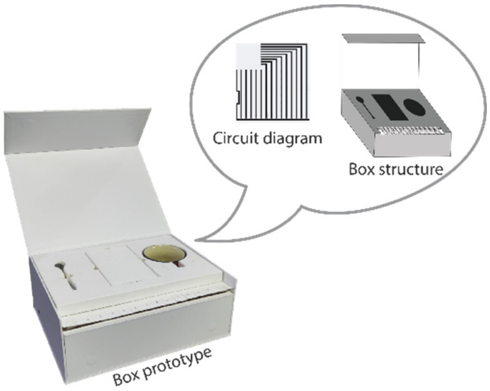
Figure 4: Design thinking process

3.4 Activity in Innovative Product Creation

A competition is organized for students at our university, where they will design and manufacture an innovative print-related product. The activity requires participants to be divided into groups with members from different disciplinary backgrounds, creating a STEAM skills environment. After completing the products, their projects are ranked and awarded. Students are encouraged to design innovative products focusing on aspects such as function, shape, material, and the application of techniques. Some of the students' works are shown in Figure 5.

a. Pop-up structure featuring Chinese traditional cultural elements

b. Cotton paper with special texture



c. Chip and circuit control in a packaging box

d. Multi-color foil stamping work

Figure 5: Students' works

4. CONCLUSIONS

Amid current society development, modern university education should prioritize developing systematic thinking to enhance the student's mindsets rather than viewing knowledge transfer as the most important task. Graphic technologies are utilized not only by the printing industry but also by industries involved in colour and detailed presentation. This paper proposes that cultivating innovative, product-based, and systematic design engineering talents is a crucial training aspect for students majoring in graphic technology at universities. The training process involves learning print-related theories, integrating cross-media content, mastering design thinking methodologies, and immersing students in a STEAM skills environment. The formidable challenge of discipline gaps in university education can be addressed or alleviated by prioritizing the promotion of team collaboration.

The methods proposed in this paper cannot yet be claimed as successful. They remain in the conceptual stage and need further promotion and development. It is hoped that this paper will receive more global attention and support, encouraging collaboration in advancing the development of university majors related to graphic technology.

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