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理事長序

現今科技與藝術發展迅速，創新思維，結合設計及數位科技，跳脫傳統媒介與框架已成趨勢。了解設計本身的內容，將傳統媒介進化並運用數位科技，從以往的傳統媒介轉變為新興的數位工具，建構出豐富的面貌及內涵。不同的學術、藝術創作及評論如此豐富多樣。研究以不同角度涵蓋美學、設計、情感、科技等不同領域，以客觀的角度探究並思索其中的課題，並作為未來研究，創作交流的方向與基礎。結合文化創意產業、透過視覺化傳播方法達到文化行銷與傳播。

自 2009 年 IJDMD 國際數位媒體設計學刊發刊以來，已進入第八年，本期為今年發行之第八卷第二期期刊，共收錄兩篇英文研究論文、三篇中文論文。探討內容包括有(1)英文論文「Modeling Distributed Interaction with Dynamic Agent Role Interplay System (DARIS)」運用 DARIS 系統將角色扮演理論應用於設計師互動行為中內、外部的設計情況及設計過程；(2)英文論文「The Challenge of Online Environment for Design Teaching」探討線上環境下數位學習平台的現況及仍需解決的設計教學，達成以用戶為中心的線上環境，並提供線上環境的樣本作為未來設計教學的方向；(3)中文論文「數位遊戲融入色彩教學之適切性分析」藉由結合數位遊戲中情境模擬與所見即所得的特性，擬定有效之教學設計，結合數位遊戲與色彩教學應用在課堂之中。增強學生學習色彩的興趣與動機、學生對於配色練習適切性與課程滿意度；(4)中文論文「整合聲音、影像、文獻紀錄之文創類型展示媒體研究」將創新的軟性電子音響(FleXpeaker™)加以設計運用，將事件、歷史時空背景和現場環境的訊息融合，形成新的美感體驗;(5)中文論文「可攜式 3D 多媒體排球教材開發及對大學生學習動機及自我學習成效之研究」融入 ARCS 動機學習理論，設計一套包含發球、托球、接球及攔網等 3D 多媒體排球教材，可以有效提高學習者的學習動機並提升自我學習成效；。

本期來稿 11 篇，經專家匿名審查後，5 篇論文接受刊登。感謝各方學術先進賜稿，擴展本刊研究範疇，以及協助審查的委員們給予學術專業協助，深化本刊學術深度及內容專業。

理事長 徐道義

Preface by the Editor-in-chief

Nowadays, technology and art develop tremendously along with ages. Combining design and digital technology, new technology can really change our ideas and lifestyle and take us out of the traditional bracket. It is important to understand the meaning of the design, and interpreting traditional mediated environment with digital tools. In order to become more diverse and exciting. The evolution of traditional media and the use of digital technology, from the traditional media into the new digital tools, to build a rich look and meaning. According to current research from the points of views of aesthetics, design, sentiment and technology, we can carry out our academic and creative research more objectively to explore, research and interact with others becomes a major important topic for researchers, as the direction and foundation of future research. To combine cultural with creative industries through visual communication to achieve culture marketing and communication.

Since 2009, the first published of International Journal of Digital Media Design (IJDMD), has been 8 years. This Issue is the volume 8th, issue 2st of this year, and including 2 English and 3 Mandarin papers. This issue including: (1) English paper of"Modeling Distributed Interaction with Dynamic Agent Role Interplay System (DARIS)". This research applies role-play theory onto modeling the interactive behaviors of designers with internal, external design situation and design process. (2) English paper of "The Research of Applying Interactive Technology and Multi-interactive Interface of Smartphone into Theme Park Applications". The paper concludes that current e-learning platforms need to address the characteristics of design teaching to achieve a user-centric online environment. A sample layout of online environment is suggested at the end to meet the needs of design studio teaching. (3)Mandarin paper of "A Study on the Appropriation of Integrating Digital Game into Color Teaching and Learning". This research was conducted to discuss the appropriation and learning effects of integrating digital game into Chromatics teaching and learning. The result of study has led to a significant outcome in students' color matching practice. (4) Mandarin paper of "The Study of Applying Creative Media and Exhibit Design to the Integration of Sounds, Images and Data in Cultural-creative Curation ". the invention of digital devices and contents has revolutionized the quality of sound, image, and data, the way in which they are contemplated, and the forms of art that produce activities and aesthetics concepts. (5) Mandarin paper of "A Research on the Development of Portable 3D Multimedia Volleyball Learning Materials and the Effects on College Students' Motivation and Self-efficacy". In this study, the ARCS theory of motivation is incorporated, and a set of 3D multimedia volleyball learning materials. And the materials are proven to be effectively enhance learning motivation and boost self-learning outcome.

This issue had received 11 papers, and we accept 5 papers after experts anonymous reviewed. Appreciate for all the papers that sent to us and support the journal to increase research range. Also thanks to the academy support by all the assist from the committees, allow our journal to have more academy depth and professional content.

Editor-in-Chief ***Tao-I Hsu***

Modeling Distributed Interaction with Dynamic Agent Role Interplay System (DARIS)

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ABSTRACT

Design is an interactive activity that will invoke different interaction between various knowledge entities within different design problems in dynamic design situations. For unleashing the interactive behaviors among those, this research applies role-play theory onto modeling the interactive behaviors of designers with internal, external design situation and design process. By adopting the mechanism of Acting Role Model (ARM) and agent technologies, an intelligent dynamic interacting design system called Dynamic Agent-based Role Interplay System (DARIS) is proposed in this paper. The implementation and an exemplary usage of DARIS in a brainstorming meeting are demonstrated.

Keywords**:** acting role model, agent-based design system, distributed interaction, design process, role interplay system, role-play.

1. Introduction

Design is an interactive activity that will invoke different interaction among various participants in the dynamic design situation, especially in the conceptual design stage. For solving design problems, designers always collaborate with each other by interacting their individual knowledge internally, as well as participants' knowledge externally (Teng-Wen Chang, 2006; Lai & Chang, 2006). Such interactions within the collaborative process involve the dynamic exchange of varied information possessed by distributed knowledge (Teng-Wen Chang, Chang, & Chen, 2011; Faste, Rachmel, Essary, & Sheehan, 2013; Lai & Chang, 2006). For example, the construction management is through the arranging resources along a time-line axis. Once the resources have been arranged, different participants (such as agent, consultants, design experts) will follow the schedule ideally and accomplish the internal and external knowledge.

First logic approach is to provide an integrated framework that can realize different aspects in different disciplines within a design session. Several large integrated frameworks such as SEED (Flemming & Woodbury, 1995), KAUS (Ohsuga, 1989) and IBDE (Fenves, Flemming, Hendrickson, Maher, & Schmitt, 1990) have been proposed and implemented for supporting collaborative and interdisciplinary design in terms of computational perspectives. Therese frameworks provide ingenious computational model for solving real and complex design problems. However, the diverse nature of components in these integrated frameworks especially the ontology of knowledge-bases in different disciplines increase the complexity of communication during design dramatically. It is very difficult to have working integrated frameworks without embedding the knowledge in the communication.

Inspired from agent system design and expert system, instead of a knowing-everything framework is to develop small, distributed but dynamic components representing the diversity of knowledge in opportunistic collaboration. Each dynamic component only needs to know input and how to react upon that knowledge.

In design practice, large companies often manage complexity by encouraging sub-contracting into small and distributed firms. This phenomena leads to design offices getting more fragmented, distributed and digitally mediated work practices. Consequently, small, specialized design offices play an important role in the current architectural and engineering design industry. Due to their design-oriented and small-scale organization, limitations such effective information exchange, meeting timelines and team flexibility are experienced in such collaborations. These limitations constrain the productivity and diversity of design generated during the design process.

Furthermore, many design problems are resolved via interacting with either designers themselves or with various domains of participants during the design process. In the interactive process, the designer not only takes appropriate "action" for solving the design problem, but also takes appropriate "re-action" to respond to different participants' knowledge. Due to the characteristics of such act/re-act (such as reflection, relation, confliction, and so on), it is hard to understand the nature of interaction among different participants in real design situations. Therefore, the primary objective of the study is to model the behavior of small design offices in dynamic and changing situations. A secondary objective is to understand how designers act/re-act with distributed collaborators during the design process.

The theory of *role-play* in cognitive psychology provides an important anchor for our study of the act/re-act process. The theory provides a mechanism to model multi-knowledge distribution, knowledge sharing, and particularized interaction in dynamic design situations (Yardley-Matwiejczuk, 1997). In the computational domain, *software agents* hereafter *agents* (Neruda & Kazik, 2010; Oey, Splunter, Ogston, Warnier, & Brazier, 2010) are modeled as autonomous entities that have reactive and communicative capabilities (Lhaksmana, Murakami, & Ishida, 2013; Loreto & Hervouet, 2012; Nguyen, Hartmann, & König, 2012; Woolbridge & Jennings, 1995). Agents interact with the external and internal situations in a dynamic manner (Klammer, Anker, & Janneck, 2010; Man, Heuvelink, & Bosch, 2012; Mangano et al., 2011; Nakamura, Taguchi, Hirose, Masahiro, & Takashima, 2011). Hence, our approach is to model dynamic and distributed interaction in engineering design practice using agent technologies based on the theory of role-play. In the next sections we elaborate on each of these components in our study.

1.1 Role Play

In the domain of cognitive psychology, role-play describes a range of activities characterized by involving participants in 'as-if ' or 'simulated' actions and circumstances. In brief, role-play is a way of deliberately constructing an approximation of aspects of a 'real life' episode or experience, but under 'controlled' conditions where much of the episode is initiated and/or defined by the experimenter or therapist. Thus, role-play offers considerable potential, largely because of its flexibility with respect to range and depth of focus. In addition, role-play is a unique potential method to acquire the participants' subjective knowledge as well as reach a better understanding of interactions between people and a virtual situation. The method of role-play is to analyze human behaviors and the use of knowledge in the simulated environment (Yardley-Matwiejczuk, 1997).

Role-play is composed of three main mechanisms: *situation*, *scenario-based interaction*, and *engagement*. The situation is what people encounter in real life or constructed conditions in experiments; based on the situation, people act/re-act respectively. The interactions between people are what we called scenario-based interaction. The engagement represents the induction on the actors' acting that people make during the play. Actors then possess their own knowledge and present the psychological actions. The three mechanisms are elaborated as follows:

(1) Situation: The design situations, or 'given circumstances', include the facts, events epoch, time, and place of action that are supplemented by people imagination. Thus, people must reconstruct and form an act according to the situation. This mechanism mirrors situated designing proposed by (Clancey, 1997; Gero, 1998) and in studies of the behavior of designers encountering different design situations.

(2) Scenario-based interaction: The interaction of role-play must be based on a specific situation. As Stanislavski claimed, "an actor can be living a part only when he seeks to communicate with his partners, when he strives to influence them and is influenced by them" (Stanislavski, 1968). Thus, the actor's performance on the stage is primarily a process of real life interaction. By following the description of the given circumstances, or environment, the interactions of characters must be the most important behavior in the play, in which they act with each other and with the material of the play.

(3) Engagement: The main behavior of role-play engagement is *induction* (Yardley-Matwiejczuk, 1997). There are three main induction principles for engagement: *personalization*, *presenting*, and *particularization*. His emphases are (1) on the actor's intimate and meticulous knowing of the 'given circumstances', (2) on the 'objectives' of the play and (3) on the search for dynamic roots in his or her own experience to be specific and realize these roots.

1.2 Agent

For the distributed nature of our problem, the computing theory concepts of agents and their applications are brought into our implementation consideration. Briefly speaking, an agent is an autonomous system that senses and acts on the environment it is situated in. Furthermore, Wooldridge and Jennings argued that an agent system should be composed of social ability and reactivity (Woolbridge & Jennings, 1995). Therefore, autonomy, reaction and communication are three important behaviors of agents.

Different agent framework often divides the domain problems into several partitions and describe the distributed behaviors among these partitions abstractly. For example, Deen and Johnson provide a cooperating knowledge-based system model based upon agents, cooperation blocks, and cooperation block hierarchies (Deen & Johnson, 2003). With these cooperation block hierarchies, the argumentation process of communicating agents can then be animated and the relationships between agents and spatial distance can then be visualized to further understand the communication among agents (Schroeder, 2000).

In addition, regarding of the model towards designing such cooperation blocks, several researches uses multi-actors or modeling agents as interactive components in collaborative and dynamic design situations. For example, Ligtenberg *et al.* advise a multi-actor-based land use modeling to deal with the allocation problem of spatial planning (Ligtenberg, Breget, & van Lammeren, 2001). Anumba *et al.* and Liu *et al.* propose collaborative design environments in which designers and software agents interact with each other for various design problems (Anumba, Ugwu, Newnham, & Thorpe, 2002; Liu, Tang, & Frazer, 2002). The conceptual framework of object-agents proposed by Aly and Krishnamurti further map agents as interactive object-agents that can perform design tasks in a design session (Aly & Krishnamurti, 2002).

Our approach of designing a distributed agent is similar to the object-agents of Aly and Krishnamurti (2002) with blocked knowledge-bases. Additionally, multi-actor concepts for multi-disciplines are developed further along with role-play theory for modeling the interactivity among these agents in the distributed situation. These situations can be related to the collaborative design activity and dynamic design conditions. This provides a useful computational mechanism for implementing our proposed dynamic role interplay.

1.3 Towards Dynamic Role Interplay

In summary, with the theory outlined by role-play, we can identify three important characteristics of role-play with respect to distributed interactions. For example, in a design process, a designer not only interacts with various participants, but also interacts with the external design environment; in addition, a designer interacts with his design knowledge of the internal design behavior (Suwa, Gero, & Purcell, 2000). Dynamic interplay thus occurs by interactive communication among participants. Conceptually, we call such distributed interactions *dynamic role interplay*. Furthermore, the three levels of role-play that construct the interactions of dynamic role interplay are described below:

(1) Interacting with internal design situation: By interacting with internal design situation (such as knowledge, experience, skills), designers achieve capabilities for problem solving and design inspiration. Through this interaction, internal designers' behavior can be performed externally.

(2) Interacting with external design situation: By interacting with external design situations (such as participants, design tasks, time constraints), designers perceive, reflect and understand the given circumstances. Such interaction influences designers' internal knowledge, experience, skill, and external performance.

(3) Interacting with design process: Design process involves a sequence of actions that interact with the design situation in a particular context. By interacting with design process (such as acting, communicating, playing), designers engage with the design situation interactively. Not only do designers have a sense of "as-if", but also the design situation will be changed dynamically.

In addition, agents can be considered as a distributed computational system. With autonomous, reactive, and communicative behavior, agents can autonomously participate in dynamic role interplay to interact with internal and external design situations. Therefore, integrating the mechanisms of role-play with agents provides an effective method to approach the interactions of dynamic role interplay. For identifying the three levels of distributed interactions the Acting Role Model (ARM) proposed by providing an effective mechanism for realizing these interactions of dynamic role interplay (Teng-Wen Chang, 2004; T.-W. Chang & Huang, 2002). A brief description of the mechanism as well as their framework is described in the following sections and shown in Figure 1.

many roles according to the scripts they are given. Actors can be either human or machines.

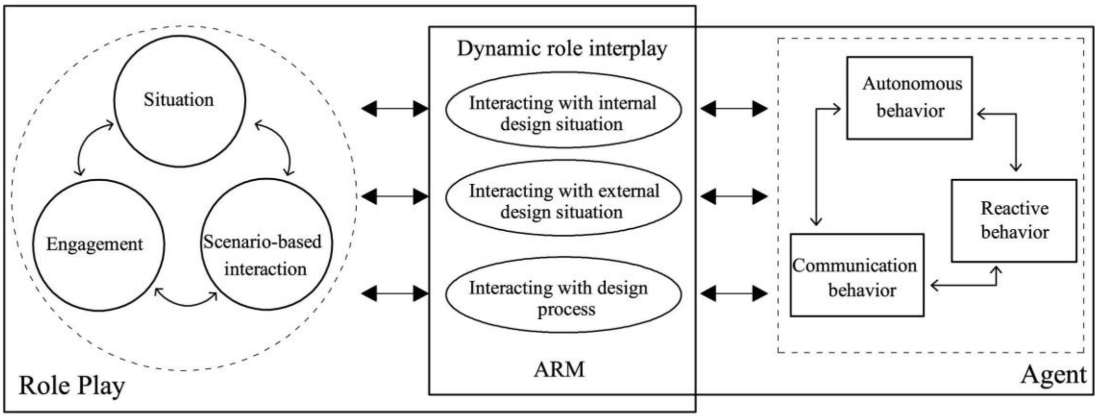

Figure 1: The diagram shows the relationship among role-play, agent and ARM

2. Acting Role Model

Acting Role Model (ARM) from Chang and Huang (2002) is a framework designed for modeling the interplay characteristics of design behavior between internal design behavior (design logics) and external design environment (the brief and context) (T.-W. Chang & Huang, 2002). Based on the separation of roles/actors and stage/scenes, ARM describes the individual interaction in terms of their capability and situated reaction. Different roles represent different sets of knowledge and behaviors that will have alternative responses to various design situations applied to them. Moreover, there are many-to-many relations between actors and roles. This gives the descriptive power of diverse situations to the design outcomes described above.

The framework of ARM is comprised of: (1) the components, (2) the interactive knowledge-bases and (3) the interplay process. Each component represents a certain aspect of interplay behavior (interactive knowledge-base) and works towards a final design outcome—the play via interplay process. Conceptually, the main components are roles, actors, stage, scripts and scenes. Each component interacts with other components under some particular definitions and mechanisms for interaction as shown in Figure 1. The definition of each component is described as follows:

(1) Actors: An actor is the participant of a play and thus is the main component of the acting role model. Actors can play

(2) Roles: Roles represent the actions that the actors can perform in the play. For example, a layout design role can only do the layout design even if the actor who plays this role might have another extensible knowledge. Obviously different actors can play the same role during different scenes of play.

(3) Stage: Stage represents the environment where the play occurs. Stage stores the play, thus the design outcome, and defines when and how the scenes can happen and the limitations a play can have.

(4) Scenes: Scenes show the sequential requirement based on the time-schedule. Only one scene at a time is shown on the stage. Each scene has either a duration time or an objective that can be satisfied by the roles on the stage.

(5) Scripts: Scripts are the name for the summary of all the descriptions above, such as stage description (including scenario narratives), role definitions and the acting policy. Each description can be regarded as a part of scripts.

In addition, three types of knowledge-bases are *role skills* and *knowledge*, the *control strategy record*, and the *design outcome*, which are associated with the actor (or role), scene and stage respectively. These types of knowledge-bases interact with others, and totally represent a particular play session in a given duration. For example, in a collaborative interplay process such as brainstorming, the components associated with individual agent knowledge interact with design situations in a dynamic manner. ARM captures this fundamental concept as distributed interactions. Following the concept, we then model an agent-based dynamic role interplay system to interact with dynamic design situations as described in the next section.

3. Dynamic Agent-Based Role Interplay System (DARIS)

ARM provides an effective method to bridge the mechanisms of role-play and the mechanisms of agent systems. Realizing ARM with the computational system is our approach. Based on the above, we model dynamic role-interplay as distributed interactions in a multi-designer collaborative environment and implement an intelligent design system called *Dynamic Agent-Based Role Interplay System* (DARIS).

3.1. Mapping three interaction with ARM

To realize the dynamic role interplay described in this paper, we map the three interactions of dynamic role interplay to the mechanisms of ARM using two strategies as shown in Figure 2. They are (1) describing internal and external distributed interactions with ARM components and knowledge, and (2) directing the interplay process to interact with the design process.

The actors indicate that designers, who possess different design knowledge and skills, play the different roles to achieve design goals in the design. Each actor (and each role) thus has individual knowledge, experience and skills to interact with the internal design situation. In addition, an actor has two more groups of knowledge, which can dynamically interplay different roles. The stage and scene represents the external design situation, including multiple design conditions, constraints, and requirements. They also have different knowledge to interact with external and internal design situations.

The script is a structure that describes an appropriate sequence of events in a particular context (Schank & Abelson, 1977). The script provides constructive information to interact with different design situations, as well as to direct the design process. For example, what roles do is to describe what the actors will do according to a certain design situation, and actors thus represent who will play which roles. Thus the diversity among actors depends on the characteristics of the role described in the script.

Interplay is an interactive behavior within the reflective actions. Interplay processes hence provide various interactions to perform the dynamic role interplay. The sequential order of interplay as well as the process itself is then defined and directed within the script. Finally, outcomes from the interplay process are competing with each other to achieve the qualification. Once qualified, the winning situation can then invoke another interplay process—learning.

3.2. Conceptual Agent Model

Based on the agent mechanism, the *role-agents* (human or software) can be analogized with actors, who can play different roles with their individual skills and knowledge. Every scene has its individual control strategy record to

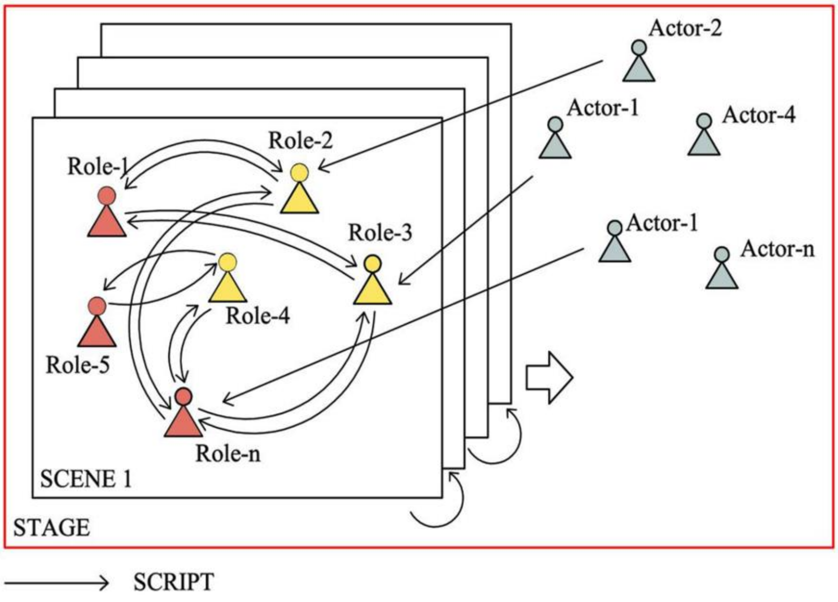

Figure 2: Component interactions in ARM

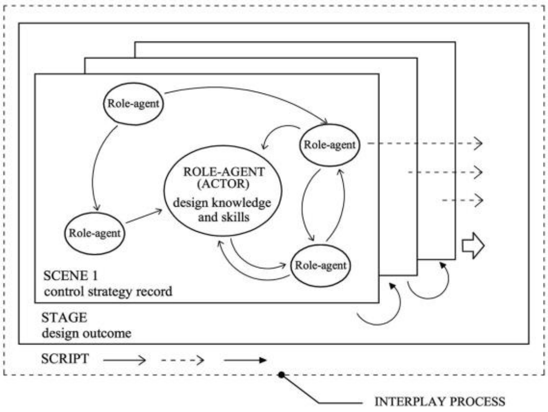

Figure 3: Conceptually mapping ARM elements with Agents

direct role-agent interactions in a communicative situation (stage). The outcome and problem of each scene can then be transmitted to the following scene. In addition, stage provides the design environment for role-agents interplay. The stage controls the scene order and stores design outcome (play) as well. Furthermore, the script is constituted as a list of events that compose a stereotypical episode, which includes role-agent list, design task, design requirements and communication messages. Through the sequential events, as described in scripts, the dynamic interplay process forms the whole play. The conceptual mapping is shown in Figure 3.

With the conceptual mapping described above, the agent model is mainly composed of three different layers for dynamic role interplay. Through these three layers, different agents dynamically interplay each other for interacting with different design situations.

3.3. Three Layers in DARIS

The three layers are: internal design situation layer, inter-process layer, and external design situation. Each layer has its own mechanism, and interacts with each layer dynamically as shown in Figure 4.

In addition, a special agent called user agent deals with the interface between DARIS and users (the human). The description of these three layers is provided below:

(1) Internal design situation layer: This layer comprises a set of role-agents. Each role-agent has its own role knowledge as well as skills for reacting to the situation assigned to it. In addition, some agents have the collaborative knowledge plus skills and role knowledge; some work alone and some works as a team. The outcomes of reflective action according to the design situation then respond back to the communication layer.

(2) Inter-process layer: Inter-process layer provides the communication required for role-agents as well as between role-agents

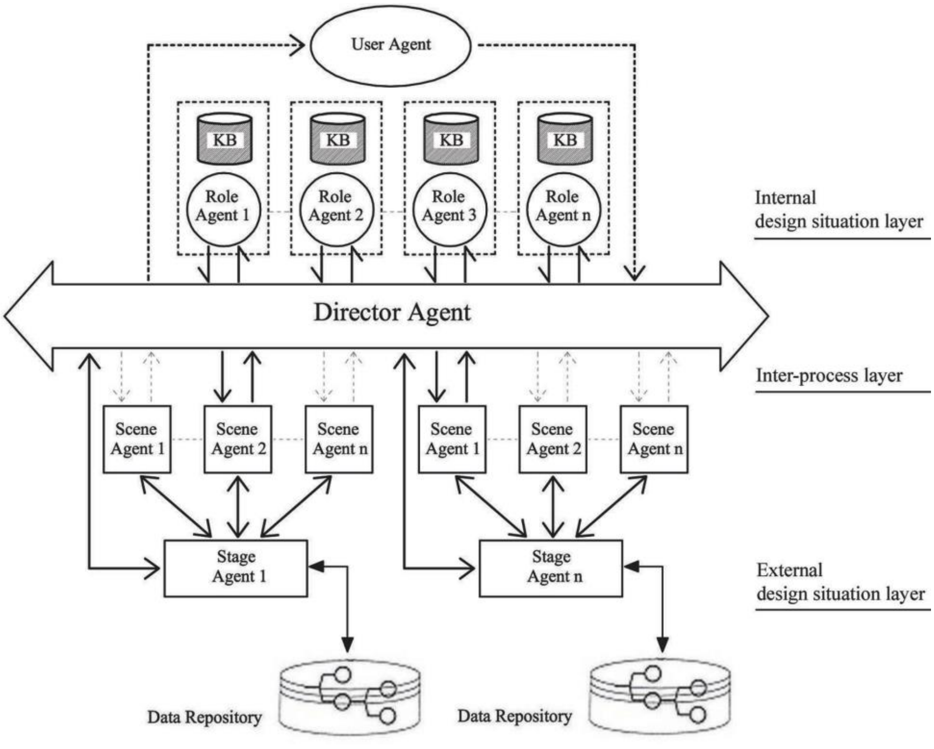

Figure 4: The interaction among three layers of DARIS

and the play. Furthermore, this layer contains only one agent who will be the coordinator for all plays as well as act as a registrar for availability of role agents.

(3) External design situation layer: This layer comprises of the stage-agents and scene-agents describing an interplay environment (when, where and who) that the role-agents will involve. Also, stage agents decide when the scene agents will be invoked and work as a bridge between interplay layer and data repository. The input of interplay comes from the inter-process layer and stores in-play objects with data repository. In addition, for storing the outcomes of the play and scene order, stage agents provide data scheme objects connecting with database for repository of interplays as well as for providing data repository to allow role-agents to learn individually.

3.4. Agent Entities in DARIS

According to the three layers described above, we define five types of agent entities: user agents, role-agents, director agents, scene agents and stage agents respectively. The agents are described as follows sections:

(1) User agents (UA): The user agent is the interface that directly interacts with the user as well as facilitates agents' interaction. For example, the user agent would ask the user to provide dimension information of the site for input parameter and send a request to the role agents. After role agents finish the user specified task, the user agent is notified and responds the result to user as shown in Figure 5.

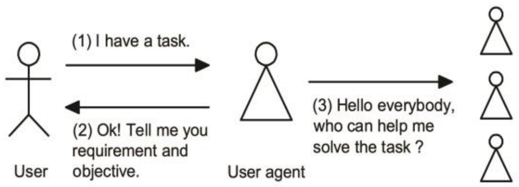

Figure 5: User agent organizes the requirement from users and builds the task requests

(2) Role-agents (RA): Each role agent has its individual problem solving skills and knowledge to solve some specific design problems. For example, a role-agent in layout problems is not necessary to fully understand different design problems other than the layout.

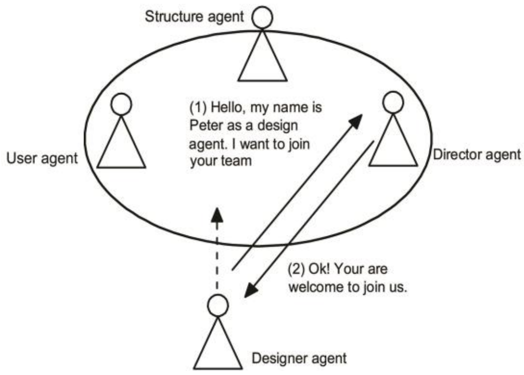

Figure 6: Each agent that wants to enter the environment must send a request to director

(3) Director Agents (DA): The director agent plays the same role as the director of the play. The major task of director agent is to be responsible for agents' participation as shown in Figure 6.
Each agent that wants to join or leave the play must ask the director agent for permission. Such operations assure that the director agent always understands how to lookup for a specific agent with specific knowledge. This is to say that the director agent provides a yellow-page like service to all kinds of agents involved in a given dynamic role interplay session as shown in Figure 7.

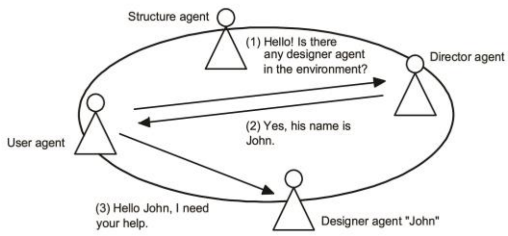

Figure 7: Director provides a yellow page like service for agent lookup

(4) Scene agent (ScA): The scene agents control three main tasks, including defining role-list, enforcing time schedule and evaluating interplay outcomes from role-agents against design goals. There is only one current ScA within any StA action. ScA sends a set of skill requests as well as a problem description to DA for starting the interplay of role agents and UAs. ScA also sends the successful outcomes of RAs (the acting) back to StA, and then stores these in the data repository layer.

(5) Stage agent (StA): The stage agents contain the sequential order of ScA. Once the outcomes (the control strategy and design outcome) of interplay are satisfied

by ScA and sent back to StA, StA then either sends the outcomes back to UA for user-approval or stores the acts into the data repository layer. StA is also responsible for determining which scene should be activated and which scene should be terminated. Once all the requests sent from UA are satisfied or the time is up, StA will then terminate the play.

3.5. System Implementation

For implementation, DARIS contains three main system components: agent architecture, agent communication language (ACL), and protocols of agent communication modes. In addition, the skill and role knowledge of RAs as well the capability of ScA and StA are implemented on the inference ability of JESS (Friedman-Hill, 2003). Each component will be introduced in the following sections.

Architecture

System architecture is following the agent abstract architecture provided by FIPA (Foundation for Intelligent Physical Agents) (FIPA, 1999; Poslad, Buckle, & Hadingham, 2000). There are five parts of the specification: application, abstract architecture, agent communication, agent management, and agent message transport as shown in Figure 8.

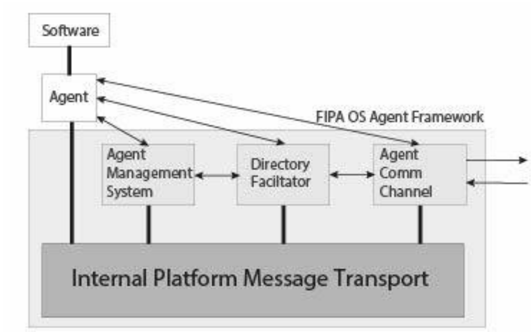

Figure 8: FIPA architecture

Agent Communication Language

The communication between our roles is via an agent communication language comprised of four components: form, content, semantics and implementation.

(1) Form: The language of DARIS is linear and thus is easily translated into a linear stream of characters for intercommunicating between layers. Since the interplay involves diverse knowledge of RAs and StA/ScA, the syntax should be extensible. This linear form can be declarative, syntactically simple, and readable by people and agents.

(2) Content: A communication language should be layered between different layers and should work well with other roles. It should express facts about the design domain. In DARIS, we define a set of ontologies according to the domain specification. In addition, DARIS provides a more feasible traverse mechanism to allow an approximate search for skillful roles (such as RAs and StAs) over a well-defined set of communicative acts between roles.

(3) Semantics: The semantics should be unambiguous and rule-based for the needs of knowledge description such as JESS. The semantic description of DARIS provides a communication model that will be useful for performance modeling, among other criteria.

(4) Implementation: DARIS is implemented in Java. Java as an object-oriented language in which it is easy to integrate and build application program interface.

Coordination Protocol

DARIS is expected to support a distributed environment. It has been designed to work with multiple transport mechanisms, and implementations have been done using CORBA objects to carry messages through the TCP/IP transport platform. In addition, CORBA is used for realizing the coordination channel between the agents in DARIS.

By implementing DARIS we can then explore and examine computational issues and reification of our methodology in terms of distributed design situations and dynamic interactions. Finally, we take brainstorming as an example to demonstrate our approach in the dynamic agent-based role interplay system.

4. An Application Example

In this section, we describe an exemplary application of dynamic role interplay using a domain design task. The example (the brainstorming sessions) is related to the three interactions described above and can be scripted using the mechanisms of DARIS.

The session concentrates on developing ideas in the early conceptual design stage. The design task is related to the spatial arrangement of a single-family house in a specific site located in an urban area. The design problem contains three design issues: circulation, view and sunlight. Basically, there are three human designers and three software agents involved in the brainstorming meeting in this example. The interplay between these six agents generates a set of design alternatives. The scripts as well as the play are elaborated below.

4.1. The Scripts

Script is a structure for describing a sequence of events and their related components that take place during the design process in DARIS, including design tasks, roles' skills, role list and communication messages. Three layers of scripts for this spatial arrangement problem are described below:

1. Internal design situation layer: There are three human agents (UA_{human1}, UA_{human2}, UA_{human3}) and three software agents ($RA_{software1}$, $RA_{software2}$, $RA_{software3}$). Each human agent is an actor that can play two roles: UA and RA. Each software agents has pre-set design knowledge (including experience and kills) for problem solving as follows:

   $RA_{software1}$ has the design rules of Type 1.
   $RA_{software2}$ has the design rules of Type 2.
   $RA_{software3}$ has the design rules of Type 3.

   In addition, the three human agents are designer experts in different geographic locations. They use computers to conduct the brainstorming session in the DARIS environment.
2. Inter-process layer: This layer contains only the director agent (DA) who is the coordinator of all plays and also acts as a registrar for availability of role agents. Any communication messages among agents should be passed through DA.
3. External design situation layer: There are a stage agent ($StA_{spatial\ organization}$) and three scene agents ($ScA_{circulation}$, ScA_{view} and $ScA_{sunlight}$) in this layer. $StA_{spatial\ organization}$ controls role agent list, scene agent order and time duration. Each ScA has control rules to evaluate the outcomes related to the design issue within a time duration as below:

   $ScA_{circulation}$ has control rules of *circulation*.
   ScA_{view} has control rules of *view*.
   $ScA_{sunlight}$ has control rules of *sunlight*.

In addition, the scenario is based on a ring-type brainstorming session (shown in Figure 9).

4.2. The Play

The play is comprised of three scenes (circulation, view and sun-light) on a stage. Each scene has a predefined design issue that needs to be solved within the predefined duration of time. Each human agent in turn plays the role of a facilitator (via the corresponding

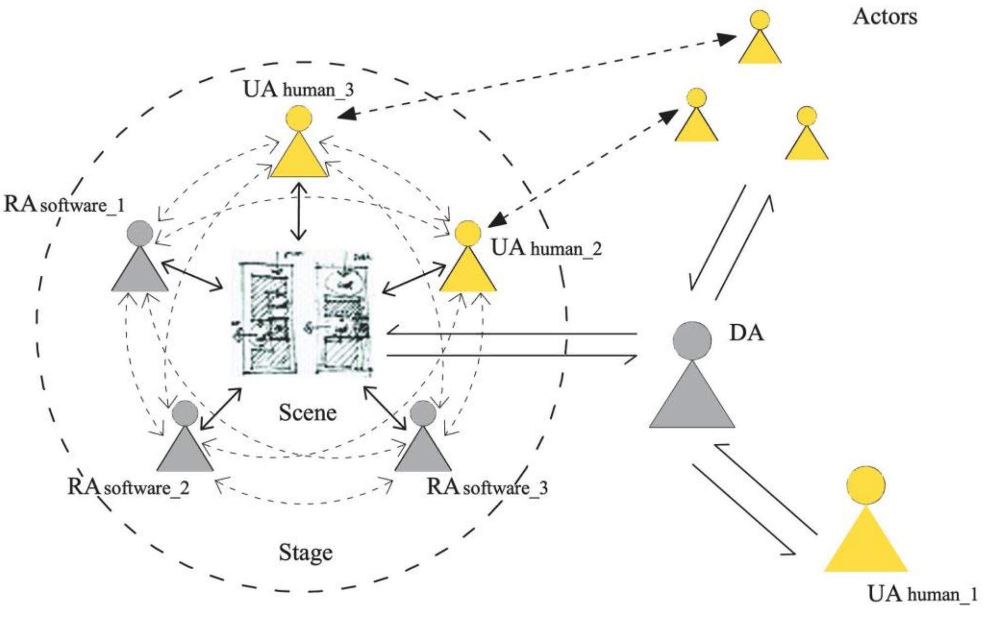

Figure 9: A ring type of brainstorming session

UAs) guiding the process in each scene. He or she acts as a facilitator that can terminate the scene and select a design outcome. The other two human agents and three software agents are invited to generate ideas. For instance, UA_{human1} inputs the first idea, and UA_{human3} terminates the whole play; therefore one example of the play can be described as shown in Figure 10. Each scene is comprised of three steps: pre-condition, idea generation process, and termination. The three scenes are described below.

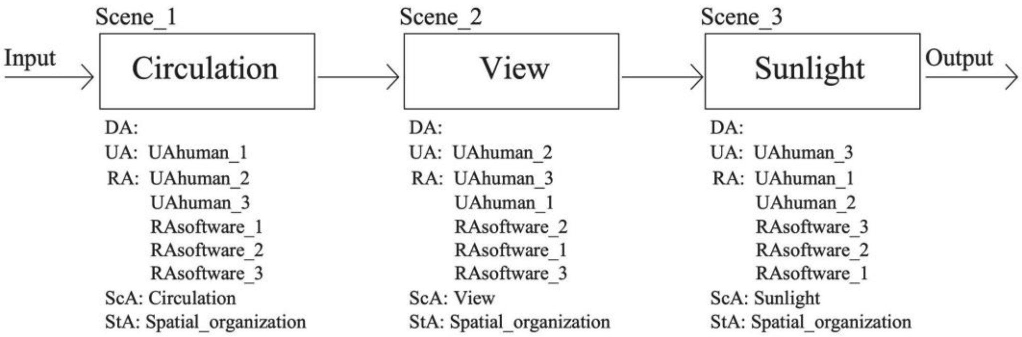

Figure 10: The scenes in the play

4.3. Scene 1: Circulation

Pre-condition

UA_{human1} acts as the facilitator and informs DA to start the play. DA receives the message, and sends this message to $ScA_{circulation}$ through $StA_{spatial\ organization}$. $ScA_{circulation}$ sends its task requirements to $UA_{human\ 2}$ through DA. A ring-type communication for idea generation starts, which involves one loop from UA_{human2}, $RA_{software1}$, $RA_{software2}$, $RA_{software3}$ to UA_{human3}.

Process

UA_{human2} starts generating the first idea "floating building". $RA_{software1}$ receives the idea, and then generates the idea "free plan". Since the idea "free plan" has conflicts with $RA_{software2}$, $RA_{software3}$ automatically generates the next idea "elevator entrance" as a reaction. Finally, UA_{human3} generates the last idea: "lifting lobby".

Termination

When the loop is over, $ScA_{circulation}$ terminates the scene, and informs $StA_{spatial\ organization}$ to store these ideas in the data repository. UA_{human1} receives the idea alternatives and selects two of the generated ideas "free plan" and "lifting lobby" through DA. DA then informs $StA_{spatial\ organization}$ to send these two ideas back to ScA_{view} as the input of Scene 2.

4.4. Scene 2: View

Pre-condition

UA_{human2} acts as the facilitator and informs DA to start the play. DA receives the message, and sends this message to ScA_{view} through $StA_{spatial\ organization}$. ScA_{view} sends its task requirements to UA_{human3} through DA. A ring-type communication for idea generation starts, which involves one loop from UA_{human3}, $RA_{software2}$, $RA_{software3}$, $RA_{software1}$ to UA_{human1}.

Process

UA_{human3} starts the scene, and generates the idea "roof garden". $RA_{software2}$ receives the idea, and then generates the idea "solid boxes" for view penetration. Following up on the idea "solid boxes", $RA_{software3}$ generates the idea "void boxes" for interior view. $RA_{software\ 1}$ then combines the ideas "solid boxes" and "void boxes", and generates the idea "solid boxes and void boxes". Finally, UA_{human1} informs ScA_{view} that he does not have ideas and passes his term.

Termination

When the loop is over, ScA_{view} terminates the scene, and informs $StA_{spatial\ organization}$ to store these ideas in the data repository. UA_{human2} receives the idea alternatives and selects two generated ideas "solid boxes and void boxes" and "roof garden" through DA. DA then informs $StA_{spatial\ organization}$ to send the two ideas to $ScA_{sunlight}$ as the input of Scene 3.

4.5. Scene 3: Sunlight

Pre-condition

UA_{human3} acts as the facilitator and informs DA to start the play. DA receives the message, and sends this message to $ScA_{sunlight}$ through $StA_{spatial\ organization}$. $ScA_{sunlight}$ sends its task requirements to UA_{human3} through DA. A ring-type communication for idea generation starts, which involves one loop from UA_{human1}, $RA_{software3}$, $RA_{software1}$, $RA_{software2}$ to UA_{human2}.

Process

UA_{human1} starts generating the first idea "courtyards" for the sunlight design issue. $RA_{software3}$ receives the idea, and then generates the idea "sunken garden" for adding sunlight to the basement. Then $RA_{software1}$ and $RA_{software2}$ generate the idea "punching windows" and "skylights" respectively. Finally, UA_{human2} generates the last idea "curtain wall".

Termination

When the loop is finish, $ScA_{sunlight}$ terminates the scene, and informs $StA_{spatial\ organization}$ to store these ideas in the data repository. UA_{human3} receives the idea alternatives and selects three generated ideas "courtyards", "sunken garden", and "roof garden" through DA. DA then informs $StA_{spatial\ organization}$ to terminate the whole play, and sends 7 selected ideas to UA_{human1}, UA_{human2}, and UA_{human3}. All the selections and decisions are recorded for further learning.

4.6. Scenes in FIPA Architecture

The above scenes can be represented as the following interactive steps of interplay in FIPA architecture of DARIS. We use scene 1 to describe the information flow as described below:

- UA_{human_1} issues a design problem of spatial organization in a single-family house (as followed) to DA.

```
(ask_one
    : content ( SPATIAL ORGANIZATION
SINGLE_FAMILY ?design issue )
    : receiver DA
    : language JESS
    : ontology SPATIAL ORGANIZATION _DESIGN )
```

- DA receives the design task, and requests a $StA_{spatial\_organization}$ to initiate a play and reply back to UA_{human_1}. UA_{human_1} then sends three design issues to $StA_{spatial\_organization}$.
- $StA_{spatial\_organization}$ then activates an initial scene $ScA_{circulation}$ and reports the required RA-skills back to DA that organizes a cooperative interplay.
- Once DA receives and broadcasts the RA-list to all registered RAs, the five RAs ($RA_{software\_1}$, $RA_{software\_2}$, $RA_{software\_3}$, UA_{human_2}, UA_{human_3}) get involved and produce acts.
- Based on a pre-defined order identified by $ScA_{spatial\_organization}$, the five RAs get involved in an interactive interplay [shown in Figure 9]. For example, $RA_{software\_1}$ generates the idea "floating building" and then issues the ideas to $RA_{software\_2}$. $RA_{architect\_2}$ receives the idea "free plan", and then follows the same steps to generate the idea and sends it to $RA_{architect\_3}$.

```
(ask_one
  : content (
      SPATIAL ORGANIZATION SINGLE_FAMILY
      circulation )
  : receiver RA software_1
  : language JESS
  : ontology SPATIAL ORGANIZATION _DESIGN )
```

- $ScA_{circulation}$ terminates the interplay in a predefined time duration (one loop), and then issues the final outcome DA through $StA_{spatial\_organization}$.
- UA_{human_1} receives the outcome through DA, and selects the design outcome as the input of the next scene. While $StA_{spatial\_organization}$ receives the selected ideas through DA, $StA_{spatial\_organization}$ stores them into the data repository, and informs ScA_{view} to start scene 2. ScA_{view} and $ScA_{sunlight}$ repeat the above steps.
- When the last scene $ScA_{sunlight}$ finishes the last design issue, it reports back to $StA_{spatial\_organization}$ for termination. $StA_{spatial\_organization}$ then sends all the selected ideas (an example of messages is shown below) to UA_{human_1}, UA_{human_2} and UA_{human_3}.

```
(generate
  : content (
      SPATIAL ORGANIZATION_DESIGN_SINGLE F
      [ CIRCULATION 35 12 10 ],
      [ VIEW 25 18 12 ],
      [ SUNLIGHT 15 12 13 ] )
  : receiver UAhuman_1,UAhuman_2,UAhuman_3)
```

- All the selections and decisions will be recorded for further learning.

5. Discussion and Conclusion

This research addresses the problem of distributed interaction in dynamic design situations. It introduces a model of human-to-human interplay combined with agent-to-agent knowledge interaction in a framework called DARIS for interactions between humans and software agents. By introducing a model of dynamic role interplay between software and human agents, DARIS represents a significant advance over current agent frameworks proposed for the conceptual phases of design. The model of dynamic role interplay in DARIS extends the Acting Role Model (roles, stages, scenes and scripts) to an open-ended design space. All interactions are based on different distributed roles (user-agents, role-agents, director-agents, scene-agents and stage-agents) and external design situations implemented in a distributed environment (JESS).

DARIS provides the following contributions: Firstly, multiple design participants: DARIS models three types of collaborations, human-to-human, machine-to-machine and human-to-machine for distributed collaboration.

Secondly, distributed knowledge representation in design: DARIS models both cooperation and conflict as a distributed knowledge problem. Agents cooperate to extend design outcomes. When a design outcome has conflicts with an agent, the outcome is passed to another agent who can accept the outcome. Thus distributed knowledge model resolves conflicts and enhances diversity and originality of design through the dynamic interactions among agent entities.

Finally, representing user engagement: human experts control the dynamic role interplay between agents; the system will improve the efficiency of interplay and shorten the long learning curve. Furthermore, the user will feel more comfortable letting the agent delegate his tasks, which will therefore build trust between the user and the software agents. Lastly, DARIS provides design particularities according to the user's preference of design.

Some limitations in DARIS such as the dynamic interplay order will be investigated in our future research.

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The Challenge of Online Environment for Design Teaching

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ABSTRACT

Following the development of Internet technology, online education has become an important trend in higher education. Many educational institutes have been incorporating e-learning into their curriculums. Design education is also affected by this development with a greater challenge. As design teaching often involves many activities, especially practices and studio works, the design of online teaching environment is an area that needs more attention. By reviewing the history and literature of e-learning and online design teaching, this paper aims to investigate the current context and identify the problems of online environment for design teaching. The paper concludes that current e-learning platforms still need to address the characteristics of design teaching to achieve a user-centric online environment. A sample layout of online environment is suggested at the end to meet the needs of design studio teaching. It may contribute to the future direction and design of online environment for design teaching, highlighting the importance of studio context.

***Keywords*:** Design Teaching, Online Teaching Environment, User-centric.

1. Introduction

Following the rapid development of Information & Communication Technology (ICT) and e-learning, design education is gradually adopting online teaching. For example, the development of virtual design studio started to gain attention in the 1990s, aiming to provide an online environment for design collaboration and communication. (Sulek, 1994) There were early accounts experimenting with virtual design studio for online teaching. (Wojtowicz, 1995b) Although online teaching may provide new ways of conducting design education, there have been issues raised in pedagogical aspect. (Kvan, 2001) It is then important to investigate its current state, so a better environment can be further developed. Drawing from the literature of online and design education, this paper investigates the context of online design teaching and identifies the needs and challenges for a teacher-centric environment. It starts with the evolution of online teaching since the early use of e-learning tools, clarifying the current state of online education and terms that are used in the paper. As the core of design education, the history, roles and functions of design studio are then investigated. The section of the Emergence of Online Design Studio Teaching examines the rise and development of online design studio and identifies the lack of considering teachers' needs and behaviours in online teaching environment. Finally the paper calls for a user-centric teaching environment, identifying the fundamental needs for successful online design teaching. A sample layout of online teaching environment is also suggested for designers to consider teachers' needs and future development.

2. The Evolution of Online Teaching

Since the late 1960s, e-learning has been leveraging Internet's capacities to extend the learning boundaries and change existing models of learning (Harasim, 2006, p. 7). Before educational institutes largely adopting internet communication tools, technology in education was limited 'within the confines of four walls for a designed time period'. (Lazarus, 2003) The most popular technology was projectors for transmitting printed or electronic files. Other popular audio-visual tools in classrooms were TV, video or DVD players. Moreover, the intranet broadcasting system was used in many computer laboratories. These tools provided synchronous transmission in the physical classroom. For asynchronous method, the world's largest educational television (ETV) infrastructure was built in 1964 in American Samoa. (Goldfarb, 2002, p. 28) ETV was proposed as a model of asynchronous media for both long distance and on-campus learning. Today the format is still utilized by educational institutes.

In the mid-1970s, university courses started utilizing e-mail and video conferencing as supplementary teaching tools.(Harasim, 2006; Hiltz & Wellman, 1997, pp. 73-74) The first totally online undergraduate classroom, the 'Virtual Classroom' project, was launched in 1986 by Murray Turoff at the New Jersey Institute of Technology. By the end of the 1990s the first large scale online courses, Open University, were developed in the United Kingdom. The focus of these early developments was to enable collaboration among members who were separated by long distances. These projects provided the foundation for the development of virtual classrooms including virtual design studio.

At the end of 20th Century, since the financial crisis of Southeast Asia, emerging global energy tension and declining birth rate in developed countries, the immediacy and easy connectivity of e-learning started to show the benefits for both distance learners and on campus students. Due to the new demands of education, such as students' 'media savvy'; the raising request of personalization; and the growth of global communication, online education environment can provide great flexibility in terms of time and space. Moreover, through peer review and sharing forums, online courses could support enormous academic community and constitute a global knowledge network. The results of instructing material with digital media would further give impacts on students' learning effects and evaluation. As technology is ushering education to an era of lifelong and mobile learning, construction of digital learning platforms and design of professional curriculum would be critical for success. The combination of new technology and humane concern produces new models for digital learning. Teaching materials featuring multiple media and interaction can help students enjoy their learning to achieve 'edutaining' effects. The popular uses of e-learning platforms like Moodle, Blackboard, and authoring tools like Storyline, Lectora indicate the wide spread of e-learning in educational institutes.

As online education continues to grow in higher education, many studies have tried to map out the status in different areas. Early in the 2001, it has been estimated that there will be between 30 and 80 million online students in the world by 2025. (Organisation for Economic Co-operation and Development, 2005) Due to the difficulty in defining an online student, there is huge difference in estimates. Australia, as one of the leading countries in the move to online education has shown the interest in employing online services. Early in 2001, there were already 207 fully online courses offered by 23 Australian universities.(Bell, Bush, Nicholson, O'Brien, & Tran, 2002) Recent studies in the U.S. show that institutions that see online education as a critical component of their long-term strategy have continued to grow for the past ten years, reaching approximately the number of 1600. Thirty-one percent of all higher education students are estimated taking at least one course online. (Allen & Seaman, 2011)

Along with the development of Internet and ubiquitous computing, online education has also affected design education. Online tools, such as e-learning platforms and virtual design studio, have been developed and adopted into design curriculum. Mainly for online collaboration, virtual design studios have been tested for teaching and learning design.(Hama & Schnabelb, 2011; Yamacli & Tokman, 2009) With many new technologies available, teachers now need to integrate different tools. Text, images, animation, video, interaction, these are just some elements now teachers learning to utilise for education. However, teachers may not quickly adopt the fast evolving technology, and their e-teaching skills may not be maturely developed.

To support teaching activities in online environment, an e-learning platform often includes a Course Management System (CMS). It can be simply defined as a web application that is accessed by using web browser (Cole, 2005) or 'a web- based infrastructure for sharing digitized information among teachers and students (Moggridge, 2007). In this paper, a CMS is defined as a software system built in institutional severs, designed to facilitate the management of course material and allowed to access through Internet. Also, based on different technologies, the presentation media for a CMS may include computers and other screen-based hardware.

CMS works as a stand-alone application or supplementary role of face-to-face courses. It has been adopted by higher education institutes since 2000. There are some common functions existing in most CMS. For instance, navigation function includes course maps and navigation buttons. The content function may have activity, portfolio, journal and additional resources. Discussion Forums, chat room (asynchronous or synchronous) and e-mail are some tools for communication. Recently, features, interface and pedagogy in CMS environment have been comprehensively reviewed. CMS applications have been updated by enhancing the capability of collaboration, compatibility, and reusable building structure. Effective pedagogical experience, flexible working environment and easy-handling interface have become essential aims for CMS application. However, the environments still need more attention to fulfill teachers' needs. Some studies shows the usability issues in popular platforms like Moodle and Blackboard. (Heirdsfield, Walker, Tambyah, & Beutel, 2011; Ivanović et al., 2013; Tee, Wook, & Zainudin, 2013) Hence, many instructors use some other collaboration materials, social software, such as blogs and wiki, or other software to supplement their teaching.

Another trend affecting the design of e-learning platforms and CMS is the development of Web 2.0. The new application of internet technology for social networking and collaboration differentiates Web 2.0 platforms from the previous type of online application, Web 1.0. Weller (2013) defines Web 2.0 technologies as those technologies that are used for entertainment and personal communication. According to the author, Web 2.0 technologies such as YouTube, Skype, Facebook, Google Docs and others have brought significant advantages for educators. For example, teachers can now access these technologies from different devices such as smartphones, tablets and netbooks and can access them from anywhere in the world. In addition, many of these technologies are free and easy to use. Hence, the technological barriers to using computers for professional development of teachers have been greatly reduced. (Weller, 2013) Web 2.0 has shifted from 'hand-out published online' (O'Hear, 2005) to a more personal, social and flexible idea, called 'architecture of participation' (O'Reilly, 2005) . Central to Web 2.0 is the concept of social platforms that break down barriers for sharing information efficiently. Instead of introducing new technology, Web 2.0 aims to facilitate sharing and collaboration among users. The structure of social network software or platforms, such as MySpace, ELGG and Facebook, are much more flexible and more readily taken up by young practitioners who have come to adulthood with these digital networks as part of their everyday lives.

The development of Web 2.0 technologies has also provided an enhanced opportunity for the professional learning and training of teachers in a way that can prepare them to work effectively. (Weller, 2013) This new development in Internet services and communities has influenced the design of online teaching environments. In the past, most Course Management Systems applications were designed for the tool-centric orientation, but were not user friendly. Under the influence of Web 2.0, online education has started to adopt social networking software and provide open structures for users to construct and modify their online activities. The characteristics of Web 2.0 have found new directions for online education and the development of CMS. Personal web-based journals (Weblogs), social bookmarking (del.icio.us), modifiable collaborative web pages (wikis), media gallery (Flicker) and video-sharing sites (YouTube) enhance social interactions and behaviours. For example, as Lane (2013) points out, several free tools such as YouTube, Facebook and Twitter have created an open learning environment for teachers as well as students. According to the author, these new approaches of teaching and learning have gone beyond technology training and CMS. For example, social bookmarking services, such as Delicious, have provided a place where students and teachers can find a cost-effective way to share visual information.

Despite of the growing trend of online education, there are some doubts about the actual effects online education will have on the learning. For example, even though some academic leaders continue to press on the frequently cited advantages of e-learning such as promise of lower costs compared to conventional campus based provision, increased automation, reduced marginal costs, and lower travel and accommodation costs, many argue that the learning outcomes for online education are not comparable to those provided by face-to-face instruction (Allen & Seaman, 2013; Natale, 2011; Staker, 2011; Young & Duncan, 2014). Staker (2011) contends that virtual learning lacks safeguards on quality and that ensuring high-quality outcomes should be the first priority of institutions offering virtual programs. There are advocates who believe that even though online education may become more affordable, ensuring quality instruction to students will depend heavily on the availability of high-quality teachers skilled in online pedagogy. (Natale, 2011) Since online education differs significantly from face-to-face teaching in all aspects such as curriculum development, assessment, and communicating with students, teachers face various issues such as using complex specific technologies, building a learning community and keeping participants engaged when adapting to a virtual learning environment. This in turn affects their teaching and has adverse effects on the learning outcomes of students.(Natale, 2011) Today, many institutions are utilising technology and providing resources to their faculty to keep up with the growing pace of online education and are still optimistic about the growth and positive impact of e-learning in the future but the question about whether or not e-learning can improve the quality of education still remains as the ultimate concern.

3. Traditional Design Studio

Traditionally design education comprises of lectures (theoretic courses) and studio works. It is the studio-based courses that differentiate design education from the other disciplines. Design studios are the place where students learn to become designers. Through learning by doing rather than listening, students engage with teachers, materials and environment to develop their skills and knowledge. Arguably, Design studios are the core of design education.

Although “learning by doing” in studios seems to be putative and commonsensical in design education, it is worth of clarifying and defining in the paper. By understanding the role of studio and the activities often occur inside, the paper could reach a better view of design teaching, finding the extent of teaching phenomenon. The emphasis of learning through physical making activities can be traced back to the age of Medieval.(Lyon, 2011, p. 85) Apprentice learning at guilds suggests the transfer of knowledge or skills from the master to the novice. Through centuries, this approach continues to exist in current design education. Ecole Des Beaux Arts, French term of school of fine arts, represents one of historical apprenticeship model in art and architecture in nineteenth century. A triangle structure had made up this art world.(JSSGallery) The three points respectively are Ecole (refers to insider: professional practitioners), independent Ateliers (refers to outsider: practicing master) and Annual Paris Salon (jury and assessment). The filling centre is Café life (discourse). ‘Sitting by Nellie’ is another teaching and learning model in 19th century of weaving industry, a non-participant role model of teaching and learning. (Rothera, Howkins, & Hendry, 1991; Swan, 1989) It also presented an apprentice mode through ‘one-to-one basis’ and ‘seeing and doing’ process to learn from ‘osmosis’. (Davies, 2004, pp. 168-169)

The Ecole retained the fundamental art school model until the establishment of the Bauhaus in 1919. A concern with students’ talent, latent aptitudes, personality and technical skill had been emphasized. Bauhaus pedagogy is to ‘offer a test of the student’s abilities’, which ‘help shorten the road to self- experience’ (Moholy-Nagy, 1937, p. 8) Later on, New Bauhaus inherited the Bauhaus philosophy but advantage science as its third element (Art, Technology, Science). Moholy- Nagy believed that ‘a new individuality was a prerequisite condition for a new society’.(Findeli, 1990) Findeli addresses that the significant influence form New Bauhaus workshop is their ‘promotion of a method of analysis of design problems’; this ’process- oriented education’ had modified many pedagogical prototypes in the twentieth century. (1990, p. 15)

Many authors have considered various aspects of the design studio as a physical place where students learn to become practitioners through learning by doing rather than conventional transmitting knowledge. One of the earliest theorists of design education, Donald Schön, identifies three ways in which active learning can be framed and applied within the design studio: self-instructed, apprenticeship and practicum. (Waks, 1999, p. 307) Experienced in architectural studio teaching, Schön suggested that ‘studios are prototypes of individual and collective learning by doing under the guidance and criticism of master practitioners’.(Schön, 1985, pp. 232-238) He formulated the studio method as ‘reflection-in-action’. Schön’s approach emphasizes a model of learning with a specific focus on professional activity. Although Schön’s theory mainly describes the activities within architecture studios, the principles can be applied to other design studios, which have also long valued the spirit of learning by way of novices working with masters practitioners.

Among the three methods, Schön’s taxonomy of acquiring professional knowledge, apprenticeship and practicum has a reliance on the guidance from teachers or those with mastery in a field. Apprenticeship, according to Waks, is ‘learning “on-line” in real-world contexts’(Waks, 2004). However, Waks believes this method to be ‘inefficient’ and potentially ‘negative’ for professional practice.(Waks, 2001, p. 42) Hence, the practicum is thought of as a standard studio in a physical environment. In contrast for Schön, the practicum is in an ‘off-line’ situation, while the trainee encounters hierarchic problems always guided by master practitioners. When skilled practitioners encounter problems, they could exploit their competence (knowing-in-action) to accomplish the loops of reflection-in–action process. For example, on the spot problem solving; theory-building; re-appreciation of the solution are modes of learning that would be generated through ‘conversation with the situation’ by inquirers.(Schön, 1985, p. 27) In this way, the teacher or master is able to guide the student in their professional development.

Schön’s theory is considered to be canonical in design studio education. Educators guide the amateur (beginner) by adopting the process of reflection-in-action to promote students through a trial and error process to detect and solve systematic problems. For sophisticated practitioners, 'analogues' reflect their experience and professional knowledge. In design studio practice, a tutor's guidance creates 'analogues' for learners which can be analysed and discussed in order to stimulate awareness in the amateur's judgment. Without such guidance, the experiences in 'indeterminate zones of practice'(Schön, 1985, p. 25) for beginners will be time-consuming and 'wicked'--a situation involving many factors that are too complex to be solved by rational systematic processes.(Rittel & Webber, 1973; Whelton & Balla, 2002, p. 375)

Other theorists also examine the characteristics of design studio. Broadfoot and Bennett (2003, pp. 9-10) devise four characteristics for both traditional and contemporary design studio settings: learning by doing, one-to-one dialogue, collaborative context and process-focused practice. Therefore, design studio provides environment for consuming process of learning to train learners becoming practitioners of design above all maturing and personal development. Though many studio teachers comprise knowledge component in projects undertaken, learning by doing often replaces information acquisitions. From psychological and emotional perspective, Austerlits and Aravot (2002) propose studio characteristics involving four procedures: empirical learning and reflective process; personal creative process; structure guide and accompany both educational and creative processes; exposure and self- disclosure. Furthermore, they address the relationship between instructors and students, which consists of ambiguity and uncertainty, collaboration, dynamic evaluation and outsider's criticism, and dynamic change in self-esteem.

From the literature, several authors consider the various aspects of the teacher's role in the design studio. These can be summarised as the senior manager (outlining the brief/ project), the client (assessment) (Davies, 2004, p. 169) and the professional practitioner. Design teachers take on the role of facilitator, who enables learning by doing. The teacher is the insider who knows the practice, including the operational moves (demonstrations) and the associated ways of thinking and talking (descriptions/explanations).(Waks, 1999, pp. 309-310) These tasks can be summarised in Figure 1.

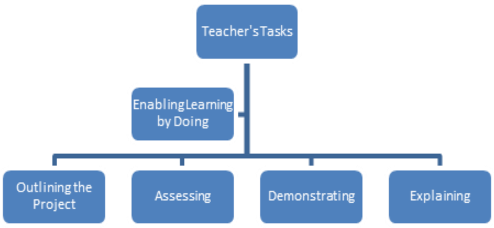

Figure 1: Teachers' tasks in design studios.

Schön suggests that studio masters are obliged to examine their knowing, make 'systematic descriptions of their practice and coaching', and embed self-reflection in the learning process.(1985, p. 7) Obviously design teachers need to communicate and practice with students in studio works.

The conception and practice of design studio have evolved a lot since the dawn of modern design education at Bauhaus. Nowadays design teachers need to play many different roles in studio settings, requiring various teaching activities to match teachers' roles. Although learning by doing remains as one of the characteristics of design studio, the implementation of studio teaching is now affected by many other factors, such as pedagogy, technology, conception of design education and personal style. Especially, online technology may present a new paradigm of studio teaching.

4. The Emergence of Online Design Studio Teaching

Following the development of online education, design studios have started finding their venues in online environment, and design education has started to shift from the physical to virtual environments. One direction is the development of Virtual Design Studio. The term Virtual Design Studio, thereafter VDS, was coined by William J. Mitchell, (Wojtowicz, 1995a), to define a computer supported environment for collaborative design. Design information, such as text, images, and drawings can be imported into VDS for discussion and modification across computer networks. There are at least two major functions found in VDS: sharing and communicating design information. VDS is hoped to provide 'an environment for collaboration that has no walls, an environment that facilitates sharing design information and supporting interaction regardless of place and time'(Maher, Simoff, & Cicognani, 2006, p. 3).

Seeing the benefit of working in virtual environment at any time and places, the idea of VDS is based on project collaboration and can be described as a networked design studio.

(Maher et al., 2006) Initially starting from architecture schools then expanding into other design disciplines, VDS presents a model of creating cooperative design environment. Online studios have been flourishing since the mid-1990s, a period that is described as a 'watershed in Virtual Design Studio (VDS) evolution' (Laiserin, 2002, p. 141). There are several characteristics of VDS: broadening time and space boundaries; designing and communicating with computer-mediated and computer-supported platforms; representing the process and outcomes with electronic forms (Maher, Simoff, & Cicognani, 1996, p. 2); accessed through the Internet; providing asynchronous and synchronous communication; and supervision by professional practitioners. (Maher et al., 2006)

The first main asynchronous Virtual Design Studio was initiated in 1992 entitled ‘Distanced Collaboration’ by the University of British Columbia and Harvard University. One of the significant projects undertaken between 1995 and 1997 was the International Design Studio. This collaborative project involved several architecture schools globally (USA, UK, Singapore, Australia). The major aim of this trans-national project was that students, through a single task, were able to collaborate and share design concepts and beliefs.(Maher et al., 1996, p. 4) The first and largest graphic VDS project, OMNIUM 1.0- Small Red car, was established in 1999 by the University of New South Wales. It was a collaborative project involving fifty students from different countries and was facilitated by a custom-built network interface (Bennett, 2001). Focusing on artists and designers, Omnium is an on-going research and platform for conducting on-line collaboration and creativity. Since 1999 the Omnium project has conducted international projects and conferences to examine the questions of design education and collaborative creativity in on-line environments. More recently, Creative Waves 2005 was a global online design project involving art and design students, teachers, practitioners and writers. This group aimed to confront the challenges of individual and collaborative studios through a dialogical mode of interaction (Bennett & Dziekan, 2005).

Without the spatial barrier, many of these early projects experimented on the collaboration aspects of VDS. Due to the scale of the growth of global communication and the accessibility of on-line technology, many projects were tested on an international scale. A recent project, the Global Studio, tested the idea of distributed design in higher education to help students develop cross-organisational and cross-cultural communication and collaboration. (Bohemia, Harman, & Lauche, 2009)

The development of social networking, such as Web 2.0, also has had a profound effect on the use and design of VDS. Central to Web 2.0 is the concept of social platforms that have been breaking down barriers for sharing information efficiently.(O'Reilly, 2005) The social aspect of computer mediated communication ‘that considers the development of community is relevant to a VDS because the ability to effectively collaborate depends on the development of a community’(Maher et al., 2006, p. 72). As group discussion and collaboration are important components of design studios, VDS environments also include functions that are often found in social networking platforms. Moreover, a study on sketch recognition, ‘Multimodal Intelligent Design Studio’, conducted by MIT, intends to investigate more expected interface for the combination of sketch, speech, and gesture in the design studio.(Adler, Eisenstein, Oltmans, Guttentag, & David, 2004) ‘World Wide database’ or ‘semantic Web’(Berners-Lee, 1998) (for the idea of adding meaning) is predicted to be the innovative approach of Web 3.0.(Markoff, 2006) There is no doubt that VDS will continue to incorporate new technology to increase operational and social functions. In the past, teachers quite often delivered online education through content management systems, such as Blackboard, and play the role of content provider. Nowadays, under the influence of Web 2.0, the role of teachers has shifted from providers to participants who teach, study and collaborate in a learning society. The designs of online teaching environments need to reflect the new trend and develop new framework.

As the development of VDS has become more mature, the concept and technologies of collaborative design have been gradually adopted and integrated into wider on-line design courses. Some e-learning platforms, such as OMNIUM and Blackboard, have started to integrate the concept of VDS and provide this learning environment to a broader range of users. VDS is gradually finding its way into design education.

Despite this being a rich area of research and development, there are still many questions about how best to develop and deliver such learning platforms and methods for engaging people in these virtual environments, particularly within design education. Although VDS has been experimented in educational settings, the teaching aspect of VDS has not been fully explored. Since the initiation of VDS, the focus has been on collaboration. Most efforts have been focused on the learner side. One characteristic of design education is the different grouping and activities formed in classrooms. In physical setting, teacher can easily assign groups with different task and conduct different activities. Gestures, sketches and conversation are commonly used in communicating with individuals or small groups. Big groups happen when teachers give lectures or information important to the whole class. Although online teaching environment has started to consider grouping functions, monitoring the activities happening in each group is hard to accomplish. Unlike in physical settings, teachers cannot visually perceive all the activities happening in VDS and provide support instantly. It hampers the interaction that often exists in physical classrooms. Although information technology may empower the design medium, ‘the means of production, eliminating drafting tables, rulers, set squares, rubber cement, and the like’ (Frascara, 2004, p. 169), the speed and effortless from technology easily defocus the initial and essence of design itself. It also refers to design education. Jorge Frascara made an illustration to describe the different design production before 1980 and later. The details such as typography kerning, line breaks, typesetting, paper qualities and surface finishing are not necessary encounter because designers can accomplish printing from personal printer or sending digital file to their client without the complicated process.

For teachers, the difficulty in using e-learning systems has been gradually recognized as an issue. The term ‘information bricolage’ (Snyder, 2002), suggested by Burnett, becomes a sense describing teachers dealing with confusing media interface. The teaching on literacy becomes very difficult because the lack of literacy of new technologies for teachers. Hence, it might be more complicated for instructors who have no or less technical training and background. 'User Frustration and Dissatisfaction’ might be a consequence to make users easily submerge into ‘Computer Rage’.(Stone, Jarrett, Woodroffe, & Minocha, 2005) Technology could be a crucial factor in achieving better quality in VDS (hardware, software, and environment). However, before embracing these kinds of powerful technologies in studio teaching, the conditions and principles for better teaching and learning in a VDS environment need to be further investigated.

Despite the use of VDS in Design education liberates the limitation of time and space, much of its development is still immature. Earlier efforts focused on the technological aspects, such as software and hardware. Issues of communication and the pedagogy within VDS have just started to gain attention by design studio educators. One of the pertinent pedagogical approaches toward VDS is proposed by Thomas Kvan. His theory is based on previous initiatives involving the Department of Architecture at the University of Hong Kong (Kvan, 2001). There are two major propositions in his framework that are of significance to this research: the principles of deliberation and collaboration. Instead of focusing on the final product, deliberation emphasizes the design process which encourages students to review and evaluate their learning process. Collaboration stresses that learning from peers and building trust are the key lessons in team work. Broadfoot and Bennett (2003, pp. 9-10), the founders of the Omnium Project, also provide four key criteria for both traditional and contemporary design studio settings: learning by doing; one-to-one dialogue for tacit knowledge experience; a collaborative context for building relationships; and a focus on process throughout design practice. One common characteristic in their theories is to enable effective communication. There is an added responsibility for the tutor in helping the students to understand the new medium, which is ‘currently unreliable, difficult and cumbersome’.(Kvan, 2001, p. 349) However, there is also a need to support teaching activities in VDS so that teachers can smoothly conduct communication. Traditionally knowledge transmission in physical classroom happens in synchronous ways. Students receive new information right in front of teachers. Internet and ubiquitous computing make asynchronous communication possible in virtual environment. Teachers and students exchanged information via email or other social networking tools. However, asynchronous communication lacks the spontaneity of communication. Teachers cannot provide instant gestures or demonstration for students’ questions. Moreover, conversing asynchronously may be time-consuming and reduce the efficiency and effectiveness of communication. Obviously, to fully utilise VDS for design teaching still need to resolve several challenges. Figure 2 shows some of them.

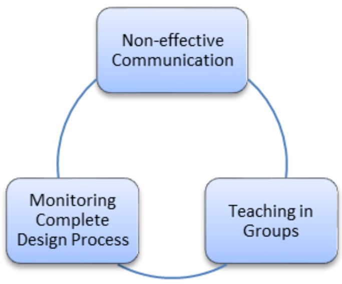

Figure 2: Problems in Teaching in Virtual Design Studio

Despite Kvan and Bennett both suggesting that VDS needs to develop its own pedagogy, one not be based on the physical design studio, many design studio teachers have received training and practices in physical settings. The physical studio tends to be the default environment for thinking the pedagogy of the VDS. The transition from a face-to-face teaching environment needs to be considered in order to help teachers develop a new pedagogy in this new virtual environment. Furthermore, in the physical design studio, students receive trainers' supervision through informal reviews and formal presentations (Kvan, 2001). This model needs to be adapted to the virtual environment; however, the virtual environment allows for a different mode of review and presentation. Whether VDS can actually replace the physical studio is still in debate. However, if VDS is to provide an appropriate educational environment, the nature of design studio needs to be further considered, particularly from the teacher's perspective.

5. The Call for a User-centric Environment for Online Design Teaching

From the review of the current context of VDS environments, there are two conclusions that can be made. Firstly, most discussions about VDS continue to focus on the learner, how teachers conduct classes and activities has not been fully explored. Teachers' needs and experiences need to be fully addressed in the fast changing on-line environments. Although young teachers have been comprehensively using information technology in many aspects of their teaching, the design of teaching environment in virtual studios has not been realized. Secondly, although the development of VDS seems to provide more possibilities for implementing design education, the environment needs to address the characteristics of design teaching, especially studio work. Studio teaching often involves hands-on activities and individual discussion, and that makes it different from teaching in a conventional classroom where making or construction is not the main focus. It is crucial to consider the nature of studio teaching and provide appropriate environments that support virtual studio teaching. Despite some programs for specialized online courses have been established, for instance OMNIUM v3.0, a well-adaptive program for practice and education in creative arts and design, the outcomes still lack of flexibility, functionality and aesthetics.

The review of design studio suggests four characteristics of design education: hands-on practice, reflection in action (learning by doing), collaboration and guidance from masters. They all relate to the implement of interaction. Students need to interact with the group, teacher, environment and themselves. Therefore, in online environment, interactions need to be spelled out more often. Online design education can be easily reduced to the collaborative construction of a written dialogue, instead of doing design. VDS represents a different type of social construct with different media and methods. Some studies have shown that design students consider digital media removed from physical process and miss the experience of making. (Lyon, 2011) For online teaching, the environments then needs to allow teachers to prepare for the setting, so interaction can happen ideally. Based on the previous discussion, the following figure (Figure 3) shows the teaching functions that need to exist in VDS.

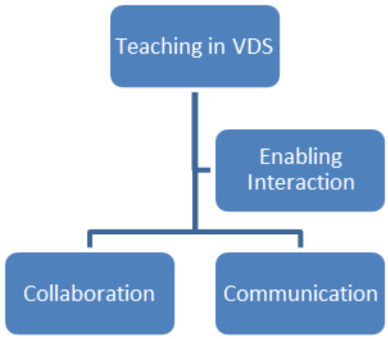

Figure 3: Teaching functions in Virtual Design Studio.

The use of digital design tools is not too far away from traditional setting. At least teachers and students still meet in the same room. The dynamic and communication happening in design education remain, only the change of media and materials. The appearance of online design education, however, makes one wonder the nature of design education, especially design studio. Can technology capture the process of design teaching? Is it worth the effort to teach design online? Can online design education provide educational services in high quality? A fundamental challenge will be to convince teachers to adopt online teaching. Beside face-to-face contact with students, more elements can be found in design teaching. For online design teaching, texting and talking over the Internet cannot meet teachers' expectation.

Although VDS can be a site for conducting teaching and learning, the major development has been trying to implement remote collaboration. At this stage it still requires teachers' great effort to integrate and utilise online tools and platforms to ensure the success of online education. Without proper teaching environment, online design teaching may require more effort on the technical issues rather than design process. As mobile computing devices are penetrating into campus, education is stepping into the virtual world. To equip design education for a flat world where the boundaries of space, time, and culture are blurry, an intuitive, user-centric environment is much needed for design teachers. For a smooth transition from the physical to online setting, the behaviours and characteristics of design teaching need to be better studied and understood so that teachers' needs can be fulfilled.

6. The Characteristics of Design Studio Teaching

As e-learning continues to expand into higher education, the need for an appropriate framework for online design education is gradually being recognised. Although the concept of cyber society emerging in the 1990s (Jones, 1998) has now developed into social network on the Internet, the challenge of computer-mediated communication still exists. Especially for studio teaching, "How can designers' tacit and esoteric knowledge be transmitted?" becomes a problem in teaching real experiences in unreal settings. To establish a framework for the design of a web-based studio course with respect to the nature of the design process, there are four aspects of design studio need to be considered: sociological, ideological, epistemological and pedagogical.(Sagun, Demirkan, & Goktepe, 2002) The sociological level is to provide computer-mediated communication among geographically distributed students. Students are oriented to group studies for learning concepts, skills and practice. Clearly, grouping plays an important role in this aspect. Whether for communication, discussion or collaboration, grouping is the first step teachers initiate, and it put the control of learning back to students so the exchange of culture, knowledge and information can happen. To allow communication to happen, a communication area accommodating all types of media needs to exist on online environment. The objective of ideological level is to educate geographically distributed students in design. Here experiencing design process is the main activity, and studio is a must. With current online tools, face-to-face communication found in physical environment, an often claimed problem of online education, can now be achieved, partially not totally, with video-conferencing and online design studios. The environment setting, including space, tools and materials, is crucial in supporting studio activities. Along with collaborative functions, environment setting provide online studio experience. Although the effect of online studios may not be the same as that of face-to-face studios, it is possible to explore design process with proper settings and current tools. For epistemological level, the web-based design studio needs to broaden the way design problems are solved. Online studios allow interaction across borders to view the ideas and styles of various cultures, disciplines and technologies. This is probably the most important advantage of online education, bringing different disciplines into contact. Design problems can be viewed, discussed and solved with online tools. A communication area is needed for this respect. For pedagogical level, it is important to teach how to observe design examples and follow the advances in design practice and technology. Knowledge in design theories and technology needs to be balanced. Therefore, various types of activities need to be utilised to help students acquire knowledge. Collaborative areas and functions can bring instructors, students, design consultants and computer consultants together to solve design problems.

To satisfy the four aspects of online design education, there are two major components need to exist in a teaching environment--communication and collaboration. A flexible communication area is the most important component, required for all four aspects. For online design education, communication needs different forms and media--text, sound, image and possibly 3d data. A communication area accommodating different formats should be the core of a teaching environment. To enable the experience of collaboration, an online studio that allows teachers and students to view, comment, and even modify design works should be one characteristic of online teaching environment. An online studio or collaboration area reinforces interaction among participants and exchange of knowledge. Supported by appropriate materials and activities, a communication area and online studio can then contribute to the four aspects of online design education.

Besides the areas for working with students, a planning area is also needed for teachers to plan teaching activities. Before communication and collaboration can happen in studios, design teachers need to plan for various teaching activities. A planner for choosing teaching approaches and activities is then important because it is the underlying structure for conducting design teaching. For online teaching, teachers can then arrange appropriate tools, materials and participants for studio works.

Figure 4 shows the three major areas need to exist for online design teaching.

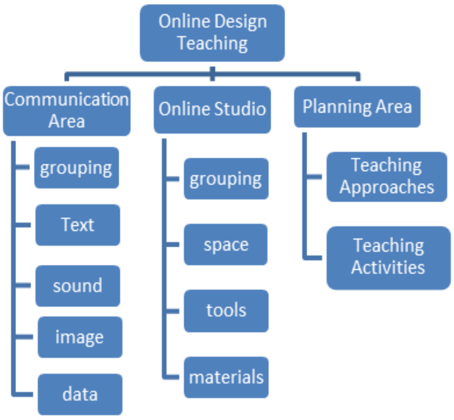

Figure 4: The areas and functions for online design teaching.

7. An Example of Online Teaching Environment

Based on the characteristics of design studio, the paper then suggests a layout of online teaching environment to meet the needs of communication and collaboration for studio teaching. (Figure 5)

Figure 5: An example of online teaching environment.

A communication area is the most important component of a teaching environment. Sitting at the core of design education, communication plays the major role in all aspects of design teaching. The communication area becomes the classroom, which needs to accommodate students, activities and materials. Teachers and students can not only see, hear and text to each other but also work together. A communication area here should be able to call in a studio where collaborative design can occur. A sample view of a working communication area is shown in Figure 6.

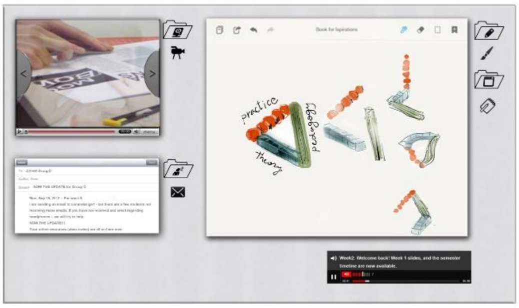

Figure 6: A sample view of a working communication area.

For linking the participants in an online classroom, a participant area shows the status of participants like students and guests. Not only the on or off state but also personal information needs to be shown on the area. As the research indicates that students are distributed in online education, teachers often feel lacking connection with students, which is not to say with the students' background or participation in class. Therefore, showing student information can help teachers build better relationship with students and provide appropriate responses. Teachers can be attentive to students' needs. Another critical function of a participant area is to support teachers' grouping of students. The paper has shown the significance of grouping in design teaching, so being able to initiate and track grouping should be a function of a participant area. Figure 7 provides an example.

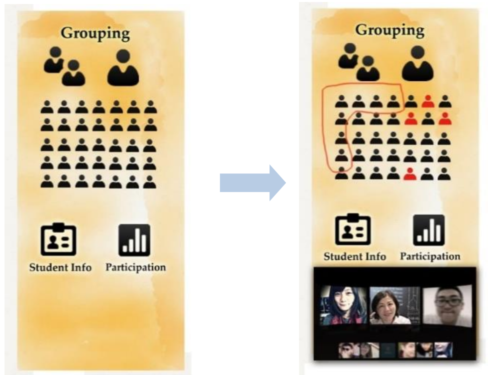

Figure 7: A participant area.

Design teaching involves different approaches and activities, and that requires an activity area to support the planning of teaching and reflecting on pedagogy. Figure 8 shows the activity area.

Figure 8: The activity area.

The possible activities, whether for individual, group or teacher construct, are listed in an activity area for teachers to choose from. There is also a planner for viewing the course structure, and hence the teaching rhythm can be revealed. The last part, a chart for showing the teaching approaches that correspond to the chosen activities, helps teachers to consider their pedagogies. With the planner and approach chart, an activity area allows teachers to reflect on their practice, and contributes to a reflective environment.

As the final component of a teaching environment, a tools and materials area contains the tools and materials that may be used in design teaching. (Figure 9) The tools may include a sketch board, online studio, video camera and possibly applications. Common teaching materials like text, sound and images could be linked to the area and form environment settings. For using tools and materials, the items can be placed into the communication area for broadcasting. As a special tool in design teaching, the studio tool provides the function for collaboration. Not just for viewing design, a studio tool should allow participants working on the same design projects. Currently there is a lack of online studios specifically for communication design; a problem needs to be resolved in the future for developing a complete platform of design education.

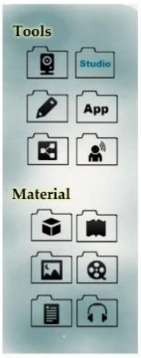

Figure 9: The tools and materials area.

Containing the four areas—communication, participant, activity, and tools and materials, a user-centric environment then serves to meet the characteristics of online design studio teaching. It provides a flattened structure, allowing easy access to all the functions and elements involved in teaching process. With sub-categories, it is possible to place in more items when they are needed, allowing the environment to be inclusive and yet accessible. For example, tools and materials can be categorised and placed into folders. Items can be simply dragged and dropped into areas to fit teaching activities.

8. Conclusion

As online education continues to grow in higher education, design education needs to develop an appropriate environment for accommodating various activities of online design teaching. The paper then reviews the history and development of online education and design teaching, and identifies the problems and challenges of online design teaching. To meet the complex phenomena of design teaching the paper calls for a user-centric teaching environment, especially studio teaching, to achieve collaboration and communication within online settings. Based on the characteristics of design studio teaching, the paper suggests an example of teaching environment containing four major areas: planning, communication, participants and tools and materials to provide a visualization for future development. Within each area, teaching functions are also included. Although technology has provided new ways of delivering education, e-learning needs to ensure providing proper learning experiences so students can master design skills. Before that can happen, teaching activities need to be satisfied and teaching environment is obviously the prerequisite for a successful design education in a digital age.

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數位遊戲融入色彩教學之適切性分析

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摘要

在藝術與設計科系的課程中色彩學被視為非常重要的核心基礎，且被列為必修課程之一，相關練習與實作也很多。然而學生在消化嚴肅的色彩理論之餘，在實作上卻也受限於練習材料，如：紙張、顏料種類的影響，導致實作效果呈現品質不一的情況。而且單純的平塗色票或配色練習，若無法與日常生活經驗產生連結，也容易減低學生色彩學習的興趣。

本研究希望藉由結合數位遊戲中情境模擬與所見即所得的特性，擬定有效之教學設計，結合數位遊戲與色彩教學應用在課堂之中。本研究以臺北市某大學視覺藝術學系的學生為實驗對象。應用數位遊戲「模擬市民 3」之角色、場景客製化設計功能，進行色彩教學與配色練習，經由量化比較分析及課後訪談，研究結果發現：1.「模擬市民 3」之角色、場景客製化設計功能，具情境模擬與即時回饋等特性，能符合色彩教學與配色練習之需求；2. 使用「模擬市民 3」進行色彩練習，不但能帶給學生樂趣，亦能增強學生學習色彩的興趣與動機、學生對於配色練習適切性與課程滿意度也呈現高度回饋。

關鍵詞：色彩教學、數位遊戲、遊戲學習、模擬市民 3。

A Study on the Appropriation of Integrating Digital Game into Color Teaching and Learning

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ABSTRACT

Chromatics is considered as very an important core foundation and is listed as one of the required courses in most of art and design curriculum. However, incomprehensible color theories along with many exercises usually cause students to loss their interest in colro learning and practices. On the other side, the skill to control technique and materials for color practices, such as paper or inks, are also make student frustrated.

Nowadays, many digital games provide possibilities for users to design their own game characters and scenes. Some games, such as The Sims 3(TS3), even equip with color picker design tool for users to customize their colors theme while designing their own characters and scenes.

Adopting the color picker design tool of the digital game TS3, this research was conducted to discuss the appropriation and learning effects of integrating digital game into Chromatics teaching and learning.

This research used pre-experimental designs. The objects of study are the Visual Arts students at Taipei Municipal University of Education. The researcher applied the color picker design tool of TS3 to conduct the same procedure. The result shows as below based on the pre-tests and post-tests:

1. The color picker design tool of *TS3* can simulate situations and provides real-time feedback, which fulfills the requirement of color teaching and color matching practices.

2. The result of study also shows that the color picker design tool of *TS3* has led to a significant outcome in students' color matching practice. The students provide positive feedback in utilizing *TS3* for color matching.

Keywords**:** Chromatics teaching, digital game, game-based learning.

1 研究背景

藝術與設計科系的課程中，色彩學是非常重要的核心基礎，往往被列為必修課程之一。傳統色彩教學方式較偏重對色彩科學化且系統性的講解—從色票的塗刷，並利用相關色彩體系之色立體模型進行色彩結構與色彩三屬性的理論說明，這樣的方式雖然提供了學生完整色彩的理論，但是卻忽略了色彩原本存在於自然、融入生活的本質性意義（林磐聳，1998a）。武井勝雄（1996）也提到現今色彩學習過於理論化，為避免傾向於知性的理論，透過構成教育的色彩指導，其理論乃建立在實際體驗之根基上。而從藝術設計科系的觀點，學生若是無法透過對色彩的瞭解，將色彩知能運用在創作與設計專業上，這樣的色彩學習將無法符合最初的課程設計與期待。

蔡佩芳（1999）透過觀察多所大專學生，及訪談美術任課教師，發現色彩學被當成是陌生且嚴肅的學科，學生對一般參考書目所介紹的內容難以理解，往往無法與日常生活中所見所聞聯想在一起，因而減低其學習興趣。且色彩學書籍出版的不足，尤其在色彩配色應用上的缺乏，亦無法將教科書之理論應用於工作相關的專業領域中（蘇美綺、陳一平，2007）。另一方面，色彩教學課程內容十分繁瑣，相關練習與實作也很多，以平塗色票為例，在練習過程中常受限於紙張、顏料的影響，也造成學生練習品質無法控制，因而降低學習意願與成效（盧俊宏、葉吉城，2003）。

越來越多學者認為，對於被稱為 G 世代（Game generation）的電玩世代而言，他們伴隨電腦科技與電玩遊戲成長，這群數位原民（digital natives）習慣快速的接收資訊，喜歡圖形化勝過文字化的資訊呈現型式，更偏好遊戲式學習（Oblinger, 2004），同時過去教育者亦強調遊戲對學童的學習是自然且必要的元素，應被鼓勵融入教學目標中，並且認為遊戲可改善教室中枯燥的學習模式。數位遊戲學習的提倡者 Prensky（2001）也提到 21 世紀是數位遊戲學習（Digital game-based learning）的世紀。

現代遊戲設計則不像以前一樣，多以反射性或特定目標類型，而有探險、策略、模擬、養成…等越來越多遊戲類型問世，提供玩家更多由由的選擇，甚至讓玩家自行創造遊戲內容，享受不同的經驗。如模擬遊戲模擬市民 3（The Sims 3），更加入人工智慧技術來提供玩家一個高度的模擬環境，同時開放結局的設定、角色、場景客製化功能、所見即所得的視覺效果，更讓它成為一個色彩教學或學習平台的可能性。

因此本研究希望透過模擬市民 3（The Sims 3）將色彩學教學與配色練習融入在遊戲之中。運用其角色、場景客製化功能，結合遊戲之高互動性、情境模擬及所見即所得等特性，進行色彩教學與配色練習。希望藉此可以把色彩練習的過程當結合娛樂，來提升學生色彩學習的動機與成效，進而將色彩學習經驗運用在專業與日常生活中。

本研究將從模擬市民 3 遊戲特性是否符合配色練習需求學生實驗課程之滿意程度，來了解模擬市民 3 應用於配色練習的適切性。

2 文獻探討

2.1 色彩教學

學者林磐聳（1998b）提到色彩學是美術教育基礎課程，對於藝術創作、設計實務應用的表現具有深遠的影響，而且色彩與形態亦是所有造形藝術或視覺藝術的基礎（曾啟雄、劉華傑，1998）。但是在台灣義務教育的階段，色彩學僅出現在物理學科和視覺藝術科目裡，對於色彩內容著墨甚少，其中物理學科是以光學來說明，而文史方面，僅針對詞意或歷史現象來介紹色彩；在視覺藝術課程中，色彩甚至被當作是水彩的一部分來做介紹（曾啟

雄，2003，p.12）。

傳統色彩教學的內容多偏重於色彩學理、設計元素的教學與應用，內容包括：建立完整色彩體系、瞭解色彩的配色原理、掌握色彩的知覺反應以及色彩調色，以及繪畫配色的練習為重點。在教學方式上，除了板書與教科書的應用，搭配色立體模型、幻燈片、影片來講解；在實作上以學習顏料混色、調色以及運筆平塗色票的技法為主（王士樵，2004；盧俊宏、葉吉城，2003）。然而實作方式上，卻常受紙張、顏料種類、顏料品牌的影響，導致實作效果呈現出品質不一的情況。可發現許多學者試圖應用有趣或生活化的教學策略與教學活動，以提升色彩教學成效與學生色彩學習動機。例如，在色彩教學策略上，王士樵（2004）運用「從做中學」、「從遊戲中學習」為基礎的色彩學課程，安排許多課程活動與作業，如：自畫像、分析名畫、空間裝潢色彩計畫、服裝搭配等，透過活動來吸引學生注意力，並且提升學生實作、訓練思考、生活應用方面的知識、技術與應用的能力，以達到學習效果。

在教材設計上，蔡佩芳（1999）透過對教師與學生之訪談，歸納出大專學生研讀的色彩學架構及相關單元，並且設計出以「創造思考教學模式」為主軸的創新教材，且在經過實驗教學之後，參考創造思考教學模式所編的教材在色彩學習成效最好；黃雅鈴（2005）應用「色彩感覺課程評量工具」、「色彩感覺多媒體電腦輔助教材」在高職美工科學生「色彩感覺」學習成效之影響，結果顯示多媒體電腦輔助教學的教材內涵適切性佳。在評量方式上，林睿琳（2006）透過色彩計畫單元的實作主題，輔以多元智慧教學以激發創作思考靈感，再由教師、同儕及自我評分進行多元實作評量，讓學生投入專業的探討創造在生活中具有價值的知識，並透過學習歷程檔案，讓師生學習自我觀察並親身經歷色彩之運用與設計的學習及成果的表現，研究結果發現學生透過實作設計可以累積學習經驗、增加想像力與潛力，設計主題和生活商品結合，可累積實務能力與經驗，增加職場專業能力，在教學上所採用的多元智慧教學，教師也給予自由的創作空間以啟發學生想像力與靈感。

2.2 資訊科技融入色彩教學

隨著資訊科技的進步、網路的盛行，色彩課程相關的輔助教具與教學方式，也開始有了轉變。電腦科技在聲音、影像、圖畫以及多媒體將與藝術創作結合，成為美術教育的主要途徑之一。伴隨著電腦科技之發達，相關軟硬體設備取得容易，亦有些學者利用電腦做為色彩教學之輔助工具，以進行混色示範與明度彩度之練習（盧俊宏、葉吉城，2003）；陳良仁（2007）應用模擬色彩混色辨識系統，透過互動程式連結資料庫，觀察學生進行色彩混色辨識之歷程，藉以分析學生之色彩混色辨識能力表現，使得教材更有學習性，比起傳統之色彩混色辨識學習有趣，更能呈現出學生色彩混合學習能力的表現。然而若僅就這些軟體來做功能性的呈現，是無法提升色彩學習動機，因此須從教學設計方面去配合課程內容、學習理論來進行色彩教學，以提升色彩學習之實施成效。

陳建雄、凃維妮（2003）應用 Malone 遊戲設計因素中的「奇幻性」與「挑戰性」設計兩款數位遊戲，藉以了解國小學童在「色彩明度」與「色彩彩度」的理解程度，結果顯示在經過互動式遊戲教學之後，學童的色彩明度的理解有顯著提升，色彩彩度則無。

除了上述提到應用美工軟體或自行開發的系統來做為色彩實作練習外，亦有研究者應用電腦影像處理科技，將數位化（Digitalized）的色相、明度、彩度、位置、面積、長度、大小等影像元素去做變化與處理（李堅萍，2001）。England（2000）探究兒童在視覺藝術上運用電腦與傳統媒材在描繪過程與創作品之間發現在線畫和造型有顯著差異，電腦繪圖繪製很多之幾何圖形亦能輕易置換色彩，比起傳統媒材可產生更強之動機。亦有研究指出學童對於採用傳統媒材與電腦媒材來畫圖的態度，學童在運用電腦媒材時，最喜歡的原因大多都集中在對電腦著色功能的肯定（黃瓊儀，2002）。

彙整上述的研究結果來看，電腦媒材特性，像是所見即所得、展現高度自主性、呈現效果的多元性等，不論是學生用來創作或是教師做為教學示範或是繪畫模擬的輔具，確實是可以提升教師美術繪畫教學示範以及學生創作的成效。

2.3 數位遊戲特性與學習

近年來數位遊戲已經成為青少年流行趨勢之一，由於數位遊戲的盛行，許多學者開始從資訊科學、文學、設計與教育等不同的領域來研究這個新興媒體做為學習工具的潛力與可能性（Malone, 1982; Squire, 2003），數位遊戲與學習的結合，從早期的「電腦輔助教學」（Computer-Assisted Instruction, CAI）到學者 Prensky （2001）提出「數位遊戲式學習」（Digital Game-Based Learning），著重的標的

已經不再只是單就學習內容的呈現，而是朝更多元與互動的方式發展，企圖將學習脈絡與遊戲結合，進而發展出悅趣化的學習經驗。在學習的領域裡，數位遊戲不僅只有歸納、手眼協調或是視覺變換等技巧性的學習活動（Greenfield, 1984），而是將電玩遊戲視為如同正規教育一樣都能增進較高層次思考能力的學習活動。

Hogle（1996）提到在學習上，遊戲可引發內在動機並提高興趣，學習者可選擇能力所及之關卡來反覆操作並可獲得即時回饋，來進行學習成效的評估，透過不斷的嘗試，學習者亦有機會進行更深一層的反思與修正，而且在不斷的練習過程中，教學內容也重複進入其記憶之中，這是學習的最佳形式。從學習曲線上來說，眾多應用軟體中數位遊戲是擁有最短學習曲線的軟體（Siang & Rao, 2003），不用花費太多的時間學習操作，亦是數位遊戲融入學習的優勢之一，而 Ellington（1982）也認為，遊戲因為具備趣味性，讓學生能在學習的過程中維持較長的注意力，幫助學生在較為輕鬆的過程中養成較高的認知技能，而遊戲能讓玩家積極參與重要關鍵是在動機，此乃透過挑戰、有趣與一部分自然的學習過程（Bisson & Luckner, 1996）。

當年輕人玩數位遊戲時，他們所投入的學習活動是比正規學校教育的活動更複雜且更有挑戰性（Gee, 2003），加上數位遊戲本身是青少年文化中的一部分，若能以遊戲作為教育媒介應是相當理想的，而近年來許多學者的相關研究也確認了數位遊戲式學習所帶來的正面教育意義（Kirriemuir & McFarlane, 2003）。

2.4 模擬遊戲與情境學習理論

模擬遊戲（simulation game），簡稱 SIM 或 SLG。以電腦模擬真實世界當中的環境、事件與規則，提供玩者一個近似於現實生活當中可能發生的情境的遊戲，都可以稱作模擬遊戲，這一類的遊戲大多沒有明顯結局（open-ended）。這類型的遊戲嘗試，在物理和事件上盡可能準確描述現實世界的情況，有幾種較為人知的模擬遊戲，主要為：賽車模擬器，飛行模擬器，以及廣受歡迎的「模擬人生」系列遊戲（Rybka,2010）。

電腦模擬教學就是運用一個強而有力的科技、藉由仿造或再製真實世界的某些部份來進行教學。亦可以讓學生依照本身條件的差異，調整學習速度（Fripp, 1993），在這樣的教學情境下，不僅學生動機增強，也因課程呈現方式與真實世界相仿，讓學習變得有趣（Alessi & Trollip, 1991）。

情境學習理論（situated learning）源自 Scribner, Rogoff, and Lave（1984）與 Suchman（1987）的研究成果，該理論強調學習者是處於情境（situated）所建構的脈絡（context）之中，知識的意義散佈在整個情境當中，透過情境的模擬，學習者置身於知識所在的情境或活動當中，透過觀察、模仿、主動的操作並探究，如此才有更深一層的反思與修正的歷程，並能逐漸掌握知識或技能的意義。Brown, Collins, and Duguid（1989）強調情境式學習是真實情境互動的歷程中，透過實際的活動使學習者學習知識、技能，並對知識建立合理化及有意義的詮釋，而學習基本上是處於某種情境（situated）的學習，它是活動（activity）、情境（context）和文化（culture）相互作用的結果（Lave & Wenger, 1991）。

科技是支援情境式學習之有利因素，科技在情境式學習的環境中，主要提供之功能有下列三項：（1）實際的學習情境（2）高度真實性的替代品（3）藉由影像或多媒體程式提供的學習情境（吳婷婷、黃國禎、宋天文，2007）。因此科技是支援情境式學習之有利因素，我們運用電腦科技、網路等技術來建置學習環境，讓學習者在進行概念學習時，透過和模擬情境的互動，去建構相關的知識背景並獲得整體的知識。因此，透過電腦科技所建置出的虛擬情境可將原本的概念具體化，來幫助學習者進行有意義的學習，並且運用在日常生活中，而不是只學到與現實生活脫節的僵化知識。

3 研究設計與實施

本研究在色彩教學課程之教學策略上，主要運用模擬市民進行色彩配色示範，以加強學生的注意力，作業設計以服飾搭配與空間色彩配置為主題，結合學生日常生活經驗，讓學生有機會置身在知識所在的情境或是活動當中，藉此增強學習印象和激發學動機。而數位遊戲的互動回饋呈現，可讓學生即時比較並修正色彩搭配，以達到最佳的視覺呈現，這樣的練習將有助於提升學生的信心與成就感，並有機會將色彩知識與生活經驗、個人感受結合在一起，將課堂所學延伸到生活領域之中。

3.1 先導研究

本先導研究以臺北市某大學視覺藝術學系 102 上學年度選修「應用色彩學」之大一學

生共 27 人（男 12 人、女 15 人）為研究對象，實施先導研究，以確定研究執行的可行性，並提供後續研究修正的觀點。

在教學設計上，本課程為學期課，教師於第十二至十七週實施六週的數位遊戲融入色彩學習與配色練習之教學，教師運用美商 EA 開發之「模擬市民 2」遊戲，配合其前面課程講授之色彩理論如：色彩感覺、配色理論、色彩調和等，在遊戲操作示範後，由學生在模擬市民 2 進行配色練習，並以色彩計劃市場調查結果進行「20 組主題服飾色彩」與「2 組主題空間色彩」分組簡報，同時實施同儕互評。另外，20 組主題服飾配色，為該課程中的加分作業，學生需在遊戲中建置伸展台，進行服裝走秀演示，演示結束後，進行遊戲融入色彩教學評量問卷調查與半結構性之訪談，課程設計如表 1。

表 1. 數位遊戲融入色彩教學課程規劃─先導研究

週次	課程主題	教學內容
第 12 週	模擬市民 2 遊戲介紹與操作示範	1. 由教師介紹模擬市民 2 及基本工具操作介紹，並配合所教授之色彩理論，運用模擬市民 2 來進行服裝配色演示與理論複習。 2. 透過模擬市民 2 來吸引學生的注意並觸發興趣，並向學生告知課程內容與目標。
第 13 週	實施色彩計劃，進行調查分析決定主題配色與用色策略+遊戲工坊	1. 分組進行色彩計劃步驟與色彩感知之市場調查。 2. 依據市場調查的結果完成主題色彩企畫與管理專案。 3. 決定用色策略並將收集來的色彩資料數位化後建立自己的主題色彩資料庫。 4. 作業說明，針對服裝配色（二十組）與空間配色（兩組）作業需求，與遊戲說明。
第 14 週	依據訂定之用色策略，進行色彩計畫報告+遊戲工坊	1. 依據「色彩計劃」問卷分析結果訂定之用色策略進行簡報。 2. 討論並複習相關色彩理論。 3. 在「模擬市民 2」，進行主題服飾色彩搭配練習。
第 15 週	應用模擬市民 2 進行服裝配色報告+遊戲工坊	1. 應用「模擬市民 2」進行主題服飾色彩配色報告。 2. 製作伸展台、走秀影片。 3. 說明空間配色作業實施與呈現方式。
第 16 週	室內設計演講，搭配模擬市民 2 空間配色實際演示與說明+遊戲工坊	1. 室內設計師以實際案例進行配色說明。 2. 「模擬市民 2」示範空間配色效果。
第 17 週	空間配色報告與虛擬伸展台演示	1. 各組運用「模擬市民 2」進行二組空間配色報告 2. 將空間與服裝之主題色彩，結合遊戲之虛擬伸展台進行走秀演示 3. 教師講評與同儕互評

圖 1. 主題服飾色彩演示，資料來源 A 組學生作業

圖 2. 模擬市民服裝走秀演示，資料來源 A 組學生作業

本研究在課程結束後，採用自編「色彩學教學導入數位遊戲評量問卷」（附錄一）進行調查。問卷份數為 25 份，佔總修課人數的 92.59%，本問卷題目分別為注意力、關聯性、信心與滿足感，另外加入學習成效等構面，以了解數位遊戲融入色彩教學是否明顯提升該課程的學習動機。

結果顯示數位遊戲融入色彩教學在注意力、關聯性、信心、滿足感與學習成效共五個構面，平均分數為 3.84 到 4.16 之間，介於五點量表「普通」和「滿意」之間，五個構面的整體平均分數為 4.05，由結果可知學生對數位遊戲融入色彩教學之滿意程度可達中上之水準，如表 2 所示。

表 2. 色彩學教學導入數位遊戲課程評量問卷結果摘要表（N=25）

層面名稱	人數	題數	平均數	標準差
注意	25	2	4.12	.696
關聯性	25	3	4.16	.586
信心	25	3	3.84	.708
滿足感	25	3	3.99	.670
成效	25	2	4.12	.726
整體結果	25	13	4.05	.573

除問卷外，課後並邀請九位（1 男 8 女）志願參與同學，進行深入的團體訪談，以了解學生在應用模擬市民進行配色練習時的學習經驗、教學設計、遊戲困難程度等問題，在訪談過程中節錄其談話內容，做成逐字稿，訪談內容如附錄二。

訪談結果顯示數位遊戲融入課程之中對學生而言是，有趣、歡樂、特別、有成就感，在進行空間配色時，覺得是在打造自己夢想的房子，並將遊戲情境和日常生活經驗做結合，從上述訪談結果推論，數位遊戲融入色彩教學可以有效提升學習動機。但因學生對遊戲熟悉與涉入程度不盡相同，考量學生遊戲操作練習的時間，因此提早告知學生作業要求並提早熟悉遊戲介面，避免時程安排過於緊湊，造成學生焦慮。

依據先導研究結果，任課教師對教學內容與過程進行修正，例如，提供統一的服裝物件，空間配色物件（壁紙、房屋），讓所有學生條件一致，將更能達成教學目的，並開設遊戲工坊進行課後補強，以降低學生因遊戲的熟悉程度而影響其配色練習之效果。

3.2 正式研究

1. 研究設計

本研究係以臺北市某大學視覺藝術學系，102 學年度第二學期「應用色彩學」課程之修課學生為研究樣本，人數為 19 人（男生 1 人、女生 18 人）參與數位遊戲融入色彩教學之實驗研究。「應用色彩學」課程從色彩學理論與配色原理出發，加入數位遊戲來輔助色彩教學與配色學習，在教學設計上 1-10 週課程主要教授色彩理論，11-18 週課程則請學生擬定色彩計畫之主題，並進行色彩感知問卷調查，再依調查結果決定色彩應用策略後，學生可以在「模擬市民 3」中利用主題色彩，進行 12 組主題服飾造型與 4 組的空間配色練習，最後並邀請專家進行色彩專題提案審查與座談。

正式研究並綜合先導研究問卷調查與課後訪談結果，針對部分問題進行修正，並規劃更完整之研究設計，修正內容包括：

(1) 數位遊戲應用於色彩教學與配色練習之實施成效與適切性

先導研究從注意、相關、信心與滿足感四個面向來探討數位遊戲應用於色彩配色練習之整體成效，結果顯示數位遊戲融入色彩配色練習能提升色彩學習動機與配色練習成效。因此，正式研究將從模擬市民 3 去分析探討，何種遊戲特性符合色彩教學與配色練習之需求。

(2) 提供具支持性之學習環境與適切之教材

先導研究發現學生在配色物件的蒐集費時且規格不一，遊戲介面操作與熟悉度之問題，而先導研究中的伸展台演示，乃為課程設計中加分（增強）之活動設計，但易受限於遊戲密技、場景物件，機造影片之拍攝與剪輯，需較高之遊戲技巧。且易造成色彩學習焦點模糊，並使學生產生學習焦慮，導致影響學生配色練習成效。

因此正式研究時，將提供統一的服裝物件，空間配色物件（壁紙、房屋），讓所有學生條件一致，將更能達成教學目的，並開設遊戲工坊進行課後補強，降低學生因不熟悉遊戲操作而產生的挫折感。

在課程目標上，「應用色彩學」課程從色彩學理論與配色原理出發，加入數位遊戲來輔助色彩教學與配色學習，並且結合數位遊戲的特性：如情境模擬、即時互動介面等來提供學生即時回饋的色彩練習與呈現體驗。藉由數位遊戲的互動功能，增加課程的豐富性、有趣性、立即性，並且結合一般人玩數位遊戲的高度投入和專注，將商業數位遊戲運用到教學示範與學生練習

本研究針對數位遊戲融入色彩教學與配色練習課程結束後，進行「模擬市民 3 遊戲操作與配色練習適切性調查」施測，問卷內容包含三個向度，分別為：遊戲操作（1~6、9 共 7 題）、配色適切性（7~8、10~14 共 7 題）、整體學習觀感（15~17 共 3 題）。在問卷效度上，本問卷初稿製成後，請五位曾經上過色彩學之學生先行讀題進行表面效度之檢核，刪除語意不清或過於艱澀之處，並請美國北伊利諾大學美術教育系王士樵教授及亞洲大學數位媒體設計系陳俊宏教授審閱問卷，進行專家效

度之檢核，確定問卷內容。在問卷信度上，則採「內部一致性法」，求得各分量表內部一致性係數（Cronbach α 值），量表各構面之 Cronbach α 係數分別為遊戲操作.752、配色適切性.751、整體學習觀感.734，全量表之 Cronbach α 係數為.883。問卷分為遊戲操作與配色適切性兩個構面，以學生在數位遊戲融入色彩教學與配色練習階段的之總分與各層面得分，來了解學生對數位遊戲融入色彩教學與配色練習的滿意度與適切性。

在教學工具上則使用「模擬市民 3」，模擬市民 3 提供了更為細緻且具彈性的人物創造工具，更擬真的遊戲場景與物件，更具彈性的遊戲或創意工具(create a pattern tool)，學生可自訂、細微調整物品顏色與花樣，並且應用在沙發、壁紙與服裝等物件上，而模擬市民 3 簡易的物體拖曳功能與操作、遊戲內建配色上所需的色相環，使用者可透過色相環、色碼、色票來配色，更能符合配色練習之需求。

以服裝為例，學生除了可以挑選遊戲內建的約八十多種的服裝款式外，亦可細部調整衣服、飾品的顏色材質，並可進入「創造風格模式」選擇遊戲內建之材質、紋飾進行置換，並可針對所選取服飾中的個別顏色，應用色票、色環、色號來進行顏色的微調或置換，以呈現出更具個性化的色彩（圖 3）。其中應用遊戲中的創建工具與 create a pattern tool，可以輕鬆地去創造家具、服裝、地板與牆壁等圖樣(圖 4-6)。

圖3. 應用色相環調整細部服飾顏色，資料來源：模擬市民3

圖4. 應用色相環調整家具、壁紙顏色，資料來源：模擬市民3

圖5. 應用圖層堆疊方式設計圖案，資料來源：模擬市民3

圖6. 以3D模式預覽效果，資料來源：模擬市民3

2. 研究結果

依據先導研究結果，任課教師對教學內容與過程進行修正，在應用模擬市民 3 進行色彩教學與配色練習後，所得到的研究結果如下：

(1) 模擬市民 3 遊戲操作與配色適切性之現況分析

在模擬市民 3 遊戲操作與配色適切性問卷整體及各層面的現況：就問卷所得的資料分析，受試者在遊戲操作與配色適切性問卷中的「遊戲操作」、「配色適切性」、「整體學習觀感」以及整體量表的平均數分別為 3.54、3.91、3.95 及 3.77，介於五點量表的選項「普通」與「同意」之間，如表 3 所示。

表 3. 遊戲操作與配色適切性各層面與整體現況分析摘要表（N=19）

層面名稱	人數	題數	平均數	標準差
遊戲操作	19	7	3.54	.48
配色適切性	19	7	3.91	.47
整體學習觀感	19	3	3.95	.67
整體量表	19	17	3.77	.41

(2) 遊戲經驗對模擬市民 3 遊戲操作與配色適切性的差異情形

本研究以模擬市民系列遊戲的遊戲經驗為自變項，以遊戲操作與配色適切性的「遊戲操作」、「配色適切性」、「整體學習觀感」以及整體量表為依變項，並依其平均數、標準差進行獨立樣本 t 考驗，以了解模擬市民遊戲經驗對遊戲操作與配色適切性各層面與整體的差異性。而受試者是否有模擬市民的遊戲經驗，經過 t 考驗的結果，並未達到.05 的顯著水準，結果顯示研究對象的遊戲經驗在遊戲操作與配色適切性的各層面與整體效果上，並未呈現差異，詳細資料分析結果，如表 4 所示。

表 4 模擬市民遊戲經驗之獨立樣本 *t* 檢定摘要表

依變項	選項	樣本數	平均數	標準差	*t* 值
遊戲操作	玩過模擬市民	16	3.50	.433	-.852*ns*
	未玩過模擬市民	3	3.76	.787	
配色適切性	玩過模擬市民	16	3.88	.473	-.705 *ns*
	未玩過模擬市民	3	4.10	.502	

整體學習觀感	玩過模擬市民	16	3.96	.719	.160 *ns*
	未玩過模擬市民	3	3.89	.385	
總量表	玩過模擬市民	16	3.74	.419	-.697 *ns*
	未玩過模擬市民	3	3.92	.400	

***ns p*>.05**

(3) 遊戲難易程度對對模擬市民 3 遊戲操作與配色適切性的差異情形

本研究以遊戲的難易程度為自變項，以遊戲操作與配色適切性的「遊戲操作」、「配色適切性」、「整體學習觀感」以及整體量表為依變項，並依其平均數、標準差進行獨立樣本 t 考驗，結果顯示遊戲的難易程度，對遊戲操作與配色適切性的各層面與整體效果上，並未呈現差異。詳細資料分析結果，如表 5 所示。

表 5 遊戲的難易程度之獨立樣本 *t* 檢定摘要表

依變項	選項	樣本數	平均數	標準差	*t* 值
遊戲操作	簡單易學	7	3.63	.47	.616 *ns*
	不是很容易，但可以克服	12	3.49	.50	
配色適切性	簡單易學	7	4.08	.52	1.18 *ns*
	不是很容易，但可以克服	12	3.82	.43	
整體學習觀感	簡單易學	7	4.33	.54	2.09 *ns*
	不是很容易，但可以克服	12	3.72	.65	
總量表	簡單易學	7	3.94	.37	1.45 *ns*
	不是很容易，但可以克服	12	3.67	.41	

***ns p*>.05**

(4) 遊戲難易程度對對模擬市民 3 遊戲操作與配色適切性的差異情形

對於模擬市民 3 應用於色彩配色練習後，產生深刻印象的特性，選項可複選。研究結果顯示，模擬市民 3 令學生產生深刻印象之特性中，可以依個人喜好，創造出具個人風格的造型與物件—客製化（100%）最多，其次是即時呈現配色效果（94.7%）、可以放大縮小，呈現細微或整體的配色效果（89.5%），生活中相關物件的應用（燈光、家具）（73.7%），而對於真實世界的情境模擬（近似真實的環境）以及直接在物件上配色，沒有繁複的流程，亦各佔了（68.40%），由於是複選題的關係，觀察值百分比之加總數字為 515.8%，表示八個題項中，每個人平均選了 5.15 個選項，結果如表 6 所示。

表 6 模擬市民 3 遊戲特性分析

題項	反應值		觀察值
	個數	百分比	百分比
可以依個人喜好，創造出具個人風格的造型與物件（客製化）	19	19.40%	100.00%
即時呈現配色效果	18	18.40%	94.70%
可以放大縮小，呈現細微或整體的配色效果	17	17.30%	89.50%
生活中相關物件的應用（燈光、家具）	14	14.30%	73.70%
對於真實世界的情境模擬（近似真實的環境）	13	13.30%	68.40%
直接在物件上配色，沒有繁複的流程	13	13.30%	68.40%
能提供豐富的遊戲資源的遊戲社群	3	3.10%	15.80%
其他─可以實現現實生活的不滿足	1	1.00%	5.30%
總數	98	100.00%	515.80%

(5) 模擬市民 3 在配色練習中所扮演的角色

模擬市民 3 在配色練習中所扮演的角色，經分析後各選項所勾選的次數及百分比如表 4-7，觀察統計結果，對於模擬市民 3 在色彩配色練習所扮演的角色，三個選項的選填人數至少有 12 人，佔了 66.70%。其中又以呈現個人特質的媒介（88.9%）最多，其次是工具（72.2%），而觸發你學習的因子則是有 12 位選填，佔了 66.7%，由於是複選題的關係，觀察值百分比之加總數字為 227.8%，表示三個題項中，每個人平均選了 2.27 個選項，結果如表 7 所示。

表 7 模擬市民 3 在配色練習所扮演的角色

題項	反應值		觀察值
	個數	百分比	百分比
呈現個人特質的媒介	16	39.0%	88.9%
工具	13	31.7%	72.2%
觸發你學習的因子	12	29.3%	66.7%
總數	41	100.00%	227.8%

(6) 課後訪談

由於研究施測樣本數較少，單就量化結果無法完整呈現並推論模擬市民 3 在期末作業針對所擬定之主題進行的色彩感知調查，並將調查結果應用模擬市民 3 進行 12 組的服裝配色與空間配色練習，在課程結束後對數位遊戲介入色彩教學策略給予正面的意見回饋，部分節錄如下:

(a) 經過這次色彩學的色彩調查與應用，除了對設計衣服和空間設計有實際的體驗之外，也覺得模擬市民真的是款不錯的遊戲。讓我覺得色彩是如此好玩的一樣學問。

(b) 從剛開始威尼斯彩虹屋的理念發想，到應用模擬市民實際把空間、服飾做出來，這個過程中，我們越來越喜歡這樣繽紛的配色！

(c) 用遊戲軟體上課是一個很特別的方式，不僅能讓學生較有動力主動參與，做起作業來也比較不會那麼辛苦。

(d) 做這作業雖然需要很多時間，但最後總是會做到欲罷不能呢。

以下為學生透過色彩調查的結果分析，擬訂主題的色彩策略，訂出基本色調與組合後應用模擬市民 3 所呈現之成果（圖 7、圖 8）。

圖7 馬戲團組應用模擬市民3所作之空間配色（學生作業）

圖8 時尚巴黎組應用模擬市民3所作之服飾、空間配色（學生作業）

而模擬市民的遊戲特性亦可歸納出三大面向，包括：個人化的需求、簡化配色練習流程及近似真實的環境與物件，這些特性是符合學生在色彩學習上的需求。

1. 個人化的需求

色彩的配色方式相當的多樣性，配色時雖然要注意到普遍流行或嗜好的顏色，但也要發揮個性，不要為傳統習慣所束縛（鄭國裕、林盤聳，2001），在嘗試配色的過程中，我們常依據主觀的想法及個人的感覺。而個人主觀的色彩視覺偏好、文化、年齡、性別都會對色彩選擇上，產生顯著的影響。因此在色彩學習上，希望學生能夠在色彩理論的基礎上，結合生活中累積的色彩經驗與主觀意象去呈現出個人化的色彩應用風格，並且能將配色的感覺予以客觀化，以符合實際需求，將課程所學之專業知能，延伸至其他相關的課程、日常生活或是未來的藝術創作及設計之中。

2. 簡化配色流程

遊戲中的即時呈現配色效果、直接在物件上配色，這些特性改善了傳統平塗色票練習中，耗時且又易受限於紙張、顏料的影響，也造成學生練習品質無法控制的問題（盧俊宏、葉吉城，2003）。而在遊戲中應用色票、色環、色號來進行顏色的微調或置換，除了能切合色彩教學的需求外，亦能準確的掌握色彩，做好色彩色票的管理，而且透過數位遊戲的互動回饋呈現，學生可以即時比較並修正色彩搭配，以整體或微觀的方式調整配色的效果，以達到最佳的視覺呈現，藉此加強色彩學習成效與學生的成就感。

3. 近似真實的環境與物件的應用

模擬市民 3 遊戲營造類似真實生活的情境，讓學習者能夠藉由與情境互動中進行學習，有助於將所學知識遷移至實際生活應用上（Smith & Ragan, 1993），而色彩學習的最終目的，就是希望能將色彩活用在生活上；此外，在空間設計中，色彩具有支配整體空間感的呈現效果，有助於表達空間特色的作用（王建柱，1984），而且在視覺上的觀感，會比應用在其他方面如：平面、產品、服裝等色彩更能刺激人的感覺（林姬瑩，2005），也因此，遊戲中豐富的視覺參考，如：整體或細微呈現配色效果，以及燈光家具的應用，將能更精準的掌握空間配色。

在 Brophy（1987）所提出能提升色彩學習動機的策略上，除了建立有意義的學習目標、肯定學生表現以及建構適度的競爭氣氛外，教學設計、教材亦是刺激學生學習動機的重要元素，教學時配合學生興趣，提供新奇且具創意之教材、模擬的機會或學習情境與遊戲化的學習活動；而作業有趣味且有價值，學習活動要能引發學生好奇心，並將各項教材予以

個人化、具體化及熟悉化等，這些因素與模擬市民 3 的遊戲特性是相符的。

4 結論

4.1 模擬市民 3 之遊戲特性符合配色練習之需求

本研究調查發現，模擬市民 3 對於學生而言是呈現個人特質的媒介、色彩學習的工具，亦是觸發他們學習的因子，學生選填的比例高於七成以上，結果顯示模擬市民 3 在學生色彩配色練習中所扮演的角色為呈現個人特質，並且進一步分析是模擬市民 3 遊戲中的創造個人風格的造型與物件（客製化）、即時呈現配色效果、可呈現細微或整體的配色效果及視覺參考等特點，充分獲得學生的肯定，而遊戲中與真實世界相仿的物件與場景，更是他們能把生活中的色彩經驗轉化至遊戲中的重要因子。

而色彩的配色方式相當的多樣性，配色時雖然要注意到普遍流行或嗜好的顏色，但也要發揮個性，不要為傳統習慣所束縛（鄭國裕、林盤聳，2001），在嘗試配色的過程中，我們常依據主觀的想法及個人的感覺。而個人主觀的色彩視覺偏好、文化、年齡、性別都會對色彩選擇上，產生顯著的影響。因此在色彩學習上，希望學生能夠在色彩理論的基礎上，結合生活中累積的色彩經驗與主觀意象去呈現出個人化的色彩應用風格，並且能將配色的感覺予以客觀化，以符合實際需求，將課程所學之專業知能，延伸至其他相關的課程、日常生活或是未來的藝術創作及設計之中。

4.2 學生實驗課程滿意度高

應用數位遊戲做為色彩配色練習工具的滿意度與色彩學習的實施成效有很大的關聯，因為遊戲的情境模擬、視覺參考及簡易的操作介面等，滿足學生配色練習之需求。從學生所執行的色彩專案計畫課程單元中，應用模擬市民 3 進行服裝以及空間配色的成果展示後的課程回饋中發現，模擬市民 3 觸發了學生色彩學習的興趣、主動參與，讓學生藉由遊戲自由創作、呈現自我風格，做作業不再是件枯燥、辛苦的事情，甚至有欲罷不能的感覺，色彩學成了一門好玩的學問。

4.3 模擬市民 3 遊戲呈現配色高度適切性

從研究結果顯示學生的遊戲經驗（是否有玩過模擬市民）、模擬市民遊戲的難易程度，並不會影響學生在模擬市民 3 的遊戲操作與配色適切性以及色彩學習的意願，維持很高的學習興趣，進一步從學生在課後針對應用模擬市民 3 所進行的服裝、空間配色練習的學習心得中，也顯示模擬市民 3 帶給學生樂趣、滿足感，也激發了他們主動學習與參與的動力，並且能增進色彩學習動機的媒介。

5. 建議與討論

雖然數位遊戲所扮演的角色是觸發學生色彩學習的因子、呈現個人特質的媒介及配色練習工具，但整體而言對色彩學習是有所助益。雖然此商業遊戲非專門為色彩練習所設計，也因此在教學與練習上人多少受限。但透過教學設計，可適時將遊戲導入教學內容中，則是數位遊戲融入教學之中，所必須重視的課題。因此在未來在思考數位遊戲融入色彩教學設計中，仍須從課程內容的整體面向來規劃，釐清色彩學習的重點，適時佐以色彩學理論與色彩配色原理，讓學生有機會養成對周遭環境觀察的習慣，訓練自己在生活中不斷的觀察色彩、體會色彩，收集並思考日常生活中色彩組合所蘊含的社會文化意義，培養他們在色彩及其文化面向上的敏銳度，這樣由生活所獲得的色彩經驗累積，才能增強學生未來在色彩掌控與運用的能力。

此外，在課程中數位遊戲所扮演的角色是提供學生近似現實生活的情境，讓學習者透過「做中學」來反覆練習、操作配色效果，即時提供學習者配色效果，像是空間、家具物品等，讓學習者能夠藉由與情境互動中進行學習，有助於將所學的色彩知識遷移至實際生活應用、藝術創作、設計呈現或居家生活之上，讓學生能充分活用色彩，以達到配色應用與表現的技能。藉以促進學生色彩學習成效、學習動機與成就感，並跳脫傳統色彩學習過於理論化，而忽略了色彩學習需要建立在對日常生活的觀察與實際練習體驗的重要性。

因此，在未來應用遊戲融入色彩教學與配色練習時，應特別考量遊戲與教學目標的適切性、合適的遊戲環境設定、讓學習者產生黏著度、具有良好的互動性等，如此才能吸引學生使用，且對學習成效有正面的助益。

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【附錄一】

數位遊戲融入色彩教學評量問卷（先導研究）

基本資料：

性別：□男 □女

是否有玩遊戲的經驗：□有 □無

曾經玩過哪些遊戲：□PC 遊戲 □電視遊樂器（如：Wii、PS2、XBOX360） □掌機（如：NDSL、PSP） □手機遊戲

喜歡的遊戲類型有哪些？（可複選）

□角色扮演 □戰爭策略 □模擬經營 □動作射擊 □文字冒險 □戀愛養成

□音樂舞蹈 □休閒競技 □動腦益智 □桌棋牌類

每週玩遊戲的時間：□1~3 小時以內 □3~5 小時 □5~7 小時 □7 小時以上

每週上網時間：□1~3 小時以內 □3~5 小時 □5~7 小時 □7 小時以上

你有選修過將遊戲融入教學的課程嗎？□有 課程是___________________ □無

編號	請您仔細閱讀下列題項後，依據個人實際的經驗與想法，在右側欄位中，圈選適合的數字選項。	非常同意	同意	普通	不同意	非常不同意
1	色彩學課程中導入電玩模擬市民 2 來做配色練習，可以增進你的學習興趣	5	4	3	2	1
2	你認為利用模擬市民 2 進行配色練習，可以把原本繁複的配色練習流程簡化了	5	4	3	2	1
3	你認為模擬市民 2 中的場景，對於配色效果的呈現是有幫助的	5	4	3	2	1
4	你認為在遊戲的虛擬環境裡，可以降低你對色彩搭配嘗試上不安感	5	4	3	2	1
5	你認為在遊戲裡練習配色，可展現高度的自主權與發揮掌控能力	5	4	3	2	1
6	你認為利用遊戲所見即所得的特性，對於你操作配色練習是有幫助的	5	4	3	2	1
7	你認為能透過遊戲將色彩學作業完成，對你而言是有成就感的	5	4	3	2	1
8	遊戲中的物件，可提升配色效果呈現的多元性	5	4	3	2	1
9	你認為整體遊戲操作介面是簡單容易的	5	4	3	2	1
10	在遊戲操作的過程裡，我樂在其中	5	4	3	2	1
11	在運用遊戲配色練習的過程中，我比平常更加專注	5	4	3	2	1

12	你認為遊戲中服裝搭配之效果，會讓你想嘗試搭配日常服裝	5	4	3	2	1
13	你認為利用模擬市民 2 的情境模擬（如：客廳與臥室）所進行配色的練習心得，將來有機會運用在日常生活中	5	4	3	2	1
14	你認為運用遊戲中的伸展台呈現配色成果，可提高自我滿足感	5	4	3	2	1
15	你認為透過同儕互評的方式，可以評量出學習成果	5	4	3	2	1
16	整體而言，你認為遊戲融入教學中對於色彩的理論吸收是有幫助的	5	4	3	2	1
17	你認為本次的學習經驗可以應用在其他課程的學習	5	4	3	2	1

【附錄二】

先導研究學生訪談內容與摘要

學生以序號來做為代碼，如 STU_1 代表學生 1。以下為訪談的內容與摘要：

問題一：在應用色彩學的課程進行過程中，你對那個單元的作業或活動比較感興趣？為什麼？這些教學設計有達到你一開始來修這門課的期待嗎？

STU_3：我最喜歡配色作業，因為遊戲很有趣

STU_2：模擬市民，因為很特別，沒上過這種課

STU_7：用 Photoshop 來做配色和調色

STU_9：模擬市民，因為可以蓋很漂亮的房子

STU_4：季節色彩的配色吧！

STU_5：伸展台蓋好後還滿有成就感

STU_3：這門課很歡樂

STU_4：用 Photoshop 把相關色變成色票，很實用

STU_1：遊戲比較好玩，Photoshop 雖然可以調很多顏色，但是比較無聊

問題二：透過這次的經驗，你覺得將遊戲融入教學設計的好處？缺點？可能遇到困難是甚麼？你是怎麼克服？

STU_6：蒐集資料還有調查比較花時間

STU_3：用遊戲來做作業，會讓人比較有動力還有成就感

STU_2：很特別，但是找衣服還有物件很花時間

STU_6：不熟悉遊戲時，操作有點困難

STU_5：感覺像在蓋自己夢想的房子，幻想自己住在裡面

STU_8：要花時間玩，但是還滿有趣的

STU_6：找衣服比較花時間，錄影的時候會跑很慢

STU_4：多玩就會熟了之後就還好

STU_9：可以看到配色的效果

STU_3：物件太多，電腦有點跑不動有些物件還跑不出來

STU_1：比較有成就感

STU_7：人最難控制，四處亂跑亂跳還會死掉

問題三：你覺得這樣的教學（學習）設計還有甚麼地方需要改進的？

STU_7：希望能早一點去操作遊戲

STU_6：練習時間太短

STU_3：沒有，這門課很有趣

STU_1：很有趣的課

整合聲音、影像、文獻紀錄之文創類型展示媒體研究

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摘要

二十一世紀聲響技術和影像科技蓬勃發展，現今傳播媒介因跨科際整合之數位科技而有嶄新的形式結構、美學意涵，其內容亦呈現出不斷延異的變貌。本文針對整合性的資訊再現方式，剖析文創策展人如何將歷史文獻、音像和影像圖片數位化，並據以創新展示，徹底改變傳統藝文展示空間中依據人文藝術專業取向之策展思維為主導，強調科技與人文的結合、觀者於藝術活動之參與。通過運用媒體科技以創造一個個超真實的體驗環境，這種當代再現歷史及文化資產的展示形式，能使觀者於文創展演平台找到新的感知角度和建構不同的認知意義。本文藉由發展個案研究，說明如何將創新的軟性電子音響(FleXpeaker ™)加以設計運用，作者先將歷史性或社會性的文本資料加以視覺化，從拆解訊息到運用設計符號為載體進行視覺編碼，後續使影像文本印製結合在紙音響上，用以轉換成特定的聯動感官知覺的展示物件，以視聽整合的方式刺激參觀民眾的想像力，將事件、歷史時空背景和現場環境的訊息融合，形成新的美感體驗。本文發現當代文創策展人試圖在展示空間與新興媒體搭配，可以是運用如軟性電子材料等新興科技媒體，將社會的、歷史的文本內容進行擬像轉義，活化當代國民生活的共同記憶。因而，以混雜多元之異質化、交互跨越之「超文本」、符碼轉換下「超真實」三項觀點，論述當代展示形式混雜多重，改變了視覺傳播的性質、內容和展示使用載體，趨使當代文創策展人必須進行跨科際整合之設計創新。

關鍵詞：視覺傳播、展示設計、文化符碼、文創策展。

The Study of Applying Creative Media and Exhibit Design to the Integration of Sounds, Images and Data in Cultural-creative Curation

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ABSTRACT

The Digital Information communication and new media technology have the immense impact on the development of modern society and contemporary art. Within the new media revolution, the shift of old culture to computer-mediated forms of production, distribution and communication have make people start thinking about how to combine art and design with technology. Because of its appealing characteristics, such as variability, transcoding, and interaction in relation to multiple professions and disciplines, the invention of digital devices and contents has revolutionized the quality of sound, image, and data, the way in which they are contemplated, and the forms of art that produce activities and aesthetics concepts. The reproduction of contemporary sounds and images leads to the hyper-real scenes at the exhibit spaces in Sun Yun-Suan Memorial Museum in Taipei. Through the experimental practices of combing sounds, images and historical data, the museum brought together the curators, historians, scholars, sound engineers, and image-design experts in data visualization. The researcher employs case study method to discuss the main question: Could we create artistic practices in combining sounds, images and data in terms of the Aesthetics of the meta-interpretation approach? In addition, for the pulse of the times and trends, the research delves further into the new media-FleXpeaker™, as the carrier. In return, the social-context data are visualized and transcoded into specific images and life photography printed upon both sides of the surface of FleXpeaker™, as well as with sound effects to stimulate visitors' imagination of the events, the time and the underlying environment. As the result, the exhibition devices and design objects do help visitors to realize the significance of diverse elements of sounds, images and data in relation to its cultural-heritage representation.

***Keywords*:** Visual communications, Exhibit design, Cultural code, Cultural-creative curation.

1 導論

1.1 研究背景與動機

1990 年後西方學界興起討論後設詮釋影像象徵寓意與文化符碼轉義等論述觀點，對當代新媒體和文化傳播領域之研究具有相當的影響性(Sturken & Cartwright, 2005)，說明著數位化時代人們如何解構訊息內容，其內容如何被挪用、拼湊，與反思隱藏其中的「文化」內涵如何再現等問題，同時亦影響著當代設計研究，產生新興之發展趨勢。二十世紀七 O 年代起即在大眾文化與傳播研究領域中執英國伯明罕當代文化研究中心牛耳的霍爾(Stuart Hall, b.1931—)，在二十世紀末發表 Representation: Cultural representations and signifying practices 此著作中即提出：反思當代視覺傳播(visual communications)之「存在」(包括媒介本身、製播者的意圖及背後意識形態的影響)不能構成其「有」的全部條件，還需要加上觀者在其文化背景上閱讀的「意義」(Hall, 1997)。因而，作者近年來嘗試從文化再現與符碼形構的角度切入策展和展示設計研究，進而思考如何於展場空間建構視覺文化脈絡意義(significance of cultural context) 的可能方式，藉而參與一個逐漸為大眾所接受的文化符碼化的生產歷程，進行語意的再創造。

1.2 研究目的、問題與範圍

本文以觀者解讀文化符碼的方式來檢視策展實踐和展示設計，是將大眾的參觀展覽經驗轉成為一種語碼來檢視，建立策展者、文本與觀賞者之間溝通的一套語言系統。據此，本文作者提出研究問題，分述如下：

1.2.1 是甚麼改變了視覺傳播的性質、內容和載體？如何進行跨科際整合之設計創新？

1.2.2 如何使展示設計和其他媒介文本呈現一種對話關係？具體地說，文創策展人如何結合聲音、影像、文字紀錄進行跨平台展示？

1.2.3 結合科技應用之展示設計，其物件如何被觀看和使用？

因而，本文旨在探討新傳播媒體之本質與特性，以及數位化潮流下對於當代訊息傳達的表現形式、美學觀點與思維方式產生之改變。後續以個案研究方式，探討新興科技媒體一軟性電子音響 (FleXpeaker ™)的媒體特性，了解其結合影像輸出後呈現於展場的應用方式。此外，探討文創類型策展人如何將文本資料視覺化和轉換成特定的聯動感官知覺的展示物件，將不同的數位媒材如文字、影像、聲音等進行統整與編輯修改，透過資料的存取得以遊走於不同的媒體介面之間傳播，據以研討展示設計物件被觀看和互動下，觀者的多義解讀。綜論之，本文試圖以當代新興設計觀點與新科技媒體為載具，建構「設計創新」於當代文創策展之表現經驗值，期許達到在文創設計領域中應用當代科技材料之創新與實驗性。

1.3 研究方法

本文主要採用質性研究法中個案研究法(case study)，分析目前尚在探討階段，從事現象事物的探究，並探索創意媒體如何研發之研究問題。運用個案研究法在尚未有許多前人研究可資依循的研究論題上，適用於發現回應研究問題的可能面向。由於個案研究是「個別」案例的探討，研究者需要投入大量精神現場參與觀察，去蒐集資料、瞭解、衡量事實，進行分析與驗證據以呈現現象，並將研究結論提供給他人作為此事件的「客觀了解」(張紹勳，2001)。

此外，作者運用文本分析法 (textual analysis) 研究意義建構的一種過程 (Su, 2003)。研究資料收集包括文史典籍、影像檔案紀錄、多媒體設計、實地觀察展場之內容等。自資料來源而言，著重從行動研究者的角度觀察研究的現象，而不是經由控制變項過的工具，來進行效果衡量。本研究運用個案研究法所產生的論點主要來自資料的歸納，研究的發現是將具有複雜交互關係的變數綜合而成，以描述現況、檢驗和建構論點。分析觀點「文本」(text) 時，不限定於某種印刷形式存在的書籍、文物、或設計品本身，同時包含了「詮釋」研究事物及社會現象的過程，並且對

所包含的相關事件深入探索分析。作者相信在建立論述時，往往會受到社會環境、文化因素等影響，所以研究除了解事物表象意涵，同時包含了理解社會脈絡意義之相關層面(陳雍正，2008)。

再者，本文作者以符號學為本研究之重要理論基礎，二十世紀末劍橋大學出版的專書：The subjects of art history- Historical objects in contemporary perspective (1998) 收錄 Mieke Bal 一篇論文 "Seeing signs-The use of Semiotics for the understanding of visual Art." 指出符號學用以檢視視覺作品時可連結文字、聲音、圖像、象徵等文本，對作品進行細部分析；在系統化的分析架構中，文本沒有位階高低，它並且解放了領域間的藩籬(廖新田，2008)。下文中以羅蘭・巴特（Roland Barthes，1915-1980）於《符號學原理》（Éléments de Semiology）（1967）一書中，提出符號具有外延意義(denotation)與內涵意義(connotation)之論述架構為參照，以尚・布希亞（Jean Baudrillard，1929-2007）提出之擬像（simulation）、超真實（hyper-real）理論 (布希亞 著，洪凌 譯，1998)，佐以德希達(Jacques Derrida, 1930-2004)、霍爾、史特肯(Marita Sturken, b.1957—)等學者的論述觀點為參考，對展示設計中的主要符徵進行解讀與詮釋，觀察策展團隊需進行數位影音創作，以數位媒材經電腦剪輯、合成、混用等後製編修設計方式為主，利用不同的創作手法進行實驗性的影音整合，或輔以屏幕裝置、立體投影等形式作為軟性電子音響結合視覺傳達媒體之可能呈現。其中，符徵(signifier)、符指(signified)之間的互文性(intertextuality)、多重會意(polysemy)特性更顯複雜，發現符號寓意具有跨域轉碼的可變性、衍生性，因此在進行影像意涵的討論與建構時，更應將社會背景、文化因素等相關背景脈絡涵蓋在內（蘇佩萱，2013）；據此探討「設計創新」與跨科際整合議題，於當代文創類型策展時運用新媒體科技設計實務之成果。

後續，本文針對當代新數位媒體美學本質與特性，和軟性電子科技應用兩個重點進行文獻和個案探討：

2 新數位媒體美學

數位時代對人類社會之影像製播方式與既有的圖像閱讀方式產生徹底的變革，人們所接觸傳播資訊的方式，從原本於真實世界中有一對應存在的類比式再現，轉為熟習於純粹資訊編碼、電腦數據操作的數位再現方式。二十一世紀初，列夫・曼諾維奇(Lev Manovich, b. 1960—) 發表《新媒體的語言》The Language of New Media (2001) 著作中提出當代新媒體具「數值化再現(numerical representation)、模組化(modularity)、自動化(automation)、變異性(variability)、轉碼化(transcoding)」五大特性，改變了人類社會以往對於圖像的觀看方式與影像思維。奠基於這些特性的討論，國內學者包括葉謹睿(2003)產生將其中「變異性(variability)」轉換為「液體化(liquidity)」之說法；姚瑞中(2007)僅取前三項特性，再增加了非物理性介面、虛擬性與複製性、和互動機制；邱誌勇(2013)在前述五大特性上增加第六項特性「視覺化」。這些論述觀點皆反映著當代在以電腦化操作資訊編碼的建構模式下，基於 0/ 1 二位元數值透過電腦的自動化邏輯演算，不同的數位媒材如文字、影像、聲音等，其使用者皆因共用數位化編碼模式，易於進行統整、複製與編輯修改文本，透過資料的存取也得以遊走於不同的媒體介面之間 (劉于慈，2015)。

更重要的是，上述姚瑞中提出的「互動機制」說明了數位編碼可無限組合與衍生下，使在展示空間中促發觀者以觸摸、移動、發出聲響等不同的互動行為之存在，變的可能；使得展場透過參與者的互動行為，可使展示作品的形式樣態和意義隨之改變。因而，我們了解觀者與展示品互動產生出意義的變化，將取決於參與時注入變數的不同而造成不同的結果，也造成觀者後設解讀意義之高度不重複性。

新媒體的特性與原則也影響了視覺傳播意涵、美學觀點與展示設計創作模式之改變，其中邱誌勇強調「視覺化」的特性，說明經由當代數位科技之輔助，藉由各種軟硬體設備、以及影像和音訊跨平台多元化的呈現方式，使無形的思想概念、生活記憶、歷史性紀錄等轉變為可視形體，策展人將資訊視覺化，以在不同傳達媒體上「擬像」與現實高度的相似性，營造出使觀者更易於沈浸的體驗環境。傳統類比媒介與現今數位媒介在物質結構上差異性，以及行動裝置與數位介面的崛起，當代可以說是浸淫在如布希亞所稱的「擬像」的世代(蘇佩萱，2013，頁 84)，當代數位化視覺傳播媒體正以新形式結構、新介面展現出流動、不侷限單一模式的表象樣貌，但流動於各個媒介之間的數位影像和音訊，卻也顯現了當代訊息傳播虛擬與混雜的特性。其中，作者更進一步強調對應後現代主義的，「混雜」(hybrid)、「超文本」(hypertext)與「超真實」(hyper-real)三項觀點，正是這些強調形式混雜多重且可交互跨越的概念，改變了當代視覺傳播的性質、

內容和使用載體，使當代文創策展人必須進行跨科際整合之設計創新。以下分項討論之：

2.1 混雜多元之異質化

數位潮流席捲了生活一切事物並造就了新的可能，以電腦運算進行的影音產製方式，數位編碼、快速且大量的產出、易於複製修改等特性，使當代數位影像呈現跨類型的混用，並延伸出新的動態文本思維，既有的影像觀看與音訊聆賞的方式也產生改變。於是乎便於統合各種資訊、影音資料、呈現多元文化媒介的新媒體藝術，作為一種新的溝通方式，而被大量應用於當代藝術與設計創作中。曹筱玥於〈台灣數位藝術發展史〉一文中提到：

> 新媒體藝術植基於對傳統媒材的認識與掌控，運用了時代性之科技產物為媒介，和影像、互動媒材、介面整合，進而探索類比化、數位化技術與創作觀念結合，進而延伸出新的表現形態與內涵價值。（曹筱玥，國立台灣美術館台灣美術丹露專題網站，2007）

打破以往對於創作媒體的劃分與單一限制，以創作概念與藝術思維為中心，選擇適當媒介作為應用與呈現，形式與表現風格的「混雜」(hybrid)特徵，成為數位風潮下，當代藝術與設計創作的重要創意策略與主流表現之一。

因而，文中討論案例使用之影像媒材類性的混雜、以及相關影音作品呈現形式之跨媒介混雜，皆可視為「混雜」結構表現。本文中放置於創意媒體「紙喇叭」上呈顯的影像媒材，多數為策展者挪用歷史性檔案照片加以轉製之影像，以及經由影像軟體處理後數位生成之圖像與影段，若依影像媒材類型分類，可分為數位攝影、數位錄影、電腦繪圖為主的三大類型，透過影像後製軟體進行數位化處理後，可以錯置、拼貼、整併等不同手法應用於作品當中，呈現了研發創意媒體時，影像材料「地域性、取得來源、類型」以及視覺畫面表現之「混雜」。

2.2 交互跨越之「超文本」

以綜合文字、影像、聲音、資料庫等不同資訊於一體的「超文本」是當代視覺傳播之重要表現媒介。論及當代新媒體之表現形式與觀賞經驗，陳永賢於〈從幻象之丘談台灣新媒體藝術的美學意涵〉一文提到：

> 當代新媒體藝術之時間、空間與互動場域，作為一種影像的閱讀中心，影像界面因延伸、偏離或變形，而從在於一種無止境時間軸的載體之中。…透過複合材料與特殊的空間中所形成之張力，另一方面向不同領域借鏡，集合了各種經驗與形式累積。這些來自異質和複合性的元素，重新啟動了對無限運動的感知對應，進而使觀者與新媒體藝術之間，產生一種密不可分的美學關聯。（陳永賢，2010，頁 96-97）

作者特別為文討論在發展策展策略和展示設計上，所謂的「超文本」，以新科技媒體與影音媒體為主要表現形式，展示設計作品本身即是一統合影像資料、聲音等不同類型媒體資訊的超文本。除了表現形式為多媒體「超文本」，作品的內容亦為一「超文本」，從原本脈絡被切割而出，來自不同來源、時空背景、影像音訊種類之素材，以重新拼貼、挪用、嫁接等手法整合至同一載體當中，使原本的線性指向，轉而成為影像意義浮動、可向多方延伸之影音整合作品。在展示空間中策展人以片段式 (或非敘述性) 影像拼接呈現為主，不同影像、聲音元素拼接與跳躍使用，打破傳統動態影音單一時間、空間之敘述建構性方式，各個影像、聲音元素好似一個個節點，獨立存在卻又有著「互文性」(intertextuality)，在觀者觀看過程中依個人經驗、意識或自身身體的介入，在沉浸式的觀看情境與體驗中，自由地於不同的影像文本間進行超連結，使單一元素節點連結為一個「場」，帶出屬於觀者個人的觀看經驗。此類型觀看經驗也回應羅蘭・巴特於一九六八年提出的「作者已死」(the death of the author)觀念，展示設計中影像意境對線性敘事或元素脈絡間的解構手法，以及影音整合的本質，也都呼應著瓦解作者(author)/製碼者(producer)權威，開放觀者對展覽場域中展示之文本進行多元意義之解讀。

2.3 符碼轉換下「超真實」（hyperreal）

> 當代數位影像的藝術創作呈現出結合數位媒體、電腦繪圖與電腦合成影像的高度綜整性，使得一切在視覺的再現上趨近相同，經由數學抽象運算，透過同一的資料訊號，這些再現表徵皆為高度雷同的虛擬影像；更甚之，以數位媒介裝置為投映(projection)介面的圖像、攝影、錄影或電影等，皆要求觀者的身體與思維有所調整，與介面機器共同運作，以便共同創製獨特的時空感知。以

致，數位媒介不再是視覺性的、文本性的或音樂性的，它們其實皆是純粹的擬像。(龔卓軍，2008，頁 147-148)

不同於二十世紀 20-30 年代間發展出來的超現實主義(Surrealism)，依據布荷東(André Breton)1924 年〈超現實主義宣言〉中宣稱的「純精神上的自動主義，……，排除一切理性上的控制」，藝術家們進行幻想的錄寫、非理性認知事物的實驗、探討製成物(ready-made)的真實等手法(余珊珊譯，1995，頁 590)，「超真實」(hyperreal) 的具體表現產生於二十世紀下半葉數位化時代來臨之際，對應存在於媒體文本中的語言、文字、聲音、影像等皆以可被流通、共用的數碼形式存在，人們創造出一種藉由虛擬的視覺、聽覺等感官體驗，結合真實的觀看與操作媒介工具的經驗，感知一種「擬仿物」(simulacrum)的真實，卻是「真實之復生的幻想」、「它會比真實更加逼真，比真相更加地擬真」(洪凌譯，1998，頁 212)，指陳所「再現」的影像等，由擬像所堆積的「擬仿物」往往比物質性的寫實更加具情境聯想效果，或更具有人文的或社會性的意味表達。

「超真實」(hyperreal)雖說也是屬於排除直接進行物質性的寫實與模仿，是觀念性的、精神性的創造活動，但所從出的時代背景、藝術和媒體之表現手法是與「超現實」(surreal)大相逕庭的。尤其，當代「超真實」的媒體文本多屬多重跨域、跨平台、多元整合的表現，於是在當代博物館、藝文機構之展示空間中，策展人使用多重軟硬體配件作為輔助，使擬像的視覺表現、聲音效果等，能更接近於一個與人們所處的世界相仿的空間，是為延伸運用了新媒體藝術中「模擬的真實」的美學觀念，而策展人所創造的虛擬真實，並非僅僅是真實的模擬、再現，透過對影音數位資訊的解構、拼貼、挪用、合成等處理方式，創造出一種「超真實」，延續新媒體媒介本質以虛擬顛覆物質之「存在」的概念，以超真實顛覆真實存在本身，觀者因而能沉浸於策展人營造的體驗環境之中，並達到全新感官經驗之體驗。

當代展示設計工作者使用的數位素材如靜態攝影或影片影段，將大部份來自日常生活的影像，得以呈現出生活化、帶有真實感的質地，另計透過與網路素材與電腦繪圖的混用，予以拼貼、錯位、調整參數、交互混用的方式進行電腦處理合成後，被並置於同一畫面中，奠基於攝影、錄影複製真實景象的性質之上，好似曾經看過的尋常風景或眼睛所見的現實，但元素之間刻意呈現的斷裂，以及視覺表現上怪異的協調性質，或可帶出策展中「超真實」的結構表現。

3 個案分析：跨科際整合之設計創新

今日資訊傳達的數位化以及新興媒體科技的蓬勃發展，對現代生活與當代藝術設計領域皆產生直接性的影響。尤其在一九九〇年後的數位革命與新媒體藝術崛起之際，對應視覺傳播媒體科技的發展和伴隨著通訊設備物件的日新月異，形成更多元方向的探索，產生更多待解決的問題，人類不斷思考著如何將藝術、設計與科技加以結合，於二十一世紀產生巨大的時代變革。Pink (2006)在《未來在等待的人才》(*A Whole New Mind*) 著作中即說明這個世界正朝向由左腦型知識工作逐漸邁向以右腦主導思考為主的趨勢發展；也就是說二十一世紀的時代潮流，從講求邏輯與效能的資訊時代轉換至重視創新、同理心與感受的創意時代。是以，當代人類社會經濟的演化，從農業時代演進到工業時代，以勞工製造生產經濟，轉變為以左腦知識型工作者為基礎經濟模式的「資訊時代」，最後演化成強調右腦能力，注重感性思考與創意生活方式的高「感性時代」。高感性(high concept) 與高體會(high touch)正是這一種創新的思考模式與生活方式的趨動要素(Pink，2006，頁 8)。

因此，本文關注這些時代脈動，提出「跨科際整合之設計創新」為命題，以「孫運璿科技與人文紀念館」為例，探討如何運用具時代特性之新興科技媒體一軟性電子音響(flexible speaker)為載體，結合其他數位影音創作的視覺傳達媒體，建構「設計創新」於當代展示空間之表現經驗值；從中檢視台灣在發展創意產業，於文創設計領域中如何將科技與人文的結合，產生應用當代媒體科技材料之創新與實驗性。

3.1 結合軟性電子音響展示的「孫運璿科技與人文紀念館」

2014 年 11 月開幕的「孫運璿科技與人文紀念館」，為一座感念孫運璿先生對臺灣的卓越貢獻，將其舊官邸以 ROT 方式成立紀念館，座落在台北市重慶南路二段六巷內，展示由他所主導的，臺灣過去五十年篳路藍縷的基礎工程與科技建設之發展歷程相關的文獻史料和文物。因二十一世紀聲響技術和影像科技蓬勃發展，該館之策展團隊將該領域中的創新科技加以搭配呈現為新媒體設計後，為當代博物館或藝文展示空間引進新形式的審美體驗。本文作者即針對「孫運璿科技人文紀念館」一樓常態展廳中整合性的資訊再現方式，剖析其中如何將臺灣電力發展歷史文獻、音像和影像照片數位化，並據以創新展示。

走入「孫運璿科技與人文紀念館」一樓展廳裡，展示陳列著有關孫院長參與臺灣電力公司工程建設之舊檔案照片，其方式是特殊的，一禎禎照片列印在一幅幅似放大相框的「紙喇叭」上(圖 1)，在「**從斷垣中出發」主題**展廳裡傳頌著情境音訊，在視覺與聽覺聯動下，加深參觀民眾的懷舊印象。在此展廳中，乍見所謂的「紙喇叭」被輕巧地接上隱藏的聲音播放器，一張張紙片，真的就放出如置身戶外情境的聲音音效了！仔細端詳「紙喇叭」，它是雙面列印影像的，多張去彩度的懷舊照片放大，記錄著 1946 年孫運璿任職臺灣電力公司擔任機電處長，與當時臺電工程師們帶領著尚在就學於省立臺北工業職業學校、臺灣省立工學院的青年學生團隊，用五個月時間修復並建置臺灣全省電力建設的軌跡(楊艾俐，1989)。作者於現場檢視其影像列印處理方式如何與聲音媒介的結合，再查閱相關科技資訊報告，了解到由工研院電子與光電研究所研發的可撓式超薄揚聲器(flexible speaker)，或稱「紙喇叭」，讓揚聲器造型薄如紙片，也可以輕便地隨身帶著走，一反多數人對音響喇叭的刻板印象；再加入工研院電光所奈米電子技術組研發組的創意，以厚度不到 1mm 的紙張為主要材質，需用兩張紙，在上面鋪以金屬薄膜當電極，並在中間夾入一層帶靜電荷的振動膜，而聲音的電子訊號在電極所產生之電場，就能讓振動膜產生吸引或排斥，進而壓縮空氣產生聲音(王秀芳，2009) (圖 2)。

圖 1. 列印著舊檔案照片之「紙喇叭」

圖 2.「紙喇叭」的質地(texture)具孔洞特性之示意圖 (影像截圖中左為孫運璿年輕時)

以「孫運璿科技人文紀念館」常態展廳為個案研究，發現紀念館中即運用創新的技術和設備—工業技術研究院軟性電子前瞻計劃實驗室發明的「紙喇叭」(FleXpeaker ™)，將歷史性或社會性的文本資料的視覺化和轉換成特定的聯覺設計展示物件(見表 1)，以刺激參觀民眾的想像力，將事件、歷史時空背景和時間和工作現場環境的訊息融合(見圖 3、圖 4)，說明前行政院長孫運璿先生對中華民國在遷台早期社會、經濟、工業建設發展之卓越貢獻。由此可見，當代的聲音和圖像的數位化再現已導致超真實(hyperreal)的場景在展覽中生產、複製和刺激觀者的方式，已然成為博物館展示之主導形式。通過運用當代媒體藝術創造一個超真實的體驗環境，這種當代再現歷史及文化資產的展示形式，能為觀者解讀找到新的角度和建構不同的意義。

表 1.從斷垣中出發(B 展廳)展示主題與媒體

主題	媒體
戰後傾頹 驚濤駭浪，站穩腳步	玻璃展示板圖文解說、短焦投影
普及電力，邁向現代化	展示板圖文解說、紙喇叭、手稿、紀念碑模型、手搖發電機裝置、壁掛電視螢幕影像
運用美援推動工業化	展示板圖文解說、觸控式液晶螢幕

(本研究製表)

圖 3. 從斷垣中出發主題展廳一景

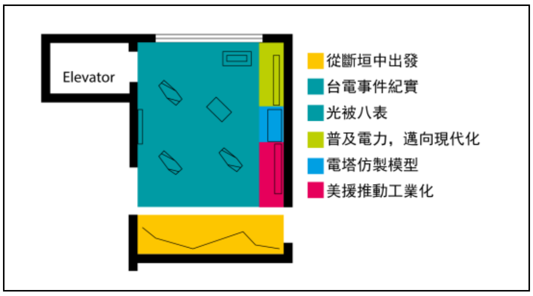


圖 4. 從斷垣中出發主題展廳平面圖(陳淑瑛、潘貞蕙協助繪製彩圖)

當代的媒體文本，在博物館等展示空間中多屬多重跨域、跨平台、多元整合的表現，孫運璿科技人文紀念館中策展團隊展場上的實作，不僅僅是在紙喇叭上列印圖片，或是在大型展示用尺寸的紙媒體中使其產生情境音效/環境音之影音結合效果，更重要的是與現場其他以電視屏幕、短焦投影機中多屏播放孫院長生平記事回顧或重要人物專訪的紀錄影片，同時存在，使能在展場空間中呈現資訊、影像和聲音內容的交疊(見圖 1、圖 3)，從中尋思此創新設計策略能提供展場上參觀民眾一個新的體驗，了解多重資訊聯覺觸發之可能性。並以訊息之斷簡殘篇化，組合碎裂片段，交織出一個 50-60 年代臺灣歷史發展時期，以多元面相並陳的手法以迴映該展廳之人文主題：「從斷垣中出發」(Setting out amidst chaos)。因此，參觀民眾可以感知結合軟性電子音響的展示空間中，交互跨越之「超文本」(hypertext)形成的混雜多元之異質化效果。

依此案例我們可以瞭解到二十一世紀各國競相發展文化創意產業，強調於人類的適性化與注重心靈層面的滿足，充滿高度感性思考與創新概念，可為人類社群增添更豐饒的生活方式與樂趣。「孫運璿科技與人文紀念館」，即是一個將前行政院長孫運璿先生重點扶植的電力與高科技科技產業發展歷程，用文創設計與文化傳播概念加以呈現的創新型文物館所機構。作者認為創意人才將主導未來世界，唯有人才始可將文化進行傳播，也唯有人才可保留與複製社會時空與情境的變遷；「孫運璿科技與人文紀念館」策展團隊累積並匯聚社會資本，將傳統科技產業提供所需的知識資訊變成是可以分享的人文資產。館所內記錄著非僅對孫院長個人生命記憶之回顧，而是臺灣長年以來社會性的集體記憶，是相關媒體報導、眾人對孫院長的感受，甚至是孫院長參與某事件的經歷、在某地曾經發生的故事；就是集結集體記憶，藉由眾人的集體記憶，提供全新的人物史料資訊並取得新時代的社會認同。

3.2 創新科技體驗與展示設計實踐

作者在「孫運璿科技人文紀念館」的參訪體驗中據以思考創新技術如何與展示設計實踐相關，再特別針對軟性電子音響(「紙喇叭」)技術，加以梳理如下：

首先，所謂的「軟性電子」，是將使用有機材料、或是使用印刷製程技術、或是將電子電路、或光電部件及系統製造、或安置在軟性基板上的技術統稱，產品具有低生產成本及柔軟可彎曲的特性。與軟性電子相關的技術項目或產品相當多(胡湘湘，2014)，其中，軟性透明導電材料 (flexible transparent conductive materials) 、可印刷式材料 (printable materials)、卷對卷製程(roll-to-roll processes)、軟性顯示器 (flexible displays)、軟性傳感器 (flexible sensors)與觸控傳感器 (touch sensors) 等皆與軟性電子揚聲器(flexible speaker)之設計應用有關。

軟性揚聲器(俗稱「紙喇叭」)，顧名思義，它的基材主要為兩張紙接著在上面加上金屬薄膜，這層金屬薄膜的用途主要是做前、後電極,並將一經過特殊處理、永久帶一極性電荷的震動薄膜置於其中(圖 5)。製作者將聲音轉換成電子訊號，再經由音源線傳送到紙喇叭，而紙喇叭中塗有金屬薄膜的紙片會根據電子訊號做變化，每當通電時，經由交替輸入正、負電壓而使兩者間產生相吸或相斥力，進而導致紙片振動。在這過程中，這兩張紙中的空氣會被推動，藉以造成聲波而產生聲音，這樣就好比人體喉嚨中聲帶的發聲原理一般 (楊嘉慧，2010) 。2006 年開始，工業技術研究院的軟電技術研發領域進行軟性揚聲器研究的一項計畫，它不僅具有平面化、可撓曲、大面積及可任意裁切等優點，相較於傳統喇叭，紙喇叭具有數倍高的電能轉換聲能效率，但電流很小，相對的整體功耗低，可節省許多用電，這讓紙喇叭成為能呼應綠色潮流趨勢的創新

產品設計典範。此外，採用類似印刷技術 roll-to-roll（捲繞式）製程的紙喇叭，可便於低成本大量連續生產。(ITRI, 2010；蘇佩萱，2015，頁 175-177)

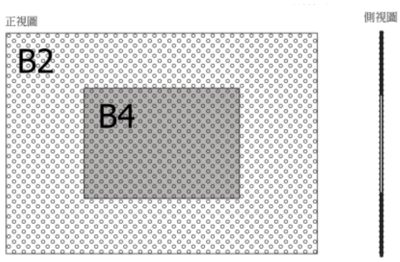


圖5. 紙喇叭結構示意圖 (印刷影像尺寸為B2: 50 x 70.7 cm，中間內含軟性揚聲器尺寸為 B4: 25 x 35.3 cm，紙喇叭厚度 0.2 cm)

上圖 3，以紙和金屬電極微材質為主，兩張紙接合，接著在上面加上金屬薄膜，厚度不到 0.2 公分，擁有輕薄、可彎曲的特性，用「印刷」方式生產，更可以隨心所欲剪裁成各種形狀。儘管它身材纖細，但發聲效果可不輸傳統喇叭，其發聲的高頻為 20KHz、低頻為200Hz，適合表現細膩的中高頻音域。值得一提的是，這款紙喇叭耗電量只有傳統喇叭的十分之一，不僅輕巧，也相當環保。目前，紙喇叭已經申請 17 案 45 件的全球專利 (魏茂國，2009)。除了可以運用在登山背包、家庭音響、車輛音響、薄片式 MP3 上，未來還可以整合到綠色建築、醫療和遊樂場、展示空間等應用領域。

藉此平面揚聲器，可使策展人朝人類兩大感官需求—聽覺、視覺—進行聯動感官知覺的設計構思，最後發展出如工研院 51 館簡報室揚聲器(圖 6)、2010 年台北市主辦的世界花卉博覽會中夢想館的有聲「科技之花」，和孫運璿科技人文紀念館的展廳中現場見到的薄型化、平面化、軟性、大面積的揚聲器，已經是第三代的產品了，目前工研院已與其他國內廠商進行商用化的合作。事實上，紙喇叭的應用範圍廣，而且可相當創新。

圖 6. 2014 年 5 月作者帶領師生赴工研院聽花博夢想館專案企劃之講解；在講者吳淑敏和師生成員之間的牆面上即嵌附著工研院高端創新科技產品白色的「紙喇叭」

本文作者再以自己在天津美院展出的平面影像結合漢字設計作品[質真若渝] (2015)系列，於 2016 年進行創意設計，將兩幅水景攝影雙面印刷在一件軟性電子音響上(圖 7)，其表面雖具均勻細密分布的孔洞特性，但不減損風景攝影之顯像影質。作者進而甚至思考著在設計上為發揮其雙層細密孔洞之結構特徵，來挑選適宜的影像文本，或如何解構圖文訊息等以形成更具超真實感的視覺媒介。

圖 7-1. [質真若渝](2015) 系列兩幅水景攝影雙面印刷在「紙喇叭」示意圖 (全彩印刷影像尺寸為 B2: 50 x 70.7 cm，影像解析度 300 dpi)

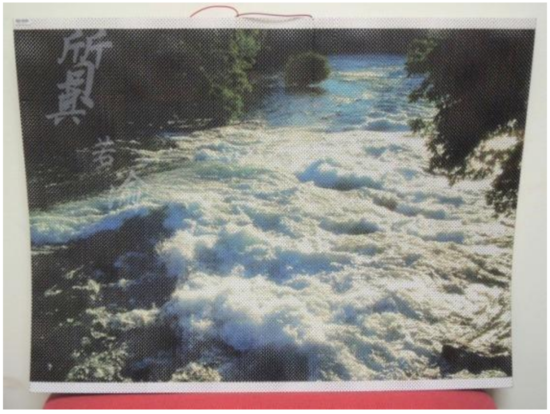


圖 7-2. [質真若渝](2015) 系列兩幅水景攝影雙面印刷在「紙喇叭」示意圖 (全彩印刷影像尺寸為 B2: 50 x 70.7 cm，影像解析度 300 dpi)

[質真若渝] (2015)系列影像，正因其為水中虛影(圖 7 上)和激流起波之自然情景(圖 7 下)，皆適合於此媒介表現，再加入與水景相關之聲響樂曲詮釋情境，影音整合，表達水性之流動與變化萬千。此外，詳見圖 7 上方呈現出一個音訊來源的藍芽接收器，代表其被藏納

或嵌附之方式，展示設計者可以再進行外框架結構之設計，以展現創意(圖 8)；作者所創作的[若渝梵響] (2016) 影像表現除雙面印刷在「紙喇叭」、嵌附在竹製外框架上，另外還有動畫影像表現投影在背景牆面上，呈現印度恆河人文風貌。更重要的是，藏納在竹框架上方的音訊來源的藍芽接收器，它代表著觀賞者可藉由跨平台的方式遠端選播音訊來源內容，如透過手機介面 APP 下載作者設計的動畫音訊內容，或連結電腦或手機進行選曲等，隨著觀賞者選擇播送與視覺影像設計相襯映的數位音樂或音效內容，感受作者的紀實攝影，以影音整合效果呈現鮮活的印度恆河風情。

在 2016 年 10 月 17-23 日於國立臺灣藝術大學國際展覽廳中「擬聲交疊：創新科技實踐之文創設計創作展」展場上(圖 9)，[若渝梵響] (2016)此參展作品有兩種呈現手法：其一，部分展出時間使用短焦投影機投影印度恆河風情之動態影像，並以日式禪風設計的水域作法——平鋪白砂，輔以綠光造境，如印度恆河上游水色瀲灩，並在白砂地一隅以聚光燈投影 ॐ 字，回應動態影片中由作者置入“OM”的梵唱回音(圖 10、圖 11、圖 12)；另外，為聚焦於分享科技的應用效果，開放讓現場參觀者體驗開啟藍芽傳輸功能與紙音響配對後，以遠端遙控方式隨選竹框屏內軟性揚聲器之聲音內容，使創作者了解該科技裝置呈現於展場後，人們對內容所產生的認知反應回饋。

作者為策展人，「擬聲交疊」，此創新設計策略，實能提供展場上參觀民眾一個新的體驗，紙音響嵌入其中，並搭配多重人文資訊、影像、光色、文字符號等複合媒材，聯動參觀者感官知覺統合觸發之可能性。並以訊息之斷簡殘篇化，組合碎裂片段，多元面相並陳，交織出一個印度恆河異國幽思之景。因此，參觀民眾可以感知結合軟性電子音響的展示空間中，交互跨越之「超文本」(hypertext)形成的混雜多元之「超真實」(hyperreal)效果。

圖 8. [若渝梵響] (2016) 展示示意圖 (竹框屏中印刷影像尺寸為 B2: 50 x 70.7 cm，影像解析度 300 dpi；牆面使用短焦投影機投影動態影像尺寸可依展示空間調整)

圖 9. 「擬聲交疊：創新科技實踐之文創設計創作展」主舞台，國立臺灣藝術大學國際展覽廳

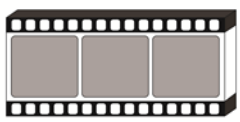
圖 10. [若渝梵響] (2016) 於「擬聲交疊：創新科技實踐之文創設計創作展」展出現場

圖 11. 綠光造境如印度恆河上游水色瀲灩，並在白砂地一隅以聚光燈投影ॐ 字特寫一景

圖 12. 綠光造境當中前面地坪上置放孔洞透貼呈現作者恆河水景攝影【靈光瀲灩】(2007)，畫面中心疊合ॐ字設計，與在白砂地一隅以聚光燈投影ॐ字相應

後續「紙喇叭」的應用面向還可藉設計學院師生團隊腦力激盪後，延伸探討至包括建築、傢俱類裝飾應用（例如壁紙－嵌入式音響、音響屏風等）、3C 應用、交通載具應用、紡織應用及其他應用。紙喇叭，可讓產品設計師、視覺設計師加入創意巧思——以紙張為材料，以更輕、薄、富變化的競爭優勢，視應用需要可在紙喇叭的外部包覆包材，應能配合客製化的需求，裁成任意尺寸與形狀，產生綠色創意設計。未來在投入更多市場分析與商品應用的研究資源後，即可開發出更多貼近生活，以及與使用者連結的創新應用。因此，作者探討嵌附紙音響材料之跨平台介面設計和外框造形設計：開發壁掛式和擺放式外框，產生文創設計展示物件，如下表 2 所示：

表 2. 紙音響材料之文創類型展示媒體設計

名稱	展示示意圖
壁掛式廣告對話框	
底片相框式展示板	
書本置物音響(有聲書)	

(林庭羽協助繪製彩圖)

4 觀者的解讀

4.1 論解碼

音訊、影像與物件的數位加工後的再創造是根據意義之關聯性所製成的編碼(encoding)，讀者可將它放置在設定好的文本脈絡中進一步的解碼(decoding)。霍爾以符號學、語義學為方法架構來面對大眾媒體文化進行研究，認為受眾(觀眾)按照自己的理解對媒體文本做出闡釋，由於受眾的文化背景、社會關係都不盡相同，所得出的闡釋也可能大相徑庭，進而提出閱聽大眾面對媒體編碼時具有三種解碼模式：優勢霸權式解讀(dominant-hegemonic reading)、協商式解讀(negotiated reading)、對立式解讀 (oppositional reading) (Sturken & Cartwright, 2005, p.57；史特肯、卡萊特 著，陳品秀 譯，2009，頁 78)。

事實上，霍爾在 *Visual culture: The reader* (1999) 中已強調「讀者」解釋權的釋放，幫助人們體驗於視覺文化與影像傳播內容之象徵意涵的解碼過程中，展現讀者其自發性與批判性的思考。因此，當代觀者需要機會去拓展他們的經驗，並在理解力、想像力、表現力之間取得平衡，並豐富感知、反思與洞察的能力。

這屬於一種強調反身性思考(reflexive thinking)之實踐活動，並指向一種逐步整合內在涵義的途徑。過程中，雖然媒體編碼者原為其文本提供了特定的解讀方式，但現實生活中只有極少數的觀看者真正佔居這個優勢霸權解讀的位置；大部分的的受眾並非全盤接受編碼者的意圖，他們可以接受，可以保留其中的一部分，甚至可能全盤否定。作為主動的解碼者，受眾可以在接觸媒體文本的過程中讀出多種多樣的意義來。所以我們可以想像那是一種協議意涵時的互動關係，發生在觀者、媒體文本和場域脈絡之中。我們因此使用「協商」這術語，比喻在心理或認知上辨識媒體文本(圖像/影像/音像)時形成對其意涵及聯想加以接

受與拒絕的過程。

針對一個媒體文本的辨讀過程總是發生在有意識及無意識之間。它受觀者的記憶、知識、文化的架構，以及影像它本身和如何對應主流意識型態的方式所影響。在這個過程中，容許特定的文化性及讀者個人的主體意識，對於編碼設計者(策展人)和廣大社會主流的意識形態能有所辨識、改變，甚至產生壓倒主流意識形態的論點。協商是指能容許我們在觀看和解讀時，在解碼的過程中，閱聽者於觀看文本關係中是主動的意義製造者，不再是傳統傳播效果研究中是被動的訊息接受者。

作者觀察展廳中策展人選取與孫運璿相關早年時空脈絡中既存的文史物件或圖像，再結合成新的影像文本，而後創作出當代新的創意媒體展示應用，與今日「孫運璿科技與人文紀念館」館所之創新精神氣象相呼應。觀看展示設計作品時，我們可以發現策展團隊並不是單純的將傳統的元素置於一件新的隨意「拼貼」文化語意的影像作品中，而是將其透過重新截取局部、調整光影明暗調性、轉換佈局位置等方式再加工，產生文本「涵義」之「延異」；反應出依循後現代主義中的「挪用」策略，在此可視之為「文化挪用」。此「拼裝加工」(bricolage) 之做法，是當代影像創作者在後製過程中著重的表現手法，是一種「再挪用」(re-appropriation) 的手法；它是一種「任意拼湊」、「隨意組成」的風格，藉各式各樣的物件臨時湊成組合，而使彼此之間產生新的意義(Sturken, M. & Cartwright, L., 2005, p.64)。突顯在視覺文化研究相關領域裡，策展工作者由於受到後現代理論、符號學、解構主義等的影響，所謂以挪用手法建構新的影像意義，指的是拷貝複製或解構再製其他不同媒介文本脈絡中經典作品之全部或部分，重新編碼組合，並且賦予新的複合式的意義。在這種將不同元素的東西湊在一起的過程，原始文本的意義即被架空或遭轉嫁，在此為擴充文本的本質，加以轉借的手法，使能塑造一種新世代意識形態的迴響(Sturken, M. & Cartwright, L., 2005)。

二十一世紀的我們正生活在一個傳播科技無遠弗屆，資訊快速分裂、複製與交換的年代，在後現代主義的知識場域中我們所觀察到的意義是浮動的、多元化的、混合的，知識論述者從操縱人的理性與對總體性(totality)的迷戀中覺醒，跨越進入後現代意義浮動的多元化世界中，但在此實際操作的過程中才可能邀請觀者解讀，建構新的「展示價值」(exhibit value) (Evans & Hall Eds., 2004, pp. 76-77)。然而，在數位化機械複製的時代趨勢下，藉由挪用進行擬像複製與形成觀者反身性批判更是後現代藝術的特質之一，在《論藝術的本質—名家精選集》第十五章〈班雅明：藝術即氣韻〉一篇專文中，華特．班雅明(Walter Benjamin, 1892-1940)即宣稱對應著原作物件現存的原真性(authenticity)，擬像與擬仿物是觀者跨越歷史與文化脈絡關係，古今映照之觀照反應，似乎就在「複製真相」後再加工的過程中，開始展露(華騰伯格 編著，張淑君等譯，2004，頁 11)。

觀者在後設解讀中呈顯文化符碼轉義之現象！羅蘭．巴特相信唯有「觀者」才是構成藝術作品或文本意義的真正要角，體現文本在特殊歷史與文化脈絡下真正或具體的功用，亦使得觀看作品時使觀者是在接近一個個「具有僭越性的真相」(「擬像」; simulation) (布希亞著，洪凌 譯，1998，頁 212)。因此，展場中並非為重建或移置一個精確無誤的歷史事件真相，雖然指涉著原初的本質和內容或許不變，但再現的影像/音像/視訊等(representations)卻有跨越時空超越真相的可能，因為由擬像堆積而成的擬仿物往往比真實更加擬真，更具有人文表達意味，即使因而將使過去史實真相反而處在虛化的地位，卻引領觀者透過自身的觀點進行後設解讀。在這樣的感知體驗與解讀過程中，文本正不斷的產生重組與「延異」(différance)，面向觀者開放。

4.2 論視覺轉義

德希達提出的解構主義觀點：「延異」(différance)一詞，探討符號在跨越媒介時轉碼，其間不斷地產生新義且不斷地被破解，「現存(作品)」短暫逗留後隨即成為過去，詮釋「文本」其語意無法成為單一或唯一的陳述來反應真實，反處於無盡的不穩定狀態中(陸蓉之，1990；陸蓉之，2003）。應用在策展上，便是反應出策展人將原始文史資料影像/音像紀錄等本意加以分解，然後重組成新的面貌，破壞物件之間原有的關係，使原有的視覺符號延異變化，並產生多義性聯想空間(Sturken & Cartwright, 2005)。

引述德希達在《論藝術的本質—名家精選集》第二十四章〈德希達：藝術即解構〉專文中，說明其解構論中揭露「意義」之所在，是「在一個再標記和再應用的超版面內，藉由套疊，在假定的中心和周邊之內、之間？或是在被框住和框架內的框框之間？」(華騰伯格 編著，張淑君等譯，2004，頁 11) 作者針對文創化的「紙喇叭」被展示在「孫運璿科技與人文紀念館」之現象進行反思，套用德希達的問

法，片面的歷史檔案照片它們被展示或放置在何處？與其他典藏文獻史料、文物、展示設計作品之關係何在？(圖 6、圖 7) 它們不僅是一段時空記憶的再現，也是一個視覺轉義，對應「今昔迴映」的有機整體的隱喻。如同德希達所言視覺轉義之衍生物：

> 發展「自它本身的概念」。沒有少掉使其成為「返回自身」的整體的任何一樣東西…有很多藝術品，它們在我們面前再現。但它們是如何被認可的呢？…[放任，laisser]是什麼意思((laisser) voir [容許看(或被看)]，(laisser) faire [容許做(或被做)]，voir faire, faire voir, faire faire[使得(某事)被做]…
> (華騰伯格 編著，張淑君等譯，2004，頁 14)

德希達宣稱 laisser 這樣的過程「不是去攪亂藝術的類型，而是去擴展隱喻。你永遠可以嘗試：形式的問題。」(華騰伯格 編著，張淑君等譯，2004，頁 18) 在展場中歷史文獻、音像、影像圖片等文本自身被再創作的活動中，忙著安置元素、支配主題之處，形成一個真實的擬像世界，讓意義在被觀看中無限延異，「充滿深淵(mise en abyme)、填滿深淵」(華騰伯格 編著，張淑君等譯，2004，頁 13)。

因著符號挪用與意義的賦予，視覺元素同時也納入一個轉化的過程，轉化為本質性的元素進行文化的建構，在當代展示機構創新「文化化」(culturalization)的過程中呈現特殊的「視覺轉義」(visual trope) (廖新田，2008，頁 14) 。這將是

> 一套可溝通的意義體系，它既有內部的邏輯運作，又不封閉自我而獨立於其他社會文本之間，因此圖像元素的詮釋呈現多層次的意涵。一個符號的指涉，在特定社會條件下不斷地被挪用 、轉化，並與其他媒介產生共鳴。
> (廖新田，2008，頁 18)

觀察策展人將各種視覺表現還原為基本的語意元素，並展現其在視覺意義上可能的共通性。原本被鎖定為文史資料的呈現，將因此方法論觀點而被「釋放」出來，與同時存在於展場的視覺傳播媒介(如影像圖片、展板、視訊影片等)產生對話的狀況(圖 13)，共同形成一種特殊時空結構下的「展示文本」，一種與其影像內容內涵義相應的意符結構，並轉換為更廣泛的文化意義之探討，讓臺灣影像設計研究走向一種更開放的系統，與文字、聲音意符共振，成為語言般的溝通系統，與時遞變。

圖 13.「孫運璿科技人文紀念館」展場中其他多媒體視覺傳播媒介

5 結論

觀諸日新月異的新科技不斷衝擊著當代傳播媒體的發展，作者檢視創意媒體在展示場域的推陳出新，於此文中提出多元異質化、符碼轉換、跨科際整合之展場美學觀；再以混雜多元之異質化、交互跨越之「超文本」、符碼轉換下「超真實」三項觀點，論述當代展示形式混雜多重且可交互跨越，改變了當代視覺傳播的性質、內容和展示使用載體，趨使當代文創策展人必須進行跨科際整合之設計創新。

與文本的視覺化相關觀點與做法，呈現在文中計有「擬像」(simulation)、「延異」(différance)、「挪用」(appropriation)、「拼裝加工」(bricolage)等討論，策展人在此實際操作的過程中挪用原始文本後再製碼(re-appropriating and encoding)，才可能邀請觀者參與者依循展示設計重新解讀文本(decoding)，建構新的「展示價值」(exhibit value)。本文主要是談策展人的跨媒體實踐，可將典藏文物、詩詞、圖像、生活經驗影像、生命記事內容等，拷貝複製或解構再製成其他不同的媒介作品，於展示空間

中使用多重媒介作品(含攝影、再製影片呈現、平面圖像設計等)之全部或部分元素，重新編碼組合，並且賦予新的複合式的意義；在這種將不同元素的東西湊在一起的過程，原始文本的意義即被架空或遭轉嫁，在此視為擴充文本的本質加以轉借的手法，使能塑造一種新世代意識形態的迴響，進行文化挪用。同時，也將焦點集中在參與者觀看過程中，如何解構社會的、歷史的文本轉換成視覺影像符碼，可在新的社會文化背景和象徵符號語意關係脈絡上進行延伸性的想像。

本文希望讓讀者們感知當代文創策展人試圖在展示空間中與新興媒體搭配，可以是將軟性電子材料等新興科技媒體加以應用，將社會的、歷史的文本內容進行擬像轉義，活化當代國民生活的共同記憶。再者，與數位媒體美學觀相互呼應，今日策展人以數位擬像手法進行重新詮釋與視覺意境之建構，利用不同類型數位媒材的混用，將具有明顯斷裂性的素材拼貼、挪用、嫁接、並置於同一展示空間中，在素材種類與視覺表現風格上，皆呈現出多元混雜之特性，回應視覺科技演進歷程中，從靜態影像過渡至影音整合、互動行為等不同的發展階段，藉由綜合多重影音資訊與跨媒介的數位化作品，展現當代新傳播媒體「形式混雜」之趨勢。

綜論之，每個觀賞者在解譯符碼過程中產生的想法都是有意義的。其意義是根據接觸時的社會、政治、文化脈絡所決定。媒體文本是根據社會跟美學的約定俗成意義被設計與製作。相對的，在觀者反身思考式的後設解讀過程當中，人們以不同觀點詮釋線索和聯想其意涵，用來解碼背後主導的意識形態與文化內涵如何召喚今日的觀者，從中亦檢視出在不同時空背景下傳播媒體文本可跨域轉義之現象。因此，策展人詮釋「永遠的行政院長—孫運璿」時，在科技輔助人文的展示情境中，能更加適切的突顯他歷任臺灣電力公司處長和總經理、中華民國交通部部長、經濟部部長與行政院院長、資政等，在將近 20 年的公職服務的任內，規劃臺灣早期科技政策，亦是臺灣科技產業之主要奠基者之功勳。

此外，作者認為當代展示設計存在著一種將文本符碼化，轉換成文化表徵的機制，呈現出視覺文化的意義。這種現象是一種視覺再現的挪用，反映出後現代性如何作用於視覺美學化的過程。所謂的「後現代性」，本身就夾雜著各種不同的複雜因素，尤其臺灣近現代歷史發展進程中深受多元異質文化的衝擊下，展示設計作品所含帶的文化意義勢必隱微複雜。

檢視在展示設計內容中表現出文化的多雜特性本是不可避免的，尤其外來文化與當代思潮等皆必須納入。作者在多元文化面向(the multi-cultural approach)下思考，文中對臺灣視覺傳播與展示設計的個案研究即不僅是地區性的研究，而是將在地視野銜接全球化文創設計的一環(賴建都，2002；林品章，2003；林榮泰，2011)。

進而由上述文創類型個案分析，如「孫運璿科技與人文紀念館」展廳展示設計、後續作者研發之展示物件設計等，可見多媒材、跨領域的體驗，如使用科技工具「紙喇叭」等裝置，可帶給觀者們多處啟發，從跨人文與科學各專業領域別，到跨影像與展示、包裝設計媒材與技術的理解，高端研發科技並不與當代新興世代距離遙遠，反倒在展覽實務和視覺傳播設計教學場所中需要被大力引薦，讓高等校院教師與年輕學子們思考更多，以擘劃出新興世代永續節能、美好生活之願景所需之適用設計。

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可攜式3D多媒體排球教材開發及對大學生學習動機及自我學習成效之研究

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摘要

多媒體教學應用在體育教學上面已經是相當的普遍，但以一般的影片播放則缺乏與使用者的互動，導致學生學習動機低落及學習成效不彰。本研究融入 ARCS 動機學習理論，設計一套包含發球、托球、接球及攔網等 3D 多媒體排球教材，除使用動作捕捉器捕捉選手實際操作以保有動作的真實性，教材以 APP 的方式呈現並借助平板電腦增加便利性，以手指滑動平板控制視角旋轉及按鈕選擇撥放速度加強互動性，由文字框說明並輔以語音提示動作步驟來加強學習的動機。正式實驗部分針對實踐大學高雄校區 173 位大學生測試學習動機及自我學習成效。結果顯示在 ARCS 學習動機 (注意、關聯、信心、滿足)中的各項數據皆在平均值以上，其中以「關聯」構面的平均得分最高。此外無論是在學習動機及自我學習成效方面，男學生明顯高於女學生，商學與資訊學院學生明顯高於文化與創意學院學生，過去有多媒體教學有使用經驗者明顯高於無使用經驗者。本研究之貢獻在以多媒體設計的觀點融入 ARCS 學習動機理論所開發的教材，經實驗證明的確可以有效提高學習者的學習動機並提升自我學習成效。

關鍵字: 3D多媒體教材製作、ARCS學習動機理論、體育教學、自我學習成效

A Research on the Development of Portable 3D Multimedia Volleyball Learning Materials and the Effects on College Students' Motivation and Self-efficacy

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ABSTRACT

Application of multimedia learning in physical education is very common. However, simply playing video clips does not provide any opportunity for interaction with users, leading to low learning motivation and poor learning outcomes in students. In this study, the ARCS theory of motivation is incorporated, and a set of 3D multimedia volleyball learning materials on serving, setting, catching, and blocking have been designed. Motion capture equipment was used to record players' actual moves, so as to ensure authenticity of the actions in the learning materials. An APP is used to present the content of the learning materials via a tablet. By swiping the tablet with their fingers, users can adjust the viewing angles of the videos, and the playback speed can be adjusted via buttons. These two functions increase the interactivity of the learning materials. In addition, learning motivation is enhanced through detailed explanations in text boxes and voice prompts for each step of the actions.

For the experiment, 173 undergraduate students in the Kaohsiung campus of Shih Chien University were tested for their learning motivation and self-learning outcome after using the multimedia learning materials. The results show that the students' scores in all factors of the ARCS motivational model (Attention, Relevance, Confidence, and Satisfaction) are above average, and "Association" has the highest mean score out of all factors. Furthermore, in both learning motivation and self-learning outcome, male students scored significantly higher than female students, students in the College of Business and Information scored significantly higher than those in the College of Culture and Creativity, and users who had experience with multimedia learning materials scored significantly higher than those with no experience. The contribution of this study is that it developed learning materials based on the ARCS theory of motivation from the perspective of multimedia design, and the materials are proven to be able to effectively enhance learning motivation and boost self-learning outcome.

Keywords: 3D multimedia learning materials, ARCS learning motivation theory, physical education, Self-efficacy.

1. 前言

1.1 多媒體輔助體育教學

體育是一門包含各種肢體動作技能並且要求準確、協調與速度的學問。體育教學最特殊的部分即是具有動作技能的教導及練習（蕭筱青、陳五洲，1999）。以往球類教學，總是老師先講解、再示範，最後讓同學們自己做一次。但是往往再老師講解完和示範完以後，學生吸收多少因人而異，往往缺乏了複習的教材而讓學習停滯不前，失去了學習的動機（姚蕾，2005）。因此如何應用發達的資訊科技，讓體育在教學方面能跟上時代的腳步，擺脫體育教學累人無聊的刻版印象，將對體育的發展有著深厚的影響。

利用多媒體電腦來輔助教學，能將正確的示範動作反覆呈現、快慢動作或靜止畫面等，可讓學生產生良好的學習效果（周靈山、周宏室、徐武宏，2000；陳五洲、李榮哲，1999；陳益祥，1999；黃清雲，1994a）。而互動式多媒體最大之優點是能把學習者的動作拍錄下來，並用來與專家的動作範型對照比較，提供學習者參考與檢討修正的機會，這正是傳統教學無法呈現的（黃清雲，1994b）。Schar 與 Krueger (2000)即指出結合視覺、聽覺的多媒體可以減少學生學習認知上的負擔，且較易於吸引學習者的專注力並增加學習效果。唐吉民（1998）提到：透過電腦多媒體，無論是基本動作上的分析、精采比賽的觀賞與講解、場地規則的認識、學生上課時練習的動作分析等等，皆可以更生動活潑的方式來呈現，以刺激學生的學習動機，達到樂趣化的上課方式與教學的效果。

本研究擬以可攜式 3D 多媒體電腦輔助排球教材之開發，並透過一連串排球基本動作運用多媒體詳細敘述描繪，加上文字敘述，讓重點跟步驟一一列出，以改善老師教學效能，提升學生學習動機與成效。

1.2 研究目的

本研究旨在將可攜式多媒體排球教材融入教學中，並透過問卷調查方式，了解大學生使用此輔助教學系統後的學習動機。具體研究課題包括：

（一） 研究並開發一個融入 ARCS 動機學習理論，包含發球、托球、接球及攔網等 3D 可攜式多媒體排球教材。

（二） 探討不同背景大學生使用可攜式多媒體排球教材後，其在學習動機各構面上之差異情形。

（三） 探討不同背景大學生使用可攜式多媒體排球教材後，其在自我學習成效上之差異情形。

1.3 研究範圍與限制

本研究係依照研究目的與課題，以實踐大學高雄校區修習排球課程學生為對象，進行問卷調查；惟所使用之問卷屬自陳式量表，其優點可獲得大量的資料，但問卷所得結果受限於研究者所欲探究的範圍，且填答者心理難免會有社會期許之效應，以致研究結果可能與實際情形有誤差存在，因此在解釋研究結果時將更謹慎小心。此外，由於本研究屬量化研究，因此針對研究結果的解釋，除非有理論文獻支持，否則將止於事實的呈現與描述，避免過度推論。

2. 文獻探討

2.1 多媒體電腦輔助體育教學

在運動技能學習中，「示範」是最常被使用的方法之一。因此，觀察正確的動作示範與瞭解動作技巧背後理論的認知活動，對於運動技能的學習有莫大的幫助。根據研究顯示，電腦多媒體在認知方面的學習，以及視、聽覺的回饋等方面都有正面的效果，同時具有正確性、一致性的特性與無時間、場地上的問題，正可以協助體育教師與運動學習者，在運動教學與學習上建立正確的動作示範，以及運動認知的獲得，對現今體育教學上有重大的輔助功效（陳五洲，1994；黃清雲，1994）。

迄今，國內已有許多利用多媒體電腦輔助教學，透過正確的示範動作反覆呈現、快慢動作或靜止畫面等數位教材功能，讓學生產生良好學習效果的成功案例。蔡嘉景與陳五洲（2008）參照 Mayer(2001)的多媒體學習理論觀點研發一套互動式羽球單打教學系統並實際運用於教學上，結果發現該系統除可有效讓學習者建構組織擊球、跑位方向外，亦可透過三度空間虛擬實境的擬真性，有效地增加學習者的長期記憶。此外，郝光中與林保源（2009）以多媒體動畫應用在籃球訓練，結果發現無論是在熱身練習、進攻、防守、快攻等各方面，使用多媒體電腦輔助系統者的失敗次數皆比未使用者少，顯示利用多媒體輔助教學系統在籃球訓練上是具效果的。藍孝勤、王炫智與陳五洲（2010）將 2D 影片與 3D 動畫的多媒體技術應用在大專生八式太極拳輔助學習上，結果發現 3D 動畫組因可多角度觀看、練習節奏可自由控制且生動、有趣，因而練習時所遭遇問題少、學習興趣較高，整體的學習效果也比較好。

多媒體資訊技術輔助體育教學的效益，除有效增進運動技能的學習外，對於學習動機、興趣等情意態度方面亦有正面的顯著效益。黃希聖（2006）的研究即發現將資訊科技融入扯鈴教學可增進學童的學習興趣，進而誘發其在學習過程中展現努力不懈和樂於學習的正面學習態度。何金龍（2000）、吳信昌（2004）、楊昌珣（2004）與蔡耀宗等人（2004）的研究也得到一致的結果，亦即透過電腦多媒體輔助教學，學童在情意發展上面的學習結果顯著優於傳統教學，並且有助於吸引學生的學習。蘇詩媚等(2008) 以 Flash 動畫進行製作模擬遊戲，遊戲發現，實驗組在排球接發球防守策略技能學習表現皆顯著優於傳統教學組。而 Papastergiou 與 Gerodimos (2012) 利用網頁多媒體課程幫助大學學生學習籃球技能，結果顯示，有助於學生對於籃球技能之知識的學習。Zou 等 (2012) 使用線上教學系統輔助國小孩童的桌球學習，結果顯示，使用國手示範之影片教材可幫助學生在桌球技能知識的學習有所幫助。劉乙正、陳五洲 (2013)則以傳統蛙式游泳教學之學習成效和多媒體輔助蛙式游泳教學之學習成效之比較。在實驗中，對照組的學生將透過教練的指導學習蛙式游泳，實驗組的學生透過教練的指導與多媒體器材的輔助之下學習蛙式游泳。結果顯示：實驗組的後測動作檢核成績明顯優於對照組成績。林國欽等人(2014)則利用平板電腦輔助教學在羽球技能學習效果與自覺學習效果之差異情形。結果顯示：平板電腦輔助教學組在發球、切球及高遠球三項技能學習顯著優於傳統教學組。平板電腦輔助教學法在自覺學習效果顯著優於傳統教學法。

2.2 ARCS(Attention,Relevance, Confidence, and Satisfaction)動機學習理論

學者 John M. Keller 在 1983 年提出 ARCS 動機模式，即 Attention、Relevance、Confidence、Satisfaction(Keller, 1983b; Keller, 1987a; Keller, 1987b; Keller & Suzuki, 1988；Keller & Kopp, 1987)，並按此四概念發展出實用的策略及方法，教學設計者能有效的安排與教學相關的資源與程序，是一系統化且可重複的原則與過程，而重點在於運用特定之策略與原則於學習動機上，以幫助教學設計人員和實際教學的教師們設計課程或改善教學，讓學習活動更具吸引力，以引起學習動機改變的過程(Naime-Diefenbach,1991; Shellnut, Knowlton, & Savage, 1999; Weiler, 2005）。

引起注意是指學習者在獲取所教的概念顯示出的了興趣。該要素被分成三類：感官的吸引，問題的探究和用變化維持。關聯的建立是透過學習者所熟悉的語言和例子。信心專注於建立學習者之間成就的正向預期。最後，學生必須獲得滿意或學習經驗獎勵。這種滿足感可以從成就感，得到來自上級的讚美，或者僅僅是很小的娛樂(Keller, 1999; Keller, 2000) 。ARCS 動機模型的要素、定義和策略詳見表 1。

表1. ARCS動機模型的要素、定義和策略(Keller,1999 ; Keller, 2000).

構成要素	定義	策略
Attention 引起注意	集中學生的注意.	1. 感官的吸引（具體性）: 使用特定的相關的例子。 2. 問題的探究: 提供角色扮演體驗或是實作的經驗。 3. 用變化維持: 利用各種資源和教學方法。
Relevance 切身相關	連結學生的需要、興趣和動機	1. 似曾相識: .結合學生的先前經驗，提高課程的熟悉度。 2. 目標導向: 藉著陳述教學與個人目標的相關性，以產生實用的知覺 3. 過程導向: 提供符合學生動機與價值學習機會，如自我學習或合作學習…等。
Confidence 建立信心	幫助增加學生的信心	1. 學習必備的條件: 訂定明確的教學目標，協助學生創造正向的成功期望。 2. 成功的機會: 提供學習者在適度範圍內，可以自我控制自我的學習。 3. 操之在我: 提供學習者有機會可以成功的達到具有挑戰性的目標。
Satisfaction 獲得滿足	獎勵學生學到新的技能	1. 自然的結果: 提供情境讓學生一展所長。 2. 正向的結果諸如： 口頭讚美、獎勵。 3. 維持公正:對於成功維持一致的目標與結果，學習的最後結果與起始設定的目標和期望一致。

2.3 ARCS 學習動機理論融入體育教學對學習動機的影響

在先前的研究中，多數研究指出多媒體應用在體育教學可以提升學習的動機。 Liu (2004)的研究顯示，八週的資訊融入體育教學對學童之學習動機與體適能有顯著提升效果。研究結果也指出體育教學媒體之使用應該與教學互補的，才有其正面效果。陳嘉弘等人(2004)以國小三、四年級進行體適能的電腦輔助教學實驗教學之研究發現，學生在專注力、自信心及滿足感，達到顯著差異，惟關聯性認知卻無顯著差異，其研究者們進一步解釋認為教學時教師應該多著重於教學回饋的口語，激起其內化遷移作用，以增強學習者關聯性認知。石國棟等人(2006)研究 ARCS 動機模式在動作技能表現、動作概念與學習動機的學習成效，研究結果為由多媒體介入的實驗組之後測動作技能表現、學習動機、專注力、關聯性認知、自信心和滿足感之顯著高於傳統教學組，但在動作概念上，兩組表現並無顯著差異水準。盧秋如等人(2006)探討多媒體輔助教學法與傳統教學法對大學學生學習桌球之學習動機影響。研究結果顯示多媒體輔助教學組之學習動機、專注力、自信心及滿足感均高於傳統教學組，且達顯著差異；惟學習動機之關聯性認知因素未達顯著差異。黃美瑤等人(2009)則以電腦影音多媒體介入體育課教學後對學生體育課學習動機之影響。其研究結果發現以電腦影音多媒體介入的實驗組學習動機中專注力程度顯著差異高於傳統教學的對照組，學習動機中的關聯性、自信心和滿足感皆與對照組無顯著差異。

綜而言之，ARCS 學習動機理論融入體育教學確實可以提升學習的動機，因此才能在學習過程中，維持高昂的學習態度，進而達成有效且有意義的學習（Dweck,1986；Hanrahan, 1998；Keller,1999）。

3. 研究方法

3.1 多媒體教材之設計

(1) 內容規劃

本研究透過多媒體電腦呈現排球基本動作的訓練。分析探討多媒體的相關文獻，參考王柏華(2007)及葛合伸元(2008)對於排球基礎教學的研究論文，瞭解目前多媒體教學的設計情形及製作方式，透過實作來建置此輔助教學系統，將所研究的問題及運用整合的新方法，以平板電腦播放呈現。在一開始的內容規劃上，本研究設計一套包含有發球、接球、托球、

殺球、攔網的訓練內容教材。這套系統包含了3D 畫面、文字的解說、及口述旁白，再輔以不同角度、不同速度的觀看加深使用者的印象，最後將成品製作成 APP 提供免費下載，方便學生使用者隨時學習(如圖 1)

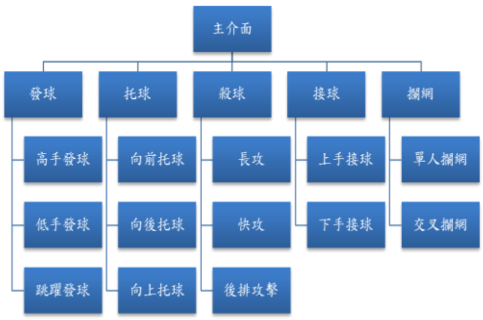

圖 1. 多媒體排球教材規劃內容

(2) 融入 ARCS 理論的設計

本研究的設計重點在於如何融入 ARCS 動機理論，因此先由 ARCS 的定義及組成要素導引出激發動機的策略，再以視覺化及搭配設計元素的方式設計一個情境將這些策略帶入(定義>策略>發展>設計情境)。表 2 是如何融入 ARCS 理論來設計教材。

表 2. 融入 ARCS 理論的動畫及遊戲教材設計

要素與組成	激發動機的策略	設計情境
A. 引起注意 1.感官的吸引 2.問題的探究 3.用變化維持	1.用新奇、非預期的方法捕捉學生的注意。 2.用奇特的問題維持好奇心。 3.變化教學的方式。	1.利用 3D 角色及動畫來吸引學生的注意力。 2.運用不同視角觀看方式及旁白口述以維持好奇心。
R．切身相關 1.似曾相識 2.目標導向 3.過程導向	1.結合學生的先前經驗，提高課程的熟悉度。 2.藉著陳述教學與個人目標的相關性，以產生實用的知覺。 3.提供符合學生動機與價值學習機會，如自我學習或合作學習…等。	1. 結合學生之前學習球類的經驗。(此排球課程屬基礎動作學習，實驗安排在第 10 週，因此經過了 9 週的練習後，因此學生對於排球學習有一定的學習經驗)。 2.依學習目標將教材分類，以合作學習共同觀摩學習的方式加深學習印象。
C.建立信心 1.學習必備的條件 2.成功的機會 3.操之在我	1.訂定明確的教學目標，協助學生創造正向的成功期望。 2. 提供學習者在適度範圍內，可以自我控制自我的學習。 3.提供學習者有機會可以成功的達到具有挑戰性的目標。	1. 依難易度將教材分類，增加學習的信心。 2.教材播放的控制可以任意前進後退，方便自我學習。
S.獲得滿足 1.自然的結果 2.正向的結果 3.維持公正	1.提供情境讓學生一展所長。 2.提供正向的結果，諸如：口頭讚美、獎勵。 3.對於成功維持一致的目標與結果，學習的最後結果與起始設定的目標和期望一致。 4. 獲得很小的娛樂	1. 在觀看完教學後，馬上操作練習並給予口頭讚美。 2. 適當的評量內容與方法。 3.利用多媒體的聲光效果帶來娛樂性。

本研究整理自 Keller（1987c）並補充融入 ARCS 動機理論的多媒體設計要點

(3) 以動作捕捉器擷取動作

本研究採用 Moven 動作捕捉感應服，它以獨特的微型慣性運動傳輸感應器（MTx）和無線 Xbus 系統為基礎，結合了符合生物力學限制的高效感應器等 Xsens 最新科技(愛迪斯科技，2016)。Moven 人體動作捕捉資料透過無線網路傳輸到電腦或筆記型電腦中，即時記錄和查看動態捕捉效果。Moven 人體動作捕捉服最獨特之處在於無需外部照相機和發射器等裝置，避免了多餘的資料傳輸線或電源線對使用者的行動限制。使用者即使將感應服隨意穿在自己衣服裡面，都絲毫不會影響動態捕捉的效果。本研究委請實踐大學高雄校區排球校隊示範排球的各項動作(如圖 2)。擷取各個項排球的動作後，利用平面設計(Photoshop)與 3D 設計(3Ds MAX)的技術來製作 3D 模型。經過 3Ds MAX 動畫軟體製作完成各種角色並套入不同動作後加以分類(如圖 3)。互動控制的部分則是以 Unity 3D 製作，將 3D 場景及人物動作匯入 Unity 3D 後，使用其外掛的 Play Maker 程式將一塊一塊程式塊拖曳到編輯區域內組合完成互動操作。

圖 2.利用動作捕捉器擷取發球動作

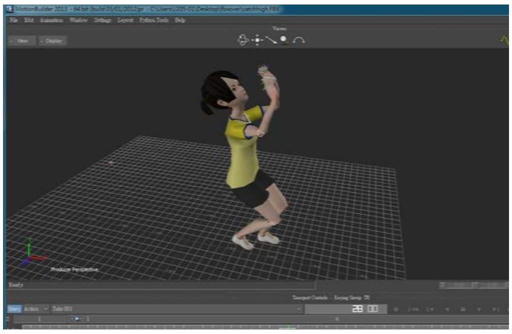

圖 3.在 3D 軟體中製作角色及匯入動作

本教學系統教材以 3D 畫面呈現，利用手指操作可控制旋轉視角及慢速撥放，另有詳細的文字解說與口述旁白，下圖為操控介面（如圖 4、5、6）。

圖 4.主畫面介面

圖 5. 教材主選單

圖 6.基礎動作教學介面

3.2 正式實驗

(1) 實驗設計

本研究係以實踐大學高雄校區修習排球課程所有學生為對象，含一年級兩班和二年級三班，合計 200 人為受試對象進行施測。此排球課程屬基礎動作學習，實驗安排在第 10 週，因此經過了 9 週的練習後 ，學生對於排球學習有一定的學習經驗。施測程序係先將學生編組，每組 4~5 人並配給一套平板電腦含數位教材，各組在了解操作方式後，隨即至指定地點一邊觀看數位教材，一邊自行練習基本動作，實際操作及練習時間計約 1 小時，最後再請所有受試者填寫「可攜式 3D 多媒體排球教材之學習動機及自我學習成效量表」。俟問卷資料回收綜整後，遂依研究目的與課題進行統計分析。

(2) 問卷設計與實施

本研究依照研究目的與課題，編製「可攜式 3D 多媒體排球教材之學習動機及自我學習成效量表」。本量表包括三個部分，第一部分學生背景變項，含性別、學院和使用經驗等，使用經驗指在本實驗進行之前，曾經使用過數位教材進行學習的同學。第二部分 ARCS 動機量表以 Keller（1987c）為主，並參考編修 Liu & Liao (2011)進行自製研究量表，第三部分自我學習效能分量表，第二三部分採 Likert 五點量表型式進行檢測。(1 =非常不同意、2 =不同意、3 =沒意見、 4 =同意、 5 =非常同意)。ARCS 學習動機量表部分，學習動機評估量經預試後表整體信度 α 值達.89（共 23 題），其中注意評估題型（共 6 題，α 值=.91）、關聯評估題型（共 5 題，α 值=.89）、信心評估題型（共 5 題，α 值=.90）、滿足評估題型（共 7 題，α 值=.86），自我學習成效量表（共 8 題，α 值=.93），顯示本量表具可信度，應可進行正式實驗之施測。以下為問卷題目分析(表 3 及表 4):

A. 專家內容效度：為瞭解本研究所編製之問卷題項是否有代表性及合適性，乃委請 3 位長期從事體育教學研究或在師範院校教授體育科教材教法之學者專家或教師，就問卷初稿各問項內容、架構及用語等加以審視，並提供修正意見。其結果，除修訂部分題項內容外，餘均合適保留之。

B. 預試：為進一步了解受試者填答和閱讀是否有困難或疑惑，遂隨機遴選 150 名大學生，進行問卷預試。合計回收 138 份，回收率 92%。所得資料除作為問卷設題修訂之參考外，另提供作為項目分析及信效度檢測之用。

C. 項目分析：按總分高低排序後，分別選取分數最高和最低的 27%（回收總份數×27%），並將之區分為高分組和低分組，再透過獨立樣本 t 檢定進行各題項之鑑別度檢測。凡臨界值（CR 值）高於 1.96 或高低分組間達 $p<.05$ 的顯著水準時，該題項始具較佳鑑別度，否則應予刪除（邱皓政，2005）。本研究項目分析結果，學習動機分量表各題項之臨界值介於 5.87~11.36 之間，且均達 $p<.05$ 的顯著水準。由此顯示，此量表所有題項均具有良好之鑑別度。

D. 信效度分析：係以主成份因素分析考驗量表的建構效度。學習動機分量表部分，採最大變異法，因子設定為 4，因素分析結果 KMO 為.93，Bartlett 球形檢定亦達 $p<.001$ 顯著水準，所有題項之共同性均高.50，總解釋變異量為 71.72%。各題項所屬因素與原量表大致相符，依序命名為注意、信心、關聯及滿足，因素負荷量如表 1 所示。在信度方面，學習動機量表刪除部分題項後之整體 Cronbachs'α 值為.96，四個因素個別的 Cronbachs'α 值介於.86~.91 之間。自我學習成效量表的 Cronbachs' α 值為.93。整體而言，學習動機和自我學習效能分量表均具有良好的效度和極佳之信度水準。

表 3. 學習動機分量表之因素分析摘要表

題項/內容	注意	信心	關聯	滿足	α值
a4能讓我產生想要繼續玩下去的想法。	.823	.319	-.066	.115	
a5內容很吸引我。	.819	.159	.127	.303	.91
a3讓我感到很有興趣。	.766	.200	.168	.284	
a1使我更加集中注意力。	.748	.097	.336	.146	

a6可幫助我專注於排球的學習上。	.661	.210	.466	.235	
a2引起我探索的動機。	.559	.197	.381	.332	
a13有信心達成排球學習目標。	.251	.807	.306	.164	
a14有信心可以成功的完成學習。	.372	.753	.317	.185	
a16能充份了解畫面操作會得到什麼樣反應。	.076	.719	.173	.343	.89
a15因我努力的付出而有好的表現。	.262	.655	.261	.334	
a12經老師講解說明後有信心知道如何操作。	.143	.487	.622	.112	
a17能從中學到知識或技能。	.334	.473	.419	.284	
a7能充份了解要表達的概念。	.146	.200	.819	.192	
a11能幫助我瞭解排球基本的打法。	.304	.472	.606	.287	
a10所學到的內容與排球課所學的經驗相連結。	.208	.404	.595	.376	.90
a9對我有幫助。	.426	.301	.417	.450	
a8所學到的內容很實用。	.479	.393	.407	.286	
a20使用此數位軟體練習有進步時會感到滿足。	.330	.254	.265	.742	
a21即使無法完全學會仍會盡力學習和練習。	.230	.202	.369	.691	.86
a19因為很有趣而覺得時間過得很快。	.293	.346	.075	.686	
a18很高興能使用此數位軟體來學習排球。	.448	.432	.204	.515	

表 4. 自我學習成效量表之分析摘要表

題項/內容	**學習效能**	α值
b9使得運動技術的學習效果更好	**.882**	
b10使得學習運動技術變得更容易	**.815**	
b11使得學習運動技術變得更方便	**.779**	
b15讓我更能正確地學習運動技術	**.740**	.93
b6使我對學習運動技術的意願變得更高	**.728**	
b7我對學習運動技術的態度更積極主動	**.677**	
b8個人自主學習（獨立學習）的時間變得更多	**.637**	
b14使我更能有效地掌握動作要領	**.630**	

(3) 問卷施測

本研究正式問卷施測方式係依選定之受試對象進行施測，施測前由研究者先解說行動多媒體排球教材的操作方式，以及說明問卷的填寫方式。合計發出問卷 200 份，總計回收 173 份，回收率達 86.5%。回收問卷經過整理及除錯後，凡漏（誤）答或填答規律者均視為廢卷，計得有效問卷 173 份，廢卷 0 份，有效率為 100%。

4. 結果分析與討論

4.1 大學生學習動機分析

大學生在整體學習動機各構面上所呈現之描述性結果，如表 5 所示。整體而言，大學生在使用可攜式行動多媒體教材後的學習動機均介於 3~4 分之間，其中以「關聯」構面的平均得分最高（M＝3.46），以「注意」構面的平均得分最低（M＝3.08）。

表 5. 大學生使用可攜式行動多媒體教材後之學習動機摘要表

構面	人數	題數	題項平均數	標準差	排序
注意	173	6	3.08	.753	4
信心	173	6	3.34	.678	2
關聯	173	5	3.46	.689	1
滿足	173	4	3.30	.773	3
整體學習動機	173	21	3.29	.655	

在關聯的部分則是測量教材是否針對學習者的目標和需要來設計。進一步就個別題項分析發現: 學生較認同此數位教材能有效幫助瞭解排球的基本打法（M＝3.63）。學生表示可攜式多媒體教材以平板的方式呈現，教學內容分類詳細，可與之前所學習的排球知識相連結，並有很好的實用性。而在注意較低的部分，題項中: 教材內容對學生較不具吸引力(M＝2.98），乃因每一個動作的示範的方式皆相同，看過一次之後如不是對排球特別喜愛的同學便覺得無趣，讓學生缺乏想繼續玩下去的動力。

4.2 不同背景大學生的學習動機之差異分析

不同背景大學生在整體學習動機上之獨立樣本 t 檢定結果發現，如表 6 所示，包括性別、學院和使用經驗等變項均具有顯著差異，其中男學生明顯高於女學生(t(171)=1.99，p＜.05)，商學與資訊學院學生明顯高於文化與創意學院學生(t(171)=3.26，p＜.05)，曾經使用過數位教材進行學習有使用經驗的同學明顯高於無使用經驗者(t(171)=2.31，p＜.05)。

表 6. 不同背景大學生在整體學習動機之獨立樣本 t 檢定

變項	t 值／F 值	顯著性	事後比較結果
性別	$t_{(171)}=1.99$*	$p=.05$	男>女
學院	$t_{(171)}=3.26$*	$p=.048$	商資>文創
使用經驗	$t_{(171)}=2.31$*	$p=.02$	是>否

註：* $p<.05$

4.3 大學生自我學習成效分析

大學生在自我學習成效所呈現之描述性結果，如表 7 所示，大學生在使用可攜式行動多媒體教材後之整體自我學習效能平均得分達 3.28。就個別題項分析得知，學生較認同課程中使用多媒體數位教材使得運動技術的學習效果更好（M＝3.64），且使得學習運動技術變得更容易（M＝3.46），惟其能使學習運動技術的態度變得更積極主動部分認同地較低。

表 7 大學生使用可攜式行動多媒體教材後之自我學習成效摘要表

構面	人數	題數	題項平均數	標準差
自我學習成效	173	8	3.28	.716

4.4 不同背景大學生的自我學習成效之差異分析

首先，不同背景大學生在自我學習成效上之獨立樣本 t 檢定結果發現，包括性別、學院和使用經驗等變項均具有顯著差異，其中男學生明顯高於女學生(t(171)=2.62，p＜.05)，商學與資訊學院學生明顯高於文化與創意學院學生(t(171)=4.01，p＜.05)，過去有使用經驗者明顯高於無使用經驗者(t(171)=2.66，p＜.05)。

整體而言，不同背景大學生在整體學習動機及自我學習成效上之獨立樣本 t 檢定結果發現，包括性別、學院和使用經驗等變項均具有顯著差異，其中男學生明顯高於女學生。據了解男生在與電腦互動歷程中能展現較高的控制性，Colley（2003）認為因為男生使用電腦的頻率通常高於女生，但多半是用來玩遊戲（Game），而這個與電腦互動的經驗也影響了男生視「電腦」為一種「玩具」或是一種成為專家的「科技」；而大部分得女生則將其視為能支持她們完成工作的「工具」，因此女生卻也因此較為缺乏自信。

而在商學與資訊學院學生的學習動機及

自我學習成效明顯高於文化與創意學院學生，也是因為商資學院不但有較多的男生(商資男女人數=1473: 1447，文創男女生人數=795: 2227)，另外商資學院中有兩個資訊類的學系(資訊管理學系與資訊通訊與科技學系)的學生也較為熟悉科技類的產品，這也是商學與資訊學院學生在學習動機及自我學習成效上明顯高於文化與創意學院學生的主因。過去有使用過數位教學經驗者的學習動機明顯高於無使用經驗者的原因在於有使用經驗者在學習時可與過去的學習經驗相連結，並認為教材所學到的內容很實用，並產生較高的學習興趣。因此在學習動機及自我學習成效上明顯高於無經驗的使用者，這也與陳騰龍（2006）及余欣鴻(2015)的研究結論相符合。

5. 結論與建議

本研究以多媒體設計的觀點融入 ARCS 學習動機理論所開發的教材，設計一套包含發球、托球、接球及攔網等 3D 多媒體排球教材，除使用動作捕捉器捕捉選手實際操作以保有動作的真實性，教材以 APP 的方式呈現並借助平板電腦的便利性，以手指滑動平板控制視角旋轉及按鈕選擇撥放速度加強互動性，由文字框說明並輔以語音提示動作步驟來加強學習的動機。經研究結果顯示在 ARCS 學習動機(注意、關聯、信心、滿足)中的各項數據皆在平均值以上，其中以「關聯」構面的平均得分最高。此外無論是在學習動機及自我學習成效方面，男學生明顯高於女學生，商學與資訊學院學生明顯高於文化與創意學院學生，過去有使用經驗者明顯高於無使用經驗者。本研究之貢獻在以多媒體設計的觀點融入 ARCS 學習動機理論所開發的教材，經實驗證明的確可以有效提高學習者的學習動機並提升自我學習成效。

有關於實驗中學習動機中注意較低的問題，本研究建議將針對教材的玩法加強創意發想，開發更多有別於市售的商業遊戲教材的遊玩互動方式(李來春、郝光中，2013)。此外可參考結合虛擬實境或擴增實境，利用更多的互動輸出裝置來吸引學習者的注意。本研究僅測試 3D 多媒體教材，尚不知其與傳統教學上各項比較的優劣。因此在未來研究方面，可以以實驗組與對照組的方式測試。以實驗組（互動教學模式）與對照組（傳統教學模式）的分組方式評估其成就測驗、學習興趣與滿意度調查的比較。

而在資訊科技應用在體育教學的前瞻性方面，可加強學生在多媒體科技融入體育教學等相關課程，學生在使用多媒體科技學習除了可帶給自我運動技能上的提升，並改變了學習態度，進而對課程產生了濃厚的興趣。此外體育教師也應增加其多媒體科技素養及能力，將其融入在教學活動中，使多媒體教學發揮最大優勢，成為體育教學的一個亮點(李達勝，2015)。最後教師在安排課程時應站在學生的立場，除以多媒體充實教學內容的多樣化，以激發學生學習的動機及自我學習意願

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