Towards establishing an educating and certification system for colour specialty: The experience of Taiwan

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Mastering colour has been an important skill for various industrial applications involving visual experience, from display, printing, dying, lighting, to all kinds of design. However, the knowledge of colour is not readily accessible to general colour users or even to colour manufacturers. This paper reports Taiwan's experience on establishing a systematic colour teaching and training program with a standardised certification process to recognise one's colour proficiency. The colour experts in Taiwan Colour Association, Technology Research Institute, and colour industry in Taiwan had jointly designed the Occupational Competency Standards (OCSs) which encapsulate the knowledge, skills, and aptitudes required in one's particular occupation related to colour specialist. The OCSs serve as a backbone for subsequent developments of colour textbooks, colour training courses, and the certification exams. With many preparation and promotion efforts, in the end of 2018, the first iPAS certification of the Associate Level of Colour has appealed over 1000 participants to sign up for the certification. We believe this ongoing project will elevate Taiwan's professional colour education and accelerating colour industrial development.

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Introduction

The term colour is a common word for everyday use, yet being a professional field it is too complicated to comprehend in depth. The knowledge of colour encompasses a multitude of domains, from physics, physiology, psychology to art and humanity aspects, and it involves numerous commercial and industrial applications. Mastering and managing colour have been essential skills for whom provide the products and services engaging people's visual experience. However, the education of colour profession has never been straightforward. To estimate one's colour professional knowledge is even more complicated. In the past two years, we have dedicated to proposing and fulfilling a promising colour educating and certifying system. This article attempts to share Taiwan's experience on establishing the methods for training and certificating colour specialty.

According to Taiwan's most prominent online human resource platform (104 Human Resource Consultancy) [1], among the current total 210,000 job vacancies, there are about 1400 named with "colo(u)r" in the job title. These occupations are colour designer, colour planner or coordinator, colour quality manager, colourist, colour engineer, colour scientist, colour stylist, colour instructor, and colour, material, finish (CMF) designer, and so on. Moreover, there are about 12,700 jobs that require colour to be one of the applicant's specialties in their recruitment descriptions. The enterprises that are recruiting people with colour specialty are from industries of display technology, printing, lighting, cosmetics, paints, retail and marketing, textile, graphical, packaging, interior, and product design, media and entertainment, and the organisations of art exhibition and art education. Colour is a desirable specialty in the employment market for a manufacturing-based economy such as Taiwan, but educating and training colour specialty seems to be challenging. We found that the comprehensive colour training and educating resources are not readily accessible to the colour educators and the colour industries in Taiwan. Although there is a considerable amount of colour courses in Taiwan's education system, their quality and the impact remain questionable. With these in mind, the Color Association of Taiwan (CAT) had conducted several surveys to investigate the status of colour education as well as the industry employment demand for the colour specialty. Our preliminary findings have actuated a four-year project that aims at building a system for educating and certifying colour specialty. This project has been conducted jointly by three organisations, CAT, Taiwan Association of Color Application (TACA) and the Industrial Technology Research Institute (ITRI). The efforts devoted to this project focus mainly on developing and integrating colour teaching materials, designing training courses, and developing examining methods for evaluating one's colour knowledge and skills. We also planned an employment promoting package for the participants/trainees who have certified their colour specialty through the system. With the many bits of help from numerous colour experts from Taiwan's academics and industries, we have successfully received the attention and support from the Ministry of Economic Affairs (MOEA) of Taiwan. Our proposal of colour certification system has been recognised to be one of the promoting items within a massive national project, Industry Professional Assessment System (iPAS). From the perspective of professional education, the whole idea about iPAS is to reduce the discrepancy between the academics and industry. It selectively supports the potential job applicants from the universities, enterprises or individuals to gain the knowledge and skills that apply to specific industries. The iPAS also introduces the participants who passed the training and certification to the selected industries, and all those tasks would be beneficial to domestic industry upgrading.

Figure 1 shows the status of the colour certification, which is called "Certified Colour Planning and Managing Colour Specialist" (CPMCP). Under the iPAS structure, the Associate level of the CPMCP was distinguished as two different fields and are titled Colour Planner and Colour Engineer, respectively. These two job titles are corresponding to the design-type and engineering-type occupations in colour related industries. A common exam subject of the two titles is Basic Colour Science, while the other two selectable subjects are Practice of Colour Planning (for CPMCP Colour Planner) and Colorimetry (for CPMCP Colour Engineer). The Specialist Level of the CPMCP targets at a specific colour application field - Colour, Material, Finish (CMF). According to our empirical surveys on the demand of enterprises for the advanced colour professionals, we find aiming at educating and certifying professionals with CMF skills would significantly strengthen Taiwan's industrial design capacity. In addition, a survey from the academics shows that the practical CMF knowledge is not readily accessible in current design education in the colleges or universities. The specialist level of the certified title will be CMF Designer. The training material and courses and certifying methods are now under development.

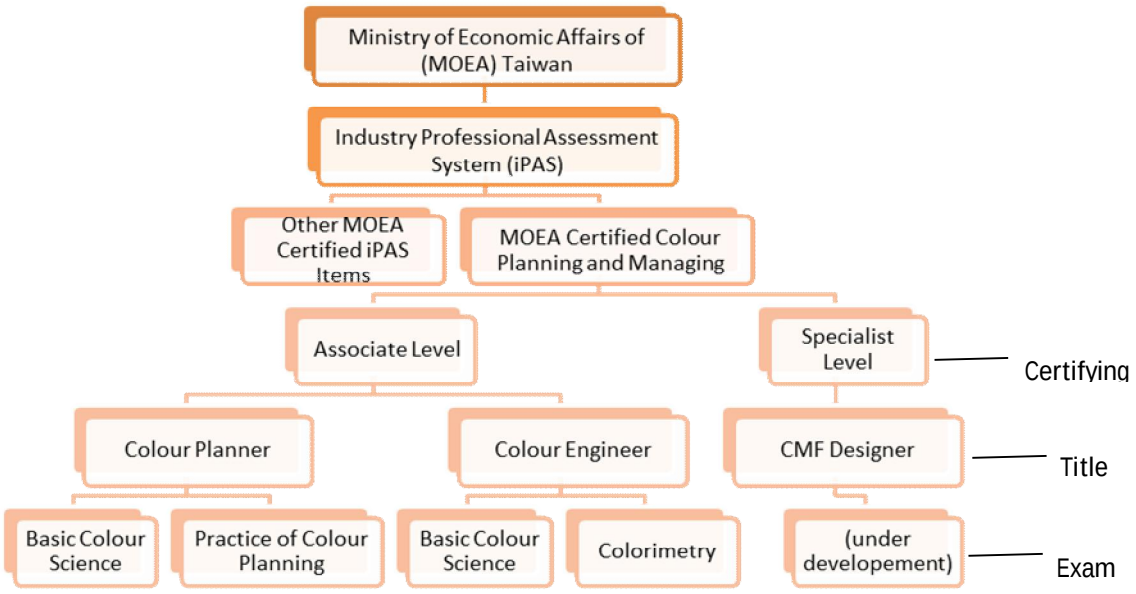

Figure 1: The structure of the MOEA the Certified Colour Planning and Managing Colour Specialist under the national project "Industry Professional Assessment System" (iPAS).

To establish the iPAS CPMCP system, we set out several staged works as listed in Figure 2. Thanks to the contributions from ITRI, CAT, and TACA, these works were successfully carried out during 2016 and 2017.

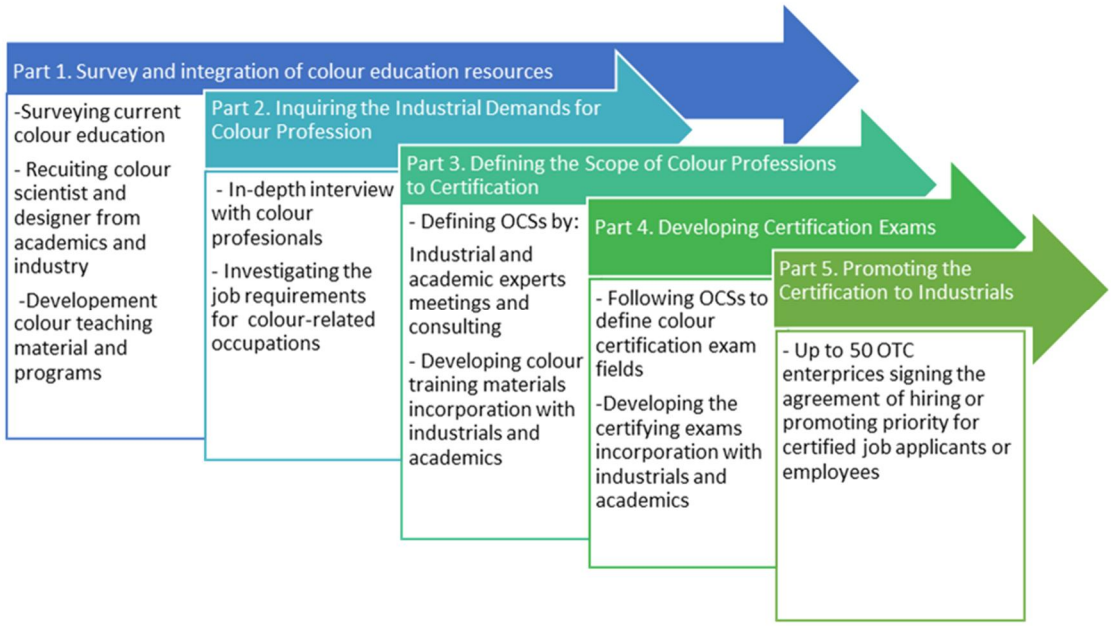

Figure 2: Overall object flow of the four-year project of MOEA Certified Colour Planning and Managing.

There are five parts of work to implement iPAS CPMCP: Part 1 - survey and integration of current colour education resources in Taiwan. Part 2 - inquiring the industrial demands of colour as a profession. Part 3 - defining the scope of colour professions to certification. Part 4 - developing the iPAS CPMCP certification exams. Part 5 - promoting the iPAS CPMCP to the Industrials. The first two parts are the preliminary groundwork of the project, which will be elaborated in later sessions of the article. Researchers in CAT conducted these two parts of works during 2016 and early 2017. The tasks

in Part 3 serve as the backbone to the follow-up works because it constructs the Occupational Competency Standards (OCSs) of the iPAS CPMCP. By definition, the OCSs encapsulate the knowledge, skills, and attitude that are essential in one's particular occupation [2-3]. The OCSs were defined in stage Part 3 which provide the particular range of colour knowledge and skills in an organised manner, so we could follow the OCSs to develop the teaching material, training course, and the certification exams. Another vital part of work is to introduce the iPAS CPMCP to related industries and make the certification influential in their employment and promoting mechanism. So far, there are over 50 OTC enterprises which have signed the agreement recognising the Associate Level of the iPAS CPMCP as an applicants' or employees' advantage in their system of hiring or promoting.

Part 1 - Survey and integration of colour education resources

Current Taiwan's institutionalised colour education

We reviewed Taiwan's current colour education resources beforehand. Within the 12-year compulsory education system in Taiwan, colour has been introduced as one of the human visual features in the first two years of primary education and later on as an aesthetic element in the areas of the arts and humanities. The incorporation of colour courses into Taiwan's professional education begins in the technical and vocational education system, where a two-credit colour course is a required course for the students of senior vocational schools with major in design. These include visual communication design, interior design, advertisement design, beauty and fashion design and so on. Their basic knowledge of colour would be evaluated in some written-based exams in some professional certifications which is held by the Ministry of Labour of Taiwan.

Taiwan's immensely popularised higher education makes the college degree become the standard requirement for most job vacancies. One will find that colour-related courses are surprisingly popular if looking into the status of colour education in Taiwan's college or universities. Figure 3 presents the colour-related courses that provided by diverse departments in Taiwan's colleges and universities.

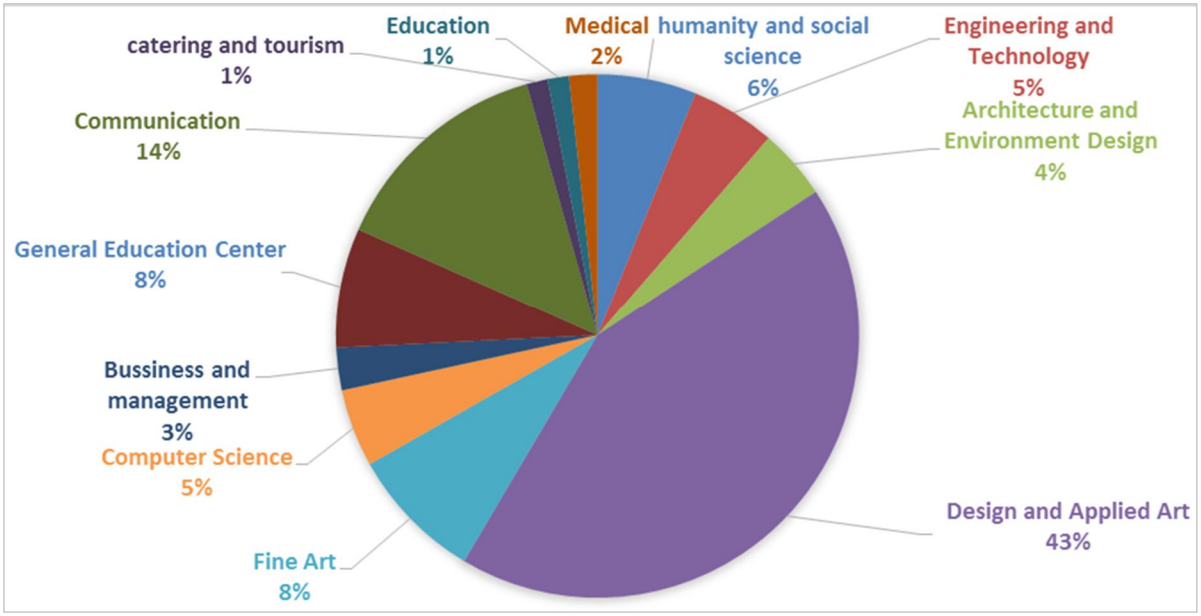

Figure 3: Colour-related courses in various departments of Taiwan's Universities.

Among the total 558 colour-related courses that opened during 2013-2017, there were 43% are from the departments of Design or Applied Arts. The others were opened by departments of Communication, Education, Fine Art, Humanity and Social Science, computer science, Engineering and Technology, Business and Management.

The publication of colour textbooks in Taiwan

Colour-related courses are widely found in Taiwan's higher education, as well as books addressing colour. Through a thorough survey of publication in Taiwan (in Traditional Chinese), we found hundreds of colour design or colour planning textbooks available, but only a few of them provide well-organised solid content. We found that a few textbooks cover the colour science and techniques, such as colorimetry or digital colour imaging. Although these few books provide rather comprehensive content of colour science, however, they describe too many technical details and that might make them inadequate as reference books for the iPAS CPMCP participants with art or design background. As a result, we concluded that the colour experts in CAT should develop a book for those without technical colour background, but with intention to prepare themselves to take the exam subject Basic Colour Science.

The writing plan of a colour textbooks

To produce a coherent colour textbook for teaching or self-learning the knowledge about basic colour science, seven colour experts in the Color Association of Taiwan have initiated a writing plan to produce a new colour textbook for the iPAS CPMCP in Traditional Chinese. The seven co-authors are from different fields, physics, industrial design, graphic design, printing, lighting, digital archiving, photometry, and colorimetry. Many of the authors are well-established scholars who have published colour textbooks or journal papers regarding colour study issues. By exchanging the points of view from each author's specialty, several plausible structures of colour knowledge had gradually emerged. The book structure integrates several studies referring to the scope of colour knowledge, for example, Su [4] described the dimensions of the colour fields by using a two-dimensional diagram where the two axes are humanities versus technologies and theoretical principles versus applications. Colour related fields such as textiles, dyeing, printing, paints, image technology, display technology, and all aspects of visual design, are distributed along these axes. No matter how diverse the colour application fields can be, all extend fields or sub-fields share the same core knowledge. Also, Bergström [5] indicated that colour science is an essential subject to creative colour education.

The scope of the new colour textbook addresses not only existing knowledge of colour from academics' view, the authors also valued integrating the theoretical and applied phases of colour knowledge. Practical issues such as how the principles of colorimetry lead to the process of colour management and to colour reproduction, or how the phenomena of colour psychology can be transformed to graphic design guidelines. To enrich the practical side of content, the authors had visited the workplaces and interviewed current leading companies with advanced colour technology or equipment in Taiwan. They also added the currently in-use industrial standards and colour workflow into the new book. With the cooperation of academics and industrials, and humanists and scientists, the first colour textbook for iPAS CPMCP in Traditional Chinese was finally published in the April of 2018. The book includes these chapters: the foundation of colour, colour vision, the principle of digital colour, the psychology of colour, colour design and planning, colorimetry, colour engineering, and finally the industrial colour applications. This writing plan featured in integrating the colour wisdom from humanity, science, and technology.

Part 2 - Inquiring the industrial demands for colour profession

The second part of the project iPAS CPMCP is to evaluate the gap between industries and academic educations on their expectations on the well-educated colour professionals. There are studies indicating that the courses of colour science are not properly provided in areas like architecture [6-7], design [8-9], technologies [9] including computer graphic [10]. To know the situation in Taiwan, the first thing we did was to survey the existing colour-related courses in the higher education system. Figure 4 is a pie chart showing the proportion of various titles of colour-related courses which have been provided in colleges and universities during 2013-2017. More than half of the courses are named "Colour Theory" which supposedly teach basic colour theory and colour phenomena demonstration. The rest of the courses focus on specific applications or sub-fields of colour, such as Colour Planning, Colour Management, Colour and Culture, Colour Science and Technology. It seems that almost half of the colour courses are introductory courses in freshman or sophomore. To know whether the students who taken the colour courses carry sufficient knowledge when they are entering a work that requires a colour professional, we conducted a questionnaire survey to acquire industrials' opinions.

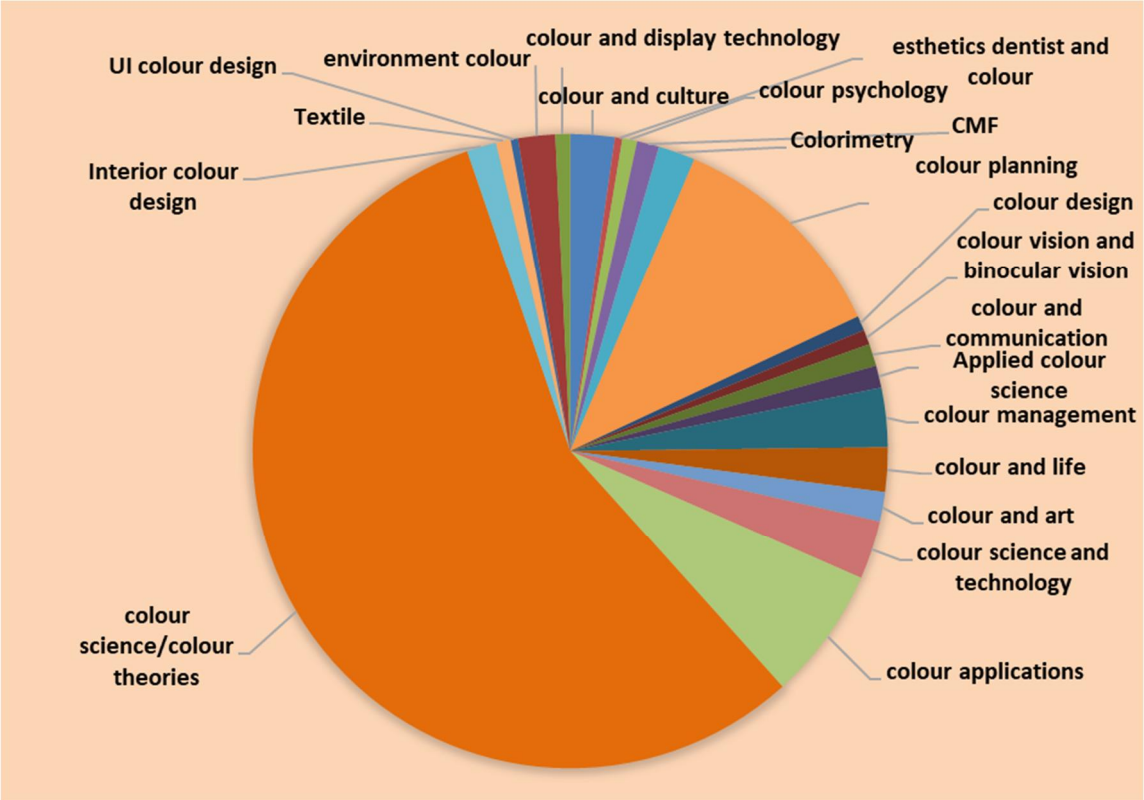

Figure 4: The title for the colour-related courses.

We invited over 50 informants to participate in the questionnaire survey, and the results have shown that the discrepancy between academics and industrials on the expectation of colour professional somewhat depends on the field of colour application. We found that there is almost no apparent discrepancy in colour engineering field such as electro-optical. However, the industrial representatives from colour engineering pointed out that current colour educators should bring more knowledge about current industrial standards of colour to the students. Also, the informants pointed out that many statements in current textbooks and other teaching materials are too old. On the other

hand, the representatives from the field of industrial design have claimed the difficulty of recruiting capable CMF designers even that the job applicants have the degrees from very competitive design departments of universities or colleges. The quality of human resource in industrial design is critical to Taiwan's economy, and the quality of CMF design is especially critical to making successful consumer products. Unfortunately, our survey revealed the fact that the current education resource cannot either provide or afford the appropriate training for the CMF design.

Through the surveys from the aspects of education and practice, the scope of an adequate colour knowledge set with consideration of local industrial need has formed. We expect this colour knowledge set would be interdisciplinary and spreadable across engineering and design fields. Most importantly, we hoped this colour knowledge system features in reflecting Taiwan's industrial environment. With these consensuses, the next step is to build the structure of this colour knowledge set.

Part 3 - Establishing colour professions standards for certification

The Occupational Competency Standards (OCSs) describe a structure of the colour knowledge set that would become the backbone that supports the development of all the preparation works of iPAS CPMCP. We defined the OCSs of CPMCP through several expert committee meetings, where there were 15 experts from different colour fields including product design, printing, lighting and colour imaging. Over half of the committees are industrial representatives, while the others are the representatives from the research centres or universities.

After intensive discussions during the OCSs meetings, the committee board sorted out four areas of industrial colour applications in Taiwan – colour design, electro-optical colour engineering, colour management, and CMF design. The colour design refers to the colour decision making works such as colour planning during the design projects of graphic, media design and industrial design. The electro-optical colour engineering refers to the colour techniques that used in the fields of developing lighting, display, and digital imaging. The colour management involved colour quality control tools and procedures that applied in printing, packaging and textile industries. The CMF application refers to the design and manufacturing works on the appearance of products through utilising different colorants, materials or surface treatments such as coating or polishing.

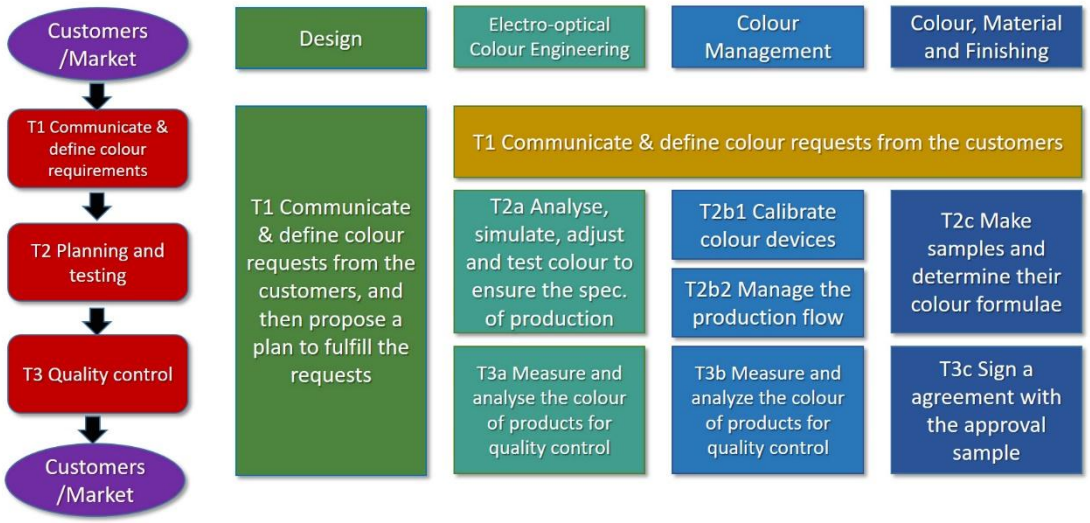

Figure 5: The specialisation of colour skills in four areas of industrial colour applications.

As the four areas of industrial colour applications in Taiwan were identified, the iPAS CPMCP experts meetings continued with clarifying the colour-related ability that mutually required among these four areas. Figure 5 is a chart presenting the specialisation of colour skills in four industrial colour applications. The left vertical chart list a general workflow of developing the colour products, and the top horizontal chart lists four colour applications areas. T1 to T3 represent the three staged tasks where each task is varied in detailed dependently on the area of applications. For example, the colour design works are heavily relying on T1, which is the communication and defining of proper colour with clients and users.

Exam Fields (Subjects)	Exam Sub-fields	Topics for Evaluation
Basic Colour Science	Colour Phenomenon	Seeing Colour
		Colour Vision Theory
		Colour and Lighting
		Components of Colour Vision
		Colour order System
		Principle of Colour Mixing
	Basic Colour Application	Digital Colour
		Basic Colorimetry
		Colour Reproduction
		Image and Software
		Basic Colour Plan
		Basic Colour Management
		Basic Electro-optical Colour
	Colour Psychological	Colour Perception
		Colour Visibility and Saliency
		Colour Contrast and Assimilation
	Principle of colour Harmony	Colour Tone and Colour Harmony
		Hue Difference Based Colour Harmony
		Tone Difference Based Colour Harmony
		Colour Similarity Based Colour Harmony
Practice	Practice of Colour Planning	Sorting Colour Samples by Order of Colour Attributes (Lightness, Chroma and Hue)
		Identify the Colour Notation
Colour Metrology	CIE System	Lighting and Vision
		Spectrum and Colour Temperature
		Light and Vision
		CIE Photometry
	Colour Measurement	CIE System of Colour Specification
		Colour Difference Formulae
		Colour Measurement Instruments

Table 1: Occupational competency standards for the associate level of colour planning and managing.

After the committees had formulated the staged tasks in each colour application field, they continued to conceive the work output, behavioural indicators, domain knowledge, and skills corresponding to every task in Figure 5. Specifically, this process is to transform the tasks into concise and workable statements so that they would guide the following training material and exam developments. For example, the work output of T1 can be a colour analysis report or colour planning document after interviewing with the clients. The behavioural indicators of T3 can be operating some colorimetrical instruments correctly. The knowledge part of the task could be some sub-area of colour theory or principles, such as trichromacy theory or additive colour mixture. Table 1 organises the scheme of tasks and each work output, behavioural indicators, domain knowledge, and skills correspondingly, and these items form the base the Occupational Competency Standards, OCSs. The OCSs present the colour knowledge and skill set for iPAS CPMCP that are well-structured, industrial-relevant, and suitable for teaching and testing. These OCSs were also merged into the structure of CAT's colour textbook and later training courses and even the examination design. Based on the OCSs, the learning and verifying scope of iPAS CPMCP is coherent.

Part 4 - Developing the certification examinations

The final, crucial part of the whole work was to develop the examinations for qualifying the colour specialty. Since the formal certification for the colour specialty exists in only a few industrial countries, so we dealt with this part very cautiously. We began with surveying and compare the existing certifying systems around the world.

Japan may have the most developed certifying system for the colour specialty. There are two colour certifications in Japan, Official Business Skill Test in Color Coordinator (OBSTCC) [11] that is organised by The Tokyo Chamber of Commerce and Industry, and AFT Color Test [12] by All Japan Fashion Teachers (AFT) and The Color Test Institute (CTI). Both certifying organisers are experienced with producing teaching and training materials and courses, and these certifications are quite popular in Japan. On average, more than fifty thousand people participate in the tests every year. There are three certification levels in both certifying system in Japan. In the certification of OBSTCC, the subjects of examination are finely divided into basic colour vision, colour psychology, colour order system and colour planning, and the advanced level includes colorimetry as an exam subject. Not only Japanese value the qualifying of colour professional, South Korea [13] and China [14] have established similar tests in recent years, and the certified participants are also named colour coordinators.

The above certification systems intend to qualify the general capability of colour. There are also some other certifications that aim at a specific type of colour competence, such as the Idealliance G7 Expert Certificate [15] is to verify colour management skills in printing quality control. Although basic colour knowledge is fundamental to the fast-growing and widely-applied field of colour imaging engineering, the qualification on colour engineer's colour knowledge seems to be underestimated. Currently, there is no certification on the application of colour engineering, but there are some available training materials. For example, the SID's International Committee for Display Metrology (ICDM) has provided solid photometry and colorimetry learning materials based on its display measurement standard [16].

Having OCSs as the backbone and referring the frame of the existing colour certification systems and examination methods, we finalised a white paper that planning all details with the certification, including the certified title, the scope of the examination, the reference publications, and regulation of

exam subjects, and content in each exam subject. The formulation method of the questions of the exams was also specified in the white paper.

There are three exam subjects at the associate level of iPAS CPMCP, where the subject Basic Colour Theory is the compulsory subject whoever choose the field of the colour planner or colour engineer. The subject Colorimetry is for one who chooses to certify the colour engineering, while the subject Practice of Colour Planning is for certifying colour planning. The form of examination would be the multiple-choice questions except for some part of the subject Practice of Colour Planning. The exam developers of the subject Practice of Colour Planning designed some hands-on questions with the tasks of arranging printed colour chips by order of colour attributes or harmony principles.

Figure 6 describes the procedure of exam development. First of all, we invited six colour experts as question developing committees and another six as question reviewing committees for each exam subject, and half of the experts are from industrials. The second step was that the exam committees produced certain amount of exam questions according to each specialty and form a question bank of each exam subject. Then we organised the first review meeting to check if the questions are clear and meaningful. The fourth step is inviting 18 testers (six for each exam subject) to take a pre-test. This step was to estimate the difficulty and the validity of all the questions. Finally, all the committees hold a second refining meeting to modifying the questions based on the results of the pre-testing.

Figure 6: The five stages of the examination development.

The exam developers documented each question within the question bank by recording the reference sources of the question, which colour topic it belongs, and the difficulty level of the question. This documentation helped us to make sure that the questions are reasonably assigned to each exam subject.

Besides creating three question banks for each of three exam subject of iPAS CPMCP, the exam development committee edited the guidebooks for participants to prepare themselves for the exams. The 70-page guidebooks comprise the content summary of the subject exam, examples of questions, and a list of reference books and extensive readings. These guidebooks are useful to teachers who tend to prepare their students to take the iPAS CPMCP exams.

Conclusions

With many preparation and promotion works, in the middle of 2018, the first iPAS certification of the Associate Level of CPMCP has appealed over 500 participants to sign up for the test. We estimate the total number of participants will reach 1,000 by the end of 2018. We believe this ongoing project will elevate Taiwan's professional colour education and accelerating colour industrial development.

Acknowledgments

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