明新學校財團法人明新科技大學
校內專題研究計畫成果報告

3D VR/AR 人才培訓之研究
A Study on Personnel Training for 3D VR/AR

計畫類別：■任務型計畫　□整合型計畫　□個人計畫

計畫編號：MUST-109 任務-20

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計畫主持人：曾俊霖

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計畫參與人員：陳昱佑

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中　華　民　國　109　年　10　月　30　日

明新學校財團法人明新科技大學校內專題成果報告

公　開　授　權　書

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在明新科技大學 人文與設計學院 多媒體與遊戲發展系所 109 年度校內專題研究計畫。

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授權人： 曾俊霖　　（請親筆正楷簽名）

中　華　民　國　109　年　10　月　30　日

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中文摘要

隨著虛擬實境(VR)與擴增實境(AR)技術的不斷提升,產業界對虛擬實境與擴增實境的需求不斷增加。而為了有效提早讓學生投入 VR/AR 創意設計領域，本計畫以「3D VR/AR 人才培訓之研究」為主題，以期加速本系學生與產業技術同步發展，並透過此一計畫之執行引領更多同學一同參與虛擬實境與擴增實境的技術領域。而為了培訓學生虛擬實境與擴增實境系統相關技術，本計畫以 HTC Vive VR、智慧型手機為主要的 VR/AR 培訓裝置，並導入 HTC Vive 所需之 Steam VR 開發套件，並依培訓目標規畫出五個主要內容，包括 VR/AR 硬體介紹、VR/AR 相關軟體介紹、VR/AR 開發環境架設、VR/AR 開發引擎實作、VR/AR 系統發佈與展示，最後將研究成果撰寫於研究報告中，做為未來 VR/AR 創意設計人才培育方向的參考。

關鍵詞：虛擬實境、擴增實境、人才培訓、創意設計

Abstract

With the raising of the techniques of virtual reality (VR) and augmented reality (AR), the demand in VR and AR for industries are decreasing. To allow students to dedicate themselves to VR and AR, this study proposed a research, called 3D VR/AR manpower cultivation. This study will lead students to study the technique of VR and AR. In the VR and AR devices, this project will employ the HTC Vive VR and Smart Phone. To develop the integrative system, this project will import the Steam VR and relative AR packages respectively. There are five topics of manpower cultivation, including introduction to VR/AR hardware, introduction to VR/AR software, VR/AR development environment, VR development engine, VR/AR system publishing and representation. Finally, we also have written a research report for the reference of VR/AR personnel cultivation.

Keywords: Virtual Reality, Augmented Reality, Personnel Training, Creativity Design

一、前言

本系(明新科技大學多媒體與遊戲發展系)自 108 學年度起正式招收第一屆學生,其主要的發展方向之一為虛擬實境(VR)與擴增實境(AR)的技術研發，然而，目前正值資訊科技突飛猛進之計，透過一般課程上的培訓腳步，不易迅速跟上科技變化的速度，秉持本校中程校務發展的「精進教學品質，確保學習成效」的主要面向，本系將提早針對本系一年級同學開始進行 VR/AR 創意設計技術紮根，培育學生對 VR/AR 的認識、VR/AR 的技術實作，以提早因應外部產業的迅速變化，對於本系教師來說，讓本系學生提早接觸 VR/AR 技術，將可厚植本系學生 VR/AR 研發能力，提升本系教師對外洽談產學合作的機會。

隨著虛擬實境(VR)與擴增實境(AR)技術的不斷提升，產業界對虛擬實境與擴增實境的需求不斷增加。而為了有效提早讓學生投入 VR/AR 創意設計領域，本計畫以「3D VR/AR 人才培訓之研究」為主題，以期加速本系學生與產業技術同步發展，並透過此一計畫之執行引領更多同學一同參與虛擬實境與擴增實境的技術領域。而為了培訓學生虛擬實境與擴增實境系統相關技術，本計畫以 HTC Vive VR、智慧型手機為主要的 VR/AR 培訓裝置，並導入 HTC Vive 所需之 Steam VR 開發套件，並依培訓目標規畫出五個主要內容，包括 VR/AR 硬體介紹、VR/AR 相關軟體介紹、VR/AR 開發環境架設、VR/AR 開發引擎實作、VR/AR 系統發佈與展示，最後將研究成果撰寫於研究報告中，做為未來 VR/AR 創意設計人才培育方向的參考。

二、研究動機與目的

本系所屬之人文與設計學院以「人文關懷與創意設計」為主要的人才培育目標，其中創意設計更是本系的教育推動方向之一，而著眼於 VR/AR 創意設計的應用越來越廣，因此，本系提出此計畫，以提升本系學生的 VR/AR 創意設計能力。

無論是虛擬實境還是擴增實境技術，近年來的應用已越來越多，包括軍事、醫療、建築、教育、工程、影視、娛樂等相關領域 [1-6]，而目前常見的頭戴式虛擬實境裝置包括 Oculus Rift [7，8]、3Glasses [9]、HTC Vive [10，11]、PlayStation VR [12]等；頭戴式擴增實境裝置則包括 Microsoft Hololens AR、Acer Windows Mixed Reality 開發版等。以下依頭戴式虛擬實境裝置與擴增實境裝置的應用分別說明如下：

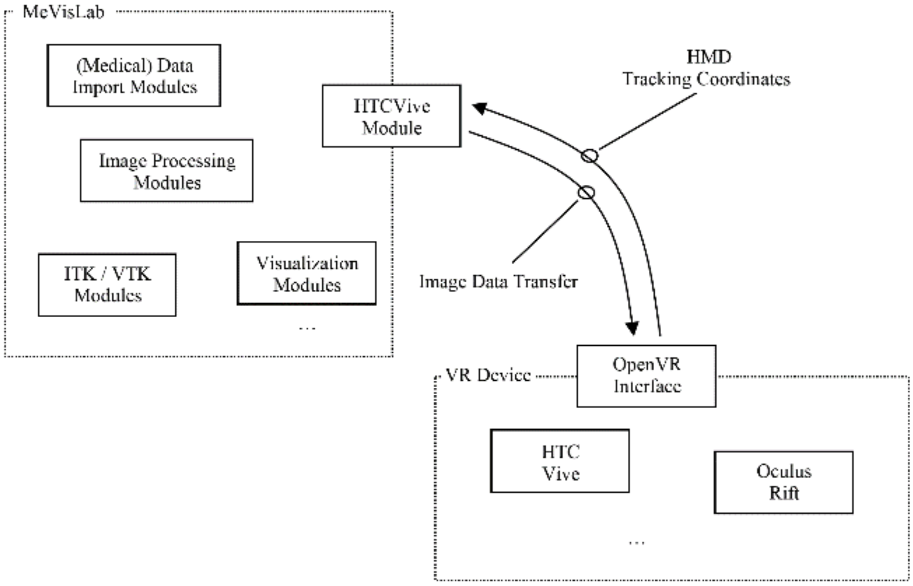
1. 虛擬實境裝置與其應用：

虛擬實境裝置提供使用者身歷其境地融入到 3D 虛擬場景之中，目前最著名的頭戴裝置包括 Oculus Rift、3Glasses、HTC Vive 和 PlayStation VR 等，其中又以 HTC Vive 最受矚目。HTC Vive 是目前最熱門的虛擬實境頭戴式顯示器之一。這款頭戴式顯示器的設計利用「房間規模」的技術，通過傳感器把一個房間變成三維空間，在虛擬世界中允許用戶自然地導航，能四處走動，並使用運動跟蹤的手持控制器來生動地操縱物體的能力，有精密的互動，交流，和沉浸式環境的體驗。為了進行定位與感應偵測，整個系統共有超過 70 個感應器，其中也包括了陀螺儀、加速器、雷射位置感測器，並可在 15 尺 x15 尺的空間進行感測追蹤。另外，在空間定位技術方面，HTC Vive 不同於 Oculus Rift 收集影像方式，HTC Vive 的定位技術以收集定位器(即官方所謂的 Lighthouse)所發射出來的光來進行計算，如圖 1 所示，顯然透過 Vive 系統中的感應器來接收光資訊的方式比其他頭戴式虛擬實境裝置，如 Oculus Rift，以收集影像的方式來的單純且既快又準。

圖 1、HTC Vive 頭戴式虛擬實境系統

雖然虛擬實境技術可以提供使用者身歷其境的視覺效果，在娛樂產業的應用上也有許多成功的例子，然而對於其他領域，要將之整合到現存的系統中，仍舊不是那麼容易，其中，醫療領域的 MeVisLab 平台便是如此。

MeVisLab 是醫療研究人員常用的系統，該系統主要透過 ITK 與 VTK 來進行建構，並利用傳統的圖形化介面來加以呈現。然而，ITK 與 VTK 皆未直接支援虛擬實境技術，因此，J. Egger et al.[13]在 MeVisLab 系統中導入了 OpenVR 介面，以便讓 MeVisLab 能透過 HTC Vive 等虛擬實境設備來進行呈現，如圖 2 所示。



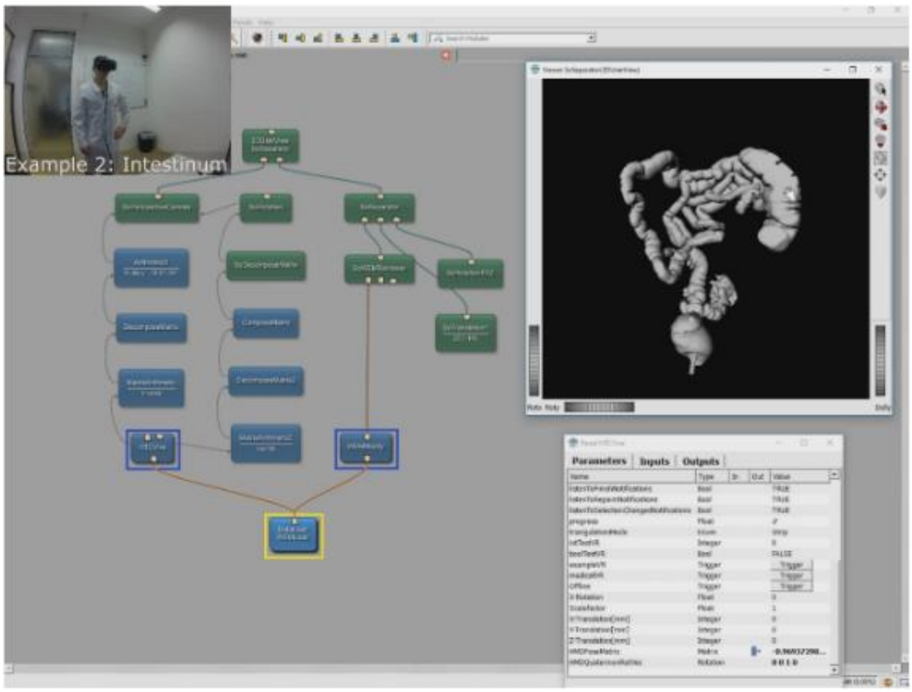


圖 2、J. Egger et al.將虛擬實境裝置導入至 MeVisLab 醫療系統中

Collier III et al. [14] 則將 HTC Vive 虛擬實境裝置與 UAV 無人飛行載具進行結合，並將之應用於虛擬校園導覽之中。Collier III et al.利用 DJI Phantom 無人飛行載具(含攝影機)在校園中進行飛行拍攝，取樣出虛擬校園所需的 3D 模型點座標資訊，並擷取出多張建置虛擬校園所需之照片資訊，最後在將之整合成 3D 場景模型，並將之導入 Unity 系統中，並透過 SteamVR 建構導覽虛擬校園所需之互動機制，進而運用 HTC Vive 可針對虛擬校園進行操作。

圖 3、Collier III et al.利用 UAV 無人飛行載具與 HTC Vive 建構虛擬校園導覽系統

2. 擴增實境裝置與其應用：

隨著 3D 技術的提升，擴增實境的應用也漸為受人矚目，目前的頭戴式擴增實境裝置包括 Microsoft Hololens、Acer Windows Mixed Reality 開發版等，如圖 4 所示，其中又以

Microsoft Hololens 最具代表性。Microsoft HoloLens 是使用 Windows Holographic 的主要設備。HoloLens 是一個在 Windows 10 作業系統上執行的智能眼鏡產品。它採用先進的傳感器、高清晰度 3D 光學頭置式全角度透鏡顯示器以及環繞音效。它允許在擴增實境中用戶界面可以與用戶透過眼神、語音和手勢互相交流。

HoloLens 使用的傳感器是一種高效節能的深度攝像頭，具有 120°×120°的視野。傳感器提供的其他功能包括頭部跟蹤，視頻拍攝，以及聲音捕捉。除了高性能的 CPU 和 GPU，HoloLens 帶有全息處理器（HPU）這一協處理器用於從所述的各種傳感器集成數據，並處理包括空間映射，手勢識別和語音識別的相關任務。

圖 4、Microsoft Hololens 頭戴裝置

由於 Hololens 頭戴裝置因具有 Holographic 的功能，因此，其不限於應用在虛擬實境或擴增實境的領域之中，換句話說，它具有更寬廣的應用範圍。另外，Hololens 與其他頭戴式裝置最大的不同點就是它本身就相當於一台電腦，它具有獨立運算的功能，無須連接到電腦伺服器之中，且可透過無線傳輸的方式將擴增實境系統訊息進行傳送或接收，提供使用者完全無線且更自由式的操作模式。

Silva et al.[15]將頭戴實境裝置應用於教育場所之中，Silva et al.在此研究中發展了一套名為 Glassist 的應用軟體，並透過此軟體協助老師進行教學管理工作。Glassist 可以讓老師自行建置，管理並分享上課學生的個人基本資料，此工具是以頭戴裝置系統來進行開發並分成教室模式，用餐模式與室外模式三種，其透過頭戴裝置上的攝影鏡頭來辨識學生的臉部，進而呈現這些學生的相關資訊。

當老師戴上頭戴裝置後，透過裝置上的攝影鏡頭可以擷取教室畫面，並辨識畫面中所有學生的臉部，並在系統右上角的部分呈現每一位學生的姓名，而為了達到擴增實境功能，Silva et al.甚至將此應用軟體開發出 see-through 模式，讓上課老師可以將頭戴裝置視為一種 see-through 裝置，方便上課教學。在用餐時，系統的用餐模式可以透過頭戴裝置提醒老師學生的用餐狀況或不可食用的食物。而在室外模式下，可以提醒老師，學生過去的不好行為紀錄以及計算上車人數等。

圖 5、Silva et al.將擴增實境技術應用於教育場域中

3D 容積掃描(Volumetric Scan)在醫學上是極為常用的一種 3D 呈現技術，而 Pham et al. [16]為了透過擴增實境技術，將 3D 容積掃描資訊更具體地呈現出來，他導入了 Hololens 頭戴裝置，並依系統操作所需設計的多種的互動手勢，提供醫學技術人員可以直接地針對系統進行操控，如置入切割平面(Place Plane)、移動物件(Move Object)、移動切割平面(Move Plane)、切割物件(Cut Object)等，如圖 6 所示。

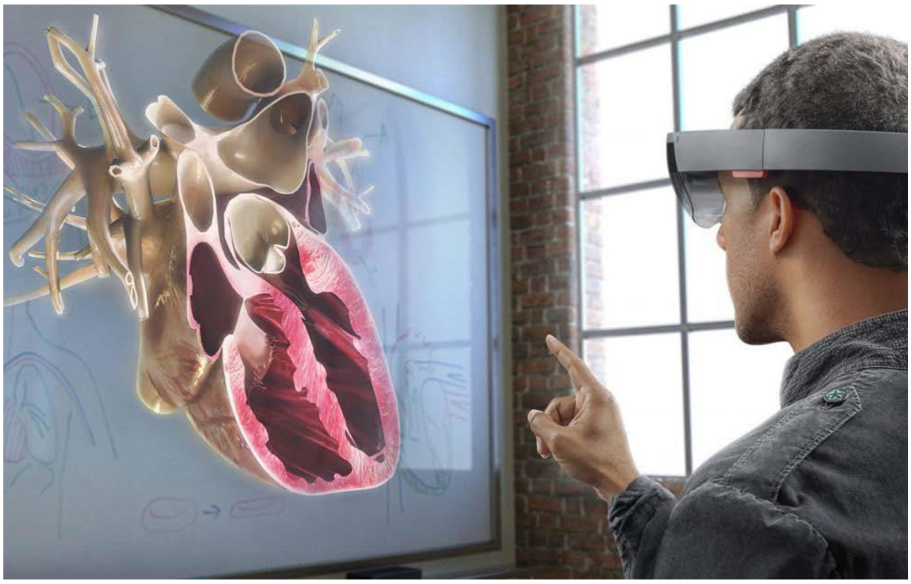


圖 6、Pham et al.在 Hololens 擴增實境系統上開發所需之操作手勢並將之應用在醫學上

隨著虛擬實境與擴增實境技術的不斷提升，其相關技術已逐步拓展到越來越多的產業之中，然而，因需求性不斷增加，培訓 VR/AR 相關人才的腳步必須加快，因此，本計畫以「3D VR/AR 人才培訓之研究」為研究主題，探討如何有效提升本系學生的 VR/AR 創意設計之相關技術，以期加速銜接產業技術。

三、相關文獻探討

3-1 虛擬實境文獻探討

近年來，虛擬實境裝置有許多不同的應用，包括遊戲、教育、電影、軍事訓練、工業仿真等。在此我們以教育應用以及工業仿真兩方面來進行探討。

3-1-1 教育應用

Elena et al. [17]在 2018 年的 EURASIA Journal of Mathematics，Science and Technology Education 期刊中發表一篇論文，該研究利用行動式虛擬實境(Mobile Virtual Reality)來做為主要的教學平台，探討融入且正面情緒感應在學習過程中的影響，從其研究中可看出，當在學習課程中導入了虛擬實境裝置後，將可有效地提升學生融入課程，並表現出正面情緒的學習態度。而當學生以平板電腦做為學習工具，擇期欠區缺了融入的效果，其正面情緒的反應也會相對大打折扣，如圖 7 所示。

圖 7、Elena et al.導入虛擬實境裝置後，探討其對學生學習過程的影響

3-1-2 工業仿真

除了在教育領域之外，虛擬實境技術也逐步朝向工業仿真上的應用[18，19]，L. P. Berg與J. M. Vance[18]在2017年發表了一篇名為” Industry Use of Virtual Reality in Product Design and Manufacturing: A Survey”的文章，在該文中說明了虛擬實境技術在工業上已可作為產品設計的重要判斷工具，以汽車製造工業來說，虛擬實境技術可應用駕駛的模擬情境上，駕駛在進行模擬開車時，虛擬實境可以提供擬真的在外環境，讓駕駛人員只需戴上頭戴式虛擬實境裝置便可輕易理解外在場景中物體(如柱子)的大小與放置地點，這大大地提高了駕駛人員的可視範圍，提高駕駛人員測試的安全性，並降低了車輛測試的成本，如圖 8 所示。

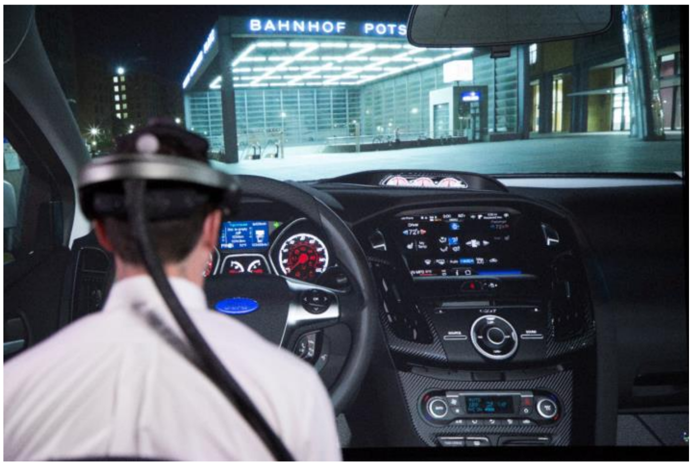


圖 8、使用者在福特廠中帶上虛擬實境裝置後，可透視觀看到汽車外的虛擬場景內容

隨著網路與資訊技術的提升，擴增實境技術已逐步應用到現今生活各領域之中，如遊戲[20]、教育[21]、工業[22]等，各領域應用簡述如下：

3-2 擴增實境文獻探討

3-2-1 遊戲應用

Zarraonandia et al. [20]在 2019 年提出了一個擴增實境遊戲，此遊戲主要是在促進了解我們當地環境中的植物。玩家在他們自己的區域中收集植物，在家裡種植這些植物。此遊戲結合了實境中的植物，並將之建置成一個 AR 花園。此遊戲整合了實境元素(帶有感測器的植物盆、具有植物資訊的 RFID 標籤)與虛擬元素(該植物的 AR 資訊顯示)，如圖 9 所示。該研究的最終目標是調查遊戲體驗在從虛擬世界移動到真實世界時受到的影響，如遊戲的前後內容、挑戰或獎勵。而在此研究中也嚴謹探討，當遊戲過程中有一半的虛擬資訊以及一半實境資訊的前提下，是否仍然可以獲得不錯的教育成效。

圖 9、Zarraonandia et al.在 2019 年所提出了擴增實境遊戲

3-2-2 教育應用

雖然目前我們正處於增強現實 (AR) 的萌芽階段，然而，部分應用領域卻有著重大發展。教育是一個經常透過新興技術來推動創新的領域之一，其中，受擴增實境的可視化功能，而直接獲益的學科之一便是物理。Pittman 與 LaViola [21]在 2019 年的研究中介紹了一系列對中學教師的訪談結果，研究中說明了他們在 AR 方面的經驗，以及從教學角度對中學教師最有利的特點。為了收集有意義的訊息，本研究開發了一個應用程式雛形，並交給了教師們，如圖 10 與圖 11 所示。根據從教師那裡收集的反饋，我們提出了一套 AR 物理教育工具的設計建議，以及許多其他有用的建議。

圖 10、Pittman 與 LaViola 在研究中利用 Hololens，擷取球在斜坡上彈跳的情形

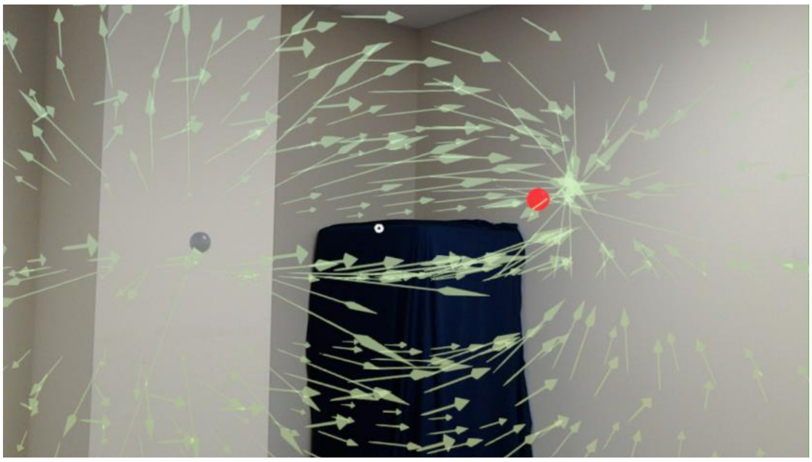


圖 11、Pittman 與 LaViola 利用 AR 頭戴裝置捕捉，在庫倫定律下電荷電場的呈現效應

3-2-3 工業應用

Bottani 與 Vignali [22]在 2019 年發表針對擴增實境技術在工業中應用進行相關文獻的回顧、歸納、並進行分析研究。近年來，AR 的技術越來越普及，由於其應用程式的開發越來越方便，而且硬體設備(如智慧手機和平板電腦)支援 AR 的開發也越來越廣泛。目前為止，已有越來越多以 AR 為主的工業應用解決方案。雖然這些應用通常只是實驗性雛形，然而，AR 的技術證明了其具有高度的靈活性，並可在眾多領域(如維護、培訓/學習、裝配或產品設計)和工業部門(如汽車、飛機或製造業)發揮其強而有力的潛質。雖然本研究主要是針對 2006 至 2017 年初所出版的 AR 文獻進行探討，以確定主要領域與範圍，然而，從研究的發展趨勢可知， AR 系統未來將會越來越普遍，如圖 12 所示。

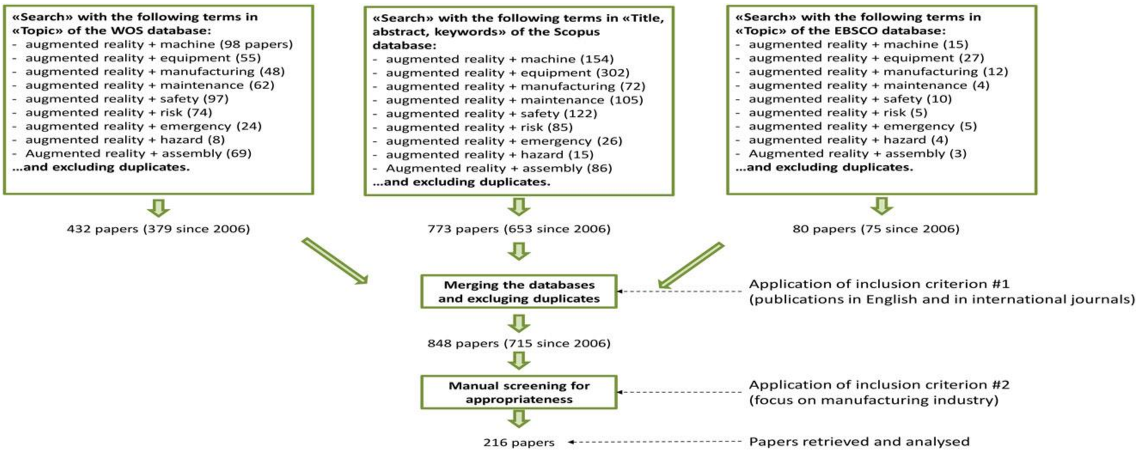


圖 12、AR 自 2006 年至 2017 年的主要研究領域分類與探討

四、研究方法

4-1 實施對象

本計畫主要的實施對象為明新科技大學多媒體與遊戲發展系 108 學年度入學學生，這些同學大部分來自於資電類、設計群、以及商管群背景，在本計畫執行期間，我們共執行了八個場次的 VR/AR 培訓，以及三個場次的 AR 培訓，共計超過 200 人次的培訓。本計畫參與的學生均為多媒體與遊戲發展系的學生，共計 17 位，而全班同儕(含未參加培訓計畫)的學生共計 38 位。

4-2 實施內容規劃

本計畫以培訓 VR/AR 相關人才為主要目的，因此，在計劃期間，我們以 VR/AR 培訓營為名，邀集學生參與 VR/AR 的培訓課程，本培訓課程將包括 VR/AR 硬體介紹、VR/AR 相關軟體介紹、VR/AR 開發環境架設、VR/AR 開發引擎實作、VR/AR 系統發佈與展示等。VR/AR 培訓現場示意如圖 13 所示，而培訓內容規劃如圖 14 所示。

圖 13、VR/AR 培訓圖

圖 14、VR/AR 培訓內容規劃

本計畫針對所規劃 VR/AR 培訓營之培訓內容說明如下：

➢ VR/AR 硬體介紹

要進行 VR/AR 相關技術的人才培訓，首先必須對 VR/AR 相關硬體設備能有所了解，如此一來，才能針對系統需求進行開發，因此，培訓的第一步，便是讓培訓的學生了解 VR/AR 的相關硬體裝置及其使用方法。

➢ VR/AR 相關軟體介紹

為了進行 VR/AR 相關硬體的開發，因此，必須導入相關開發套件，在本培訓營中，我們將導入 Unity 開發工具、SteamVR、Hololens AR ToolKit 等相關開發套件，並對培訓學生介紹這相關的開發工具。

- VR/AR 開發環境架設

了解 VR/AR 的硬體裝置以及軟體開發環境之後，再者便是先進行開發環境的架設，包括如何進行 VR/AR 硬體環境的操作、架設以及軟體安裝與操作。

- VR/AR 開發引擎實作

在本計畫中，我們將利用 Unity 作為培訓的主要開發引擎，並透過 Unity 來訓練學生 C#程式語言的實作。在此階段中，將以 VR/AR 遊戲為主要開發目標，讓學生了解 VR/AR 開發的過程，以因應未來執行產學計畫的基礎。

- VR/AR 系統發佈與展示

如何將前一階段所開發的 VR/AR 遊戲專案進行發佈與展示，是本階段主要的工作，因此，本計畫將引導學生如何將 Unity 所實作出來的內容發佈到 VR/AR 頭盔裝置之中，以便透過 VR/AR 來觀看是實作結果

4-3 實施步驟

本計畫的研究步驟包括：

- 虛擬實境系統與擴增實境系統之相關應用研究。

虛擬實境與擴增實境系統皆為近年來 3D 應用中最為熱門的技術之一，隨著資訊技術的迅速發展，目前已陸續有許多相關的研究也正如火如荼的進行著，為了加速 VR/AR 創意設計人才培育的速度，本計畫將引導學生探討相關應用研究，以便讓參與學生更快速的了解目前 VR/AR 的產業發展現況。

- Unity3D 之相關應用研究。

Unity3D 是近年來普及度最高的 3D 系統開發軟體之一，其高普及度的原因除了其具有跨平台的特性之外，更重要的是，它可與多項 3D 相關周邊設備進行整合，包括 HTC Vive、Hololens、Oculus Rift、Manus VR、Perception Neuron 等，這大大拓展了 Unity3D 的應用領域，也提升學生 Unity3D 開發平台中的實作概念，我們將在計畫中，將進行 Unity3D 相關應用的研究。

- 引導學生如何將 3D 場景與物件導入至 Unity3D 之中。

系統中主要所需的 3D 場景與物件主要是提供實作 VR/AR 系統主要展示內容之一。針對此一所需之 3D 虛擬場景與物件，我們將引導學生運用 Unity3D Terrain 的地形建置功能，

來進行 3D 地形場景之建置，而其他 3D 物件則利用目前市面上為人所熟知的 3D 模型建置軟體(如 3ds Max 或 Maya)來進行建置，並透過 FBX 格式將這些 3D 物件導入至 Unity3D 之中，以便提供後續計畫進行 VR/AR 之實作開發。

- 探討如何有效加速學生學習 VR/AR 的速度。

由於本系學生剛剛踏入 VR/AR 創意設計領域，若能了解如何有效讓學生加速投入到 VR/AR 的開發領域之中，將有助於學生未來競爭力以及提升本系教師對外引進產學合作機會。

五、研究結果

5-1 完成工作項目

本計畫完成的工作項目包括：

- 成立 VR/AR 培訓營：

為了推動 VR/AR 創意設計人才培育，本計畫將成立 VR/AR 培訓營，共執行了八個場次的 VR/AR 培訓訓練，以及三場次的 AR 培訓任務。

- 完成 VR/AR 創意設計專題實作：

本計畫引導學生進行 VR/AR 創意設計專題實作，並將實作結果發佈至 VR/AR 設備之中進行展示。

- 提供 VR/AR 相關產學計畫參與：

讓學生了解產業目前的發展現況，讓學生了解為何學習 VR/AR，因此，本計畫也導入 VR/AR 相關的實作計畫，提供學生參與計畫，讓學生了解目前產業的 VR/AR 應用方向。

參與本計畫的同學們，學習到了下列相關技術應用之薰陶：

- 3D 場景與物件之建置(接受 Unity3D Terrain 建置技術之訓練)
- VR 系統之開發(接受頭戴式虛擬實境系統 HTC Vive 及其 Steam VR 之技術開發訓練)
- AR 技術之開發(接受智慧型手機及其 HoloToolKit 之技術開發訓練)
- Unity3D 系統開發(接受 Unity3D 之整合開發技術訓練)
- 3D 程式之開發(接受 C#程式語言等 3D 產業所需之技術開發訓練)
- 了解國內外 VR/AR 相關技術之研發(相關應用研究之訓練)

相關計畫與系統開發導入如下：

- 計畫名稱：防災教育遊戲開發

合作對象：興創知能股份有限公司

執行期間：109.04-109.12

發佈設備：個人電腦 (AR 互動)

- 計畫名稱：導入 AR 技術進行社區改造

合作對象：竹北新國社區

執行期間：109.01-109.12

發佈設備：智慧型手機 (AR 互動)

- ➢ 實作遊戲開發：VR 射擊遊戲

使用軟體：Unity3D、Autodesk 3D Studio Max、SteamVR

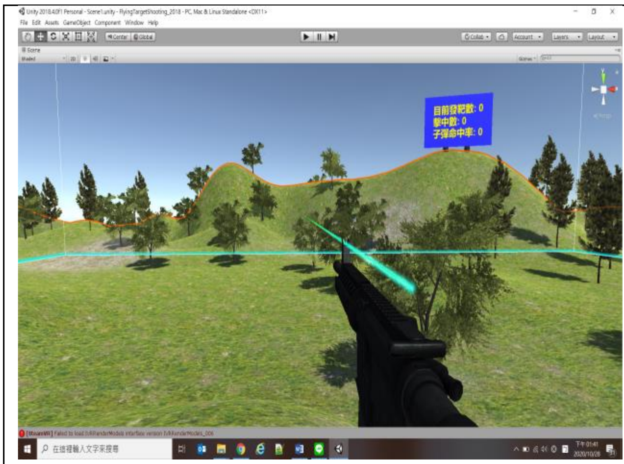
使用 VR 裝置：HTC Vive (VR 互動)

5-2 系統開發實作與培訓紀錄

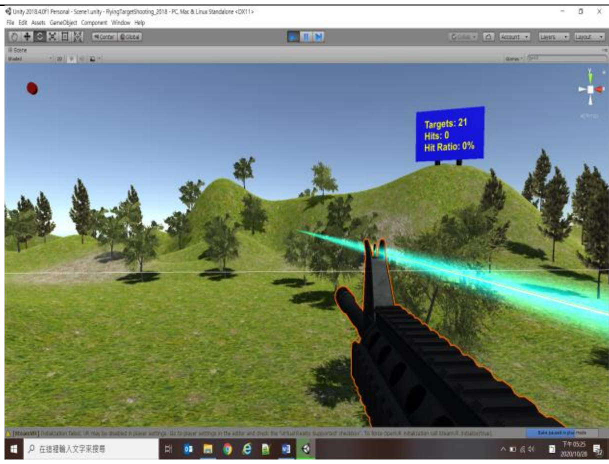
在本計畫期間，我們共進行了八個場次的 VR/AR 培訓營、三場次 AR 培訓營、開發一套 VR 射擊遊戲、一套針對竹北新國社區所設計的 AR 藥福園導覽系統、一套 AR 防災教育遊戲開發系統。各培訓活動紀錄如下表 1 所示：

表 1、培訓活動紀錄

	
VR/AR 培訓營-系統操作	VR/AR 培訓營-VR 運作概念
	
VR/AR 培訓營-硬體設備介紹	VR/AR 培訓營-VR 射擊遊戲實作教學



VR/AR 培訓營-VR 射擊遊戲場景實作畫面



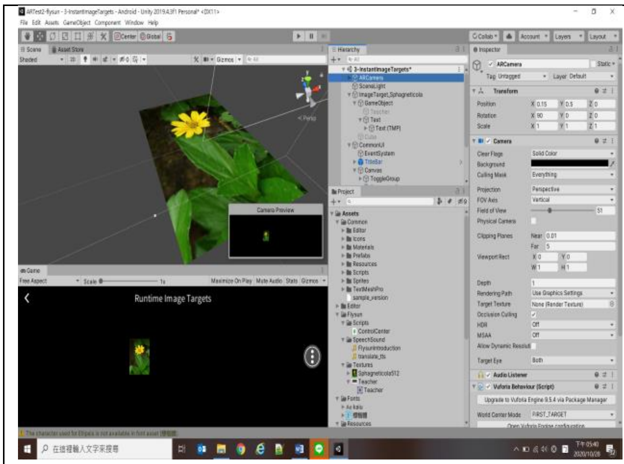
VR/AR 培訓營-VR 射擊遊戲控制畫面

AR 培訓營-攝影機影像辨識

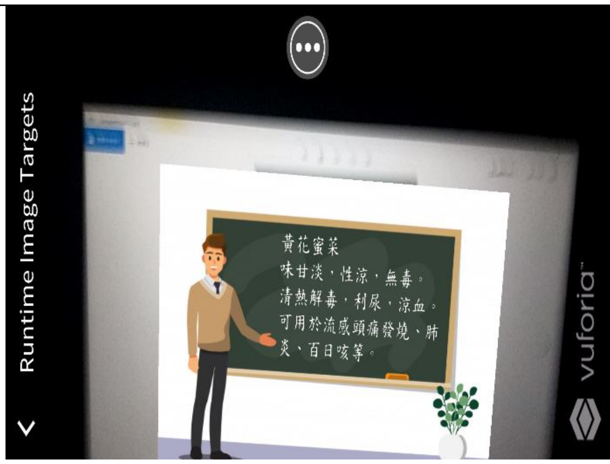
AR 培訓營-AR 系統實作

AR 培訓營-自製 AR 系統之社區教學

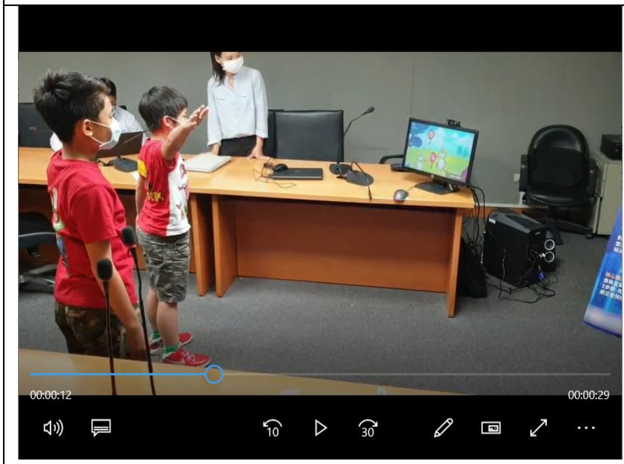
AR 培訓營-自製 AR 系統之社區教學



AR 培訓營-自製 AR 系統之開發畫面



AR 培訓營-自製 AR 系統之執行畫面



防災教育遊戲開發-遊戲 AR 互動測試

防災教育遊戲開發-遊戲開始畫面

防災教育遊戲開發-題庫設置

防災教育遊戲開發-加分時間設計

5-3 研究分析

從過去九個月的實務研究過程當中可以發現，雖然本系學生來源分布於資電類(高中多為資訊科)、設計群(高中多為廣設科、多媒體科)、商管類(高中多為資處科)，但由於 VR/AR

屬於科技導向,因此這三類群的學生皆可在 VR/AR 領域中找到一個專業應用的方向,因此,對於學生的學習上頗有幫助。

本計畫參與的學生均為多媒體與遊戲發展系的學生，共計 17 位，而全班同儕(含未參加培訓計畫)的學生共計 38 位，並透過「多媒體與遊戲設計實務」、「基礎場景設計」、「基礎角色設計」等三門課來探討其學習成效。

從表 2 可知，全班同儕此「多媒體與遊戲設計實務」、「基礎場景設計」、「基礎角色設計」三門課的成績平均分別為 75、73 與 74，而參與本計畫的學生群，此三門課的成績平均值分別為 91、82 與 83，比全班同儕的成績分別提升了 16、9 與 9 分，以百分比的方式來看，相當於是提升了 21.33%、12.33%、以及 12.16%，可見透過本計畫的培訓過程，有效地提升了學生的學習成效。

表 2、全班學生學習成效

編號	學習成效 (成績分數)			與全班同儕之平均成績差值			計畫參與
	多媒體與遊戲設計實務	基礎場景設計	基礎角色設計	多媒體與遊戲設計實務	基礎場景設計	基礎角色設計	
1	41	25	25	-34	-48	-49	
2	96	91	88	21	18	14	v
3	86	77	81	11	4	7	v
4	92	78	71	17	5	-3	
5	65	66	60	-10	-7	-14	v
6	83	84	90	8	11	16	
7	77	87	72	2	14	-2	
8	94	80	84	19	7	10	v
9	95	91	85	20	18	11	v
10	88	78	81	13	5	7	
11	97	80	73	22	7	-1	v
12	94	82	91	19	9	17	v
13	94	85	90	19	12	16	v
14	76	69	60	1	-4	-14	v
15	97	91	88	22	18	14	v
16	92	87	78	17	14	4	v

17	97	88	91	22	15	17	v
18	97	88	88	22	15	14	v
19	89	82	90	14	9	16	v
20	96	85	91	21	12	17	v
21	77	76	88	2	3	14	v
22	60	80	67	-15	7	-7	
23	85	77	82	10	4	8	
24	43	68	70	-32	-5	-4	
25	25	30	23	-50	-43	-51	
26	78	73	85	3	0	11	
27	62	69	60	-13	-4	-14	
28	42	34	38	-33	-39	-36	
29	73	88	82	-2	15	8	
30	87	68	66	12	-5	-8	
31	45	60	66	-30	-13	-8	
32	60	72	60	-15	-1	-14	
33	76	76	91	1	3	17	
34	41	60	80	-34	-13	6	
35	50	74	85	-25	1	11	
36	30	60	38	-45	-13	-36	
37	62	42	69	-13	-31	-5	
38	97	82	85	22	9	11	v
平均	75	73	74	0	0	0	

表 3、計畫參與者與全班同儕成績比較表

群類	多媒體與遊戲設計實務	基礎場景設計	基礎角色設計
全班同儕平均	75	73	74
計畫參與者平均	91	82	83
成績改善程度	+16	+9	+9
改善百分比	21.33%	12.33%	12.16%

六、結論

隨著資訊技術的迅速發展，本計畫之目的在於針對本校多媒體與遊戲發展系的學生進行實務培訓研究，針對目前就讀本系大二學生(計畫執行期間為大學部一年級)的 VR/AR 培訓機制之成效進行研究。經過八個場次 VR/AR 培訓、三個場次的 AR 培訓、一個 VR 遊戲開發、兩個 AR 的實作開發，有效提升了學生在 VR、AR、3D 遊戲方面的遊戲美術、遊戲程式等相關實務經驗，強化多媒體遊戲實作的基礎，未來也將有助於進一步推動產學合作、專題實務開發的研發能量。

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附錄、成果發表

- ✓ Juin-Ling Tseng, (2020) "Raising the Learning Effects for Learners with Low Entrance Scores using Project-Based Learning in Virtual Reality Practice", IAENG International Journal of Computer Science, Vol. 47, No. 3, pp.516-521, 2020. (EI)

Raising the Learning Effects for Learners with Low Entrance Scores using Project-Based Learning in Virtual Reality Practice

Juin-Ling Tseng

Abstract—**With the declining birthrate, the general number of students has been continually declining; this has subsequently resulted in a decrease in the average results of the Taiwan university entrance examination. It is, therefore, apparent that students' learning ability has reduced greatly. Using a virtual-reality (VR) software-development course as an example, this study explored the methods of guiding student learning and promoting learning interest. This study introduced a project-based approach to replace the paradigm-based method of teaching, with the aim of transforming the focus of teaching from the teacher to the learner. Such an approach was found to facilitate learning progress and help students correspond to the teaching pace, thereby improving their learning performance.**

Index Terms—**Project-Based Learning, reduction of the number of students, student quality, virtual reality practice**

I. Introduction

DUE to the declining birthrate, the quality of new students has declined over the past five years. Taking the author's affiliated department as an example, the scores of the college entrance examination have decreased annually. As shown in Table 1, the entrance examination score was 360 in 2014; however, by 2018, it reduced to 230 (a reduction of 36.11%). It can thus be observed that there is a decrease in the average quality of enrolled students.

TABLE I
The Scores of Entrance Examination in The Past Five Years

The Entrance Year	The Entrance Score	The Reduction (%)
2014	360	-
2015	286	20.56%
2016	226	37.22%
2017	241	33.06%
2018	230	36.11%

The present author has taught a VR-based practical course for the past five years. The course was initially delivered using a paradigm-based approach, wherein the teacher guided the students through each step of the learning process, to ensure that they could master the operation of each example given through a process of "learning by doing." With the exception of very few students who struggled to follow instructions, most students were found to adapt well to such a learning method. However, over the past two years, student learning has begun showing a noticeable change, including slower learning progress, inability to keep pace with the teacher, and struggling to understand the knowledge and skills taught; an increasing number of students have even made the decision to leave the course.

In order to minimize the aforementioned occurrences and improve students' learning performance, a project-based learning approach was introduced to shift the focus from a teacher-centered to a student-centered design, so that the teaching content better matches the quality of the learners, as shown in Fig. 1.

Fig. 1 Course Teaching – Virtual Reality

II. Literature Review

In recent years, engineering technology [1] and 3D information technology [2–4] have developed rapidly; moreover, in order to enhance engineering knowledge and 3D information technology learning, a number of different learning methods have been proposed for different technical fields [5], including Experimental Learning method proposed by Ramirez-Juidias et al. [1] and Micro-Flip Teaching method proposed by Morano-Fernandez for Aerospace Engineering Mathematics [6].

Traditional pedagogy generally adopts teacher-centered pedagogical models, where the teaching content and progress are defined by the teacher. In such models, the teacher is responsible for the delivery of the knowledge that should be taught, while the students are required to apply effort to

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absorb the knowledge taught. Such models pose no problems to students with a strong learning ability; however, students with a lower learning ability find it difficult to maintain a similar in-class pace.

Project-based learning [7–9] is a learner-centered approach that focuses on guiding students to obtain the knowledge and skills through the creation of meaningful projects. For students from technology colleges, the main focus is on training their practical and operational abilities. The project-based learning approach guides students to "learn by doing" and promotes confidence, teamwork, and self-learning ability, as well as active thinking.

According to the definition given by the National Academy Foundation [10], "projects" used in project-based learning should effectively guide students to consider the problems that they may encounter in the research field, so they are able to cultivate their decision-making ability. In addition, the output of the project should reflect the knowledge and skills acquired by students. A well-designed project [11–12] should include tasks that are related to problems and issues outside the classroom, help the students understand the need for learning a given piece of knowledge and skill, promote the students' ability to make decisions and generate ideas through participation in the project, and clearly reflect the knowledge and skills acquired by the students.

In accordance with the pedagogical design proposed by Larmer and Mergendoller (2012) [13], the following eight elements should be included in a student project: significant content, a need to know, a driving question, student voice and choice, in-depth inquiry, critique and revision, public audience, and 21st century competencies, as shown in Fig.2.

1) "Significant content" in this context implies that when designing a project, the teacher should focus on important knowledge and concepts derived from students' previous knowledge and skills. In addition, the content should also reflect the basic information related to the topic that the teacher intended to deliver.
2) "Need to know" is concerned with the idea that the design of the project should ensure that the students clearly understand the reason for learning the relevant material.
3) "Driving question" is designed to trigger student learning and is the most important feature of the project-based learning design. A good driving question helps the students to comprehend the fundamental concepts of the project and permits a sense of purpose and challenge.
4) "Student voice and choice" is observed to be one of the biggest differences between project-based learning and traditional learning. An appropriate inclusion of student voice and choice facilitates their innovative performance.
5) "In-depth inquiry" means that the design of the project should guide students to conduct in-depth inquiries based on their lack of understanding, which helps them to better understand potential problems and solutions, as well as discover new insights.
6) "Critique and revision" requires the teacher to guide the students to understand the materials and information obtained at the in-depth inquiry stage and provide critique and revision feedback on their project designs, to optimize performance results.
7) In addition to the "self-initiated revision" of the projects, the students should also be encouraged to present their project to a real audience (public audience), to obtain varied feedback on their projects, thereby improving the overall quality [14].
8) 21st century competencies: "21st century competencies" include teamwork, communication, collaboration, critical thinking, and the application of technological tools. These skills can be honed during the completion of the project to meet requirements of future employment [15–16].

Fig. 2 Eight elements of the pedagogical design proposed by Larmer and Mergendoller

III. Methodology

This study used a VR software-design course aimed at sophomores from the author's university. In order to apply the project-based learning principles to the course, the students were divided into several groups. Each group was required to complete a VR game using the Unity3D software system. The topics covered by the project included virtual scene construction, virtual character control and interaction methods, and collision detection between virtual objects. The detailed description for each section is as follows.

1) Virtual scene construction focused on the creation of 3D virtual scenes and objects, as well as importing the created 3D virtual scenes and objects into Unity3D to build the required 3D VR game scenes.
2) Virtual character control is an essential part of VR games. Control methods are associated with interactive devices (such as keyboards, mice, and VR headset); therefore, the students were taught how to use Character Controller components in Unity3D to write interactive device programs for each device.
3) Collisions between 3D virtual characters and objects are common events in VR games. The detection methods for collisions include Box Colliders, Sphere Colliders, Mesh Colliders, and Character Controllers. In order to detect the collisions between virtual objects and scenes, the course included a section to introduce and help students understand the differences between the different Colliders.

Since the course adopted a project-based learning approach, it was characterized with methods such as learner-centered, group learning, theme-based questions, and continuous assessments, as shown in Fig. 3. Specifically, the learning process of the course was centered on the learners; while the teacher only played the role of a guide and an assistant. By asking corresponding questions, the teacher encouraged the students to seek different methods to solve their own problems, further understand the relevant knowledge, and complete the development of the project. In addition, the students were divided into groups to work on the project, so as to train their teamwork, communication, collaboration, and critical thinking abilities, as well as their application skills of various technological tools. The teacher also utilized theme-related questions to drive the knowledge construction process, such as learning to use a mouse to control the virtual objects and generating 3D objects at random location points within the 3D space. Moreover, a continuous assessment process was implemented by the present research team on a weekly basis to track the progress of the projects and any inquiries made by the students, as well as to provide responses to questions. Assistance was provided to the students accordingly, so that each group was able to complete the project on time.

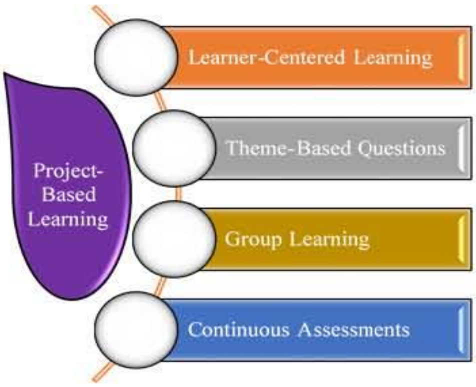

Fig 3 Four characteristics of Project-Based Learning

IV. IMPLEMENTATION

The course lasted for 18 weeks and was divided into two phases (each lasting 9 weeks). An evaluation of the learning performance was conducted in the 9th (pretest) and 18th week (posttest). Two groups of students (Group A and B) participated in the study. Group A was defined as the experimental group, and Group B was defined as the control group.

A total of 76 students (42 = experimental group, 34 = control group) participated in the study by completing both the 18-week course and evaluations. The same teaching content was used for both groups. In phase 1, both groups were taught basic knowledge related to VR (prior knowledge). In phase 2, the project-based method was adopted by the experimental group, while the control group used the paradigm-based approach, as shown in Fig. 4.

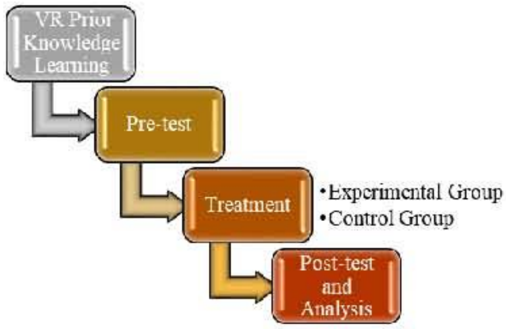

Fig. 4 Experimental Procedure

After being taught the basic knowledge related to VR (prior knowledge) for the first 8 weeks, in week 9, the students were required to complete a performance evaluation related to the knowledge imparted in phase 1 (pretest). The results of the pretest were used to analyze the homogeneity of the two groups.

The average results of the experimental and control groups were found to be 85.5952 and 83.2353 percent, respectively; the standard deviations were 9.7031 and 10.5803, respectively. The p-value of the ANOVA was 0.3146 (> 0.05), indicating that no significant differences were identified between the two groups. Moreover, the F-statistic was 1.0251 < F(0.05) = 1.7519. Therefore, the two groups were considered homogeneous, as shown in Table 2 and 3.

TABLE II
PRE-TEST SUMMARY

Group	Students	Average	Standard Deviation
Experimental	42	85.5952	9.7031
Control	34	83.2353	10.5803

TABLE III
PRE-TEST ANOVA ANALYSIS

	Sum of Squares	Degrees of Freedom	Mean Square	F-Test	p-value
Between Groups	104.6449	1	104.6449	1.0251	0.3146
Within Groups	7554.2370	74	102.0843		

After week 10, different methods were used in the experimental and control groups for a duration of 8 weeks. In order to guide the project-based learning process, a series of questions were designed to inspire learning. The students were expected to master the knowledge and skills by identifying their own solutions to their questions. The following are ten such examples of the questions asked by the students.

1) How do you place a 3D object in the system?
2) What is a Tag? How do you use a Tag?
3) What is a NullReferenceException? How can I handle a NullReferenceException?
4) How is OnTriggerEnter() used?
5) How do you make 3D objects collide with one another?
6) How do you make 3D objects move in the system?
7) How do you change the speed at which the 3D objects

move through the system?
8) How do you generate 3D objects at random location points in a 3D space?
9) How do you generate 3D objects at fixed intervals?
10) How do you remove objects from the scene?

After 8 weeks of teaching, a posttest was implemented in week 18. The distribution of the scores of both the experimental and control group also had some variations. It can be observed from Tables 4 and 5 that the distribution of scores in the experimental and control group displayed significant differences, with a P-value of 0.0021 < 0.05. Specifically, the average result of the experimental group was 41.7381 percent, 36.58% higher than that of the control group (30.5588). The distribution of the scores in the posttest (Table 6 and Fig. 5) revealed that the performance of the experimental group was significantly higher than that of the control group.

TABLE IV
POST-TEST SUMMARY

Group	Students	Average	Standard Deviation
Experimental	42	41.7381	15.8300
Control	34	30.5588	14.3362

TABLE V
POST-TEST ANOVA ANALYSIS

	Sum of Squares	Degrees of Freedom	Mean Square	F-Test	p-value
Between Groups	2348.2350	1	2348.2350	10.1879	0.0021
Within Groups	17056.5	74	230.4933		

TABLE VI
DISTRIBUTION OF THE NUMBER OF STUDENTS IN THE POST-TEST SCORE

Group	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
EG	0	1	9	16	7	5	1	2	0	1
CG	1	12	4	10	4	3	0	0	0	0

EG: Experimental Group; CG: Control Group

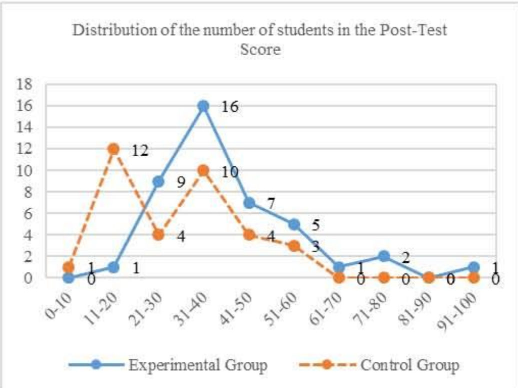

Fig. 5 Distribution of the number of students in the Post-Test Score

To compare the differences between the two groups in the same criteria, this study divided the number of students in each score interval by the number of the group and calculates the percentage value of the score interval in the group to which it belongs, as shown in Tables 7 and Fig. 6. According to this percentage distribution chart, the Project-Based Learning effectively reduced the percentage of students with 0-20 points, and even some students can reach the highest score range of 91-100. In addition, in order to make it easier to observe changes in student achievement, the study divided the two groups into three score intervals: low-score partition (0-30), medium-score partition (31-60), and high-score partition (61-100), and counted as shown in Table 8. Among them, the learning method proposed by this study effectively reduced the percentage value of low-score partition by 26.2%, and increased by 16.7% and 9.5% respectively in the medium-score and high-score partitions.

TABLE VII
PERCENTAGE DISTRIBUTION OF THE NUMBER OF STUDENTS IN THE POST-TEST SCORE (%)

Group	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
EG	0	2.38	21.43	38.10	16.67	11.90	2.38	4.76	0	2.38
CG	2.94	35.29	11.76	29.41	11.76	8.82	0	0	0	0

EG: Experimental Group; CG: Control Group

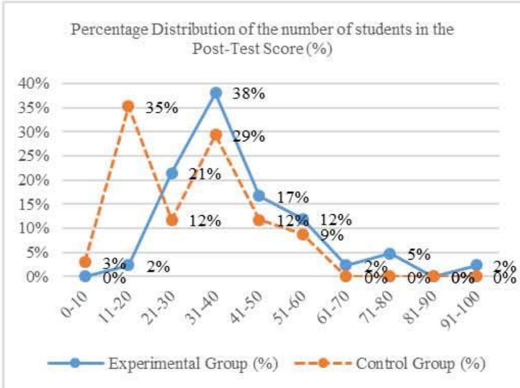

Fig. 6 Percentage Distribution of the number of students in the Post-Test Score

TABLE VIII
PERCENTAGE DIFFERENCE OF LOW-SCORE, MEDIUM-SCORE AND HIGH-SCORE PARTITIONS IN THE POST-TEST SCORE (%)

Group	Low-Score Partition (0-30)	Medium-Score Partition (31-60)	High-Score Partition (61-100)
EG	23.8%	66.7%	9.5%
CG	50.0%	50.0%	0.0%
Difference	-26.2% ↓	+16.7% ↑	+9.5% ↑

EG: Experimental Group; CG: Control Group

In addition, most of the students who enrolled for the "Virtual Reality Practice" course had registered for the "Game Design" course in the previous semester. This course was a pre-assigned course for the virtual reality practice. To completely determine the effectiveness of learning virtual reality using the project-based learning method, the students who passed the Game Design course were evaluated.

Among the students who participated in the virtual reality practice, 64 students passed the Game Design course in the previous semester; 32 were in the experimental group and 30 were in the control group. Tables 9 and 10 show the one-way analysis of variance (ANOVA) of the pre-test results. The pre-test average and standard deviation of students in the experimental group were 86.4063 and 8.6355, respectively; whereas for the control group, the pre-test average and standard deviation were 83 and 11.1107, respectively. Table 10 shows that the F-test value is 1.8295 < F(0.05) = 1.8482 and the p-value is 0.1813 (>0.05). From the results, it can be observed that there is no significant difference between these two groups.

TABLE IX
PRE-TEST SUMMARY

Group	Students	Average	Standard Deviation
EG	32	86.4063	8.6355
CG	30	83	11.1107

EG: Experimental Group; CG: Control Group

TABLE X
PRE-TEST ANOVA ANALYSIS

	Sum of Squares	Degrees of Freedom	Mean Square	F-Test	p-value
Between Groups	179.6522	1	179.6522	1.8295	0.1813
Within Groups	5891.719	60	98.1953		

After conducting the experiment on the project-based learning method, a post-test analysis was performed in this study and the results are shown in Tables 11 and 12. The post-test average and standard deviation of the experimental group were 44.4063 and 16.7426, respectively; whereas for the control group, the average and standard deviation were 29.5 and 13.9821, respectively. In case of the one-way ANOVA, the F-test value was 14.3760 > F(0.05) = 1.8482 and the p-value was 0.00035 (<0.05). Therefore, the two groups demonstrated significant differences. Additionally, the score of the experimental group was 44.4063, which is 50.53% higher than the score of 29.5 of the control group, and 13.95% higher than the improvement rate of 36.58% for all the students, as shown in Table 13. In conclusion, the implementation of the project-based learning method in the Virtual Reality Practice course effectively improved the learning for the students who passed the Game Design course in the previous semester.

TABLE XI
POST-TEST SUMMARY

Group	Students	Average	Standard Deviation
EG	32	44.4063	16.7426
CG	30	29.5	13.9821

EG: Experimental Group; CG: Control Group

TABLE XII
POST-TEST ANOVA ANALYSIS

	Sum of Squares	Degrees of Freedom	Mean Square	F-Test	p-value
Between Groups	3440.459	1	3440.459	14.3760	0.00035
Within Groups	14359.22	60	239.3203		

TABLE XIII
POST-TEST SUMMARY
(THE STUDENTS WHO PASSED THE COMPUTER GAME DESIGN)

	The Students who Passed the Computer Game Design	All
EG	44.4063	41.7381
CG	29.5	30.5588
Raised rate	50.53%	36.58%

EG: Experimental Group; CG: Control Group

V. CONCLUSIONS

With the increasingly critical situation of the declining birthrate, the results for the Taiwan university entrance examination have decreased annually, and the students' learning has shown noticeable changes, including a slower progress and trouble in keeping pace with the teaching speed during class. In order to effectively improve the learning performance of the new students who displayed a lower performance than those of the past, this study introduced a project-based learning approach in an operational-based course (VR-based software development). The results indicate that, since the project-based learning method focused on the learners, the teacher had more time to encourage student thinking and assist students to resolve problems independently. As a result, despite the low scores in the entrance examination, the students' learning performance was effectively improved.

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He currently is a member of the Institute of Electrical and Electronics Engineers (IEEE), and a senior member of the International Engineering and Technology Institute (IETI). He had the honor to get the awards of Excellent Researcher at Minghsin University of Science and Technology from 2015 to 2018.

計畫成果自評表

明新科技大學 109 年度 研究計畫執行成果自評表

計畫類別：		■任務導向計畫 □整合型計畫 □個人計畫
所屬院(部)：		□工學院 □管理學院 □服務學院 ■人文與設計學院
執行系別：		多媒體與遊戲發展系(中心)
計畫主持人：		曾俊霖 職稱：副教授
計畫名稱：		3D VR/AR 人才培訓之研究
計畫編號：		MUST-109 任務-20
計畫執行時間：		109 年 1 月 1 日 至 109 年 9 月 30 日
計畫執行成效	教學方面	1. 對於改進教學成果方面之具體成效： 讓同學提早接觸 VR/AR 相關知識，累積培訓學生 VR/AR 開發的能量。 2. 對於提昇學生論文/專題研究能力之具體成效： 提供學生進行 VR/AR 系統的安裝、開發與實作。 3. 其他方面之具體成效：受培訓的同學們參與了與社區的 AR 實務應用
	學術研究方面	1. 該計畫是否有衍生出其他計畫案 ■是 □否 計畫名稱：防災教育遊戲開發 2. 該計畫是否有產生論文並發表 ■已發表 □預定投稿/審查中 □否 發表期刊(研討會)名稱：IAENG International Journal of Computer Science 發表期刊(研討會)日期：109 年 9 月 1 日 3. 該計畫是否有要衍生產學合作案、專利、技術移轉 □是 ■否 請說明衍生項目：
成果自評		計畫預期目標：完成 VR/AR 人才培訓 計畫執行結果：完成 VR/AR 與 3D 遊戲開發相關知識的傳授，並透過實作增加學生實務操作的開發能力。 預期目標達成率：100 %
		其它具體成效： ✓ 受培訓的同學們參與了與社區的 AR 實務開發，提昇實作開發經驗。 ✓ 衍生「防災教育遊戲開發」產學合作計畫。

運用於教學成果記錄表

明新科技大學 109 年度校內專題研究計畫 運用於教學成果記錄表

<table>
<tr><td>計畫類型</td><td colspan="3">□個人型 □整合型 ■任務導向型</td><td>計畫編號</td><td colspan="2">MUST-109 任務-20</td></tr>
<tr><td>計畫名稱</td><td colspan="6">3D VR/AR 人才培訓之研究</td></tr>
<tr><td rowspan="2">計畫主持人資料</td><td>姓名</td><td colspan="2">曾俊霖</td><td>職稱</td><td colspan="2">副教授</td></tr>
<tr><td>學院</td><td colspan="2">人文與設計學院</td><td>系所</td><td colspan="2">多媒體與遊戲發展系</td></tr>
<tr><td rowspan="3">聘用助理</td><td>系科班級</td><td>學號</td><td>姓名</td><td colspan="2">聘僱起訖時間</td><td>工作內容</td></tr>
<tr><td>多遊二甲</td><td>B08280013</td><td>陳昱佑</td><td colspan="2">109/6/1-109/9/30</td><td>協助計畫執行</td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="4">融入課程</td><td>開課班級</td><td colspan="2">課程名稱</td><td>修課人數</td><td colspan="2">課程內容概述</td></tr>
<tr><td>多遊一甲</td><td colspan="2">多媒體與遊戲設計實務</td><td>48</td><td colspan="2">多媒體概念與基本遊戲開發</td></tr>
<tr><td>多遊一甲</td><td colspan="2">基礎角色設計</td><td>45</td><td colspan="2">遊戲角色設計基礎概念</td></tr>
<tr><td>多遊一甲</td><td colspan="2">基礎場景設計</td><td>49</td><td colspan="2">遊戲場景設計基礎概念</td></tr>
<tr><td rowspan="3">指導專題或碩士論文</td><td>指導班級</td><td colspan="2">專題(論文)名稱</td><td>分組人數</td><td colspan="2">專題(論文)內容概述</td></tr>
<tr><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="4">指導學生參與活動或競賽</td><td colspan="3">活動或競賽名稱</td><td>參與人數</td><td colspan="2">活動或競賽成果概述</td></tr>
<tr><td colspan="3">VR/AR 培訓營</td><td>17</td><td colspan="2">VR/AR 開發基礎概念</td></tr>
<tr><td colspan="3">AR 培訓營</td><td>17</td><td colspan="2">AR 實作基礎概念</td></tr>
<tr><td colspan="3"></td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="3">製作教材與教具</td><td colspan="3">教材與教具名稱</td><td colspan="3">教材與教具概述</td></tr>
<tr><td colspan="3">VR 射擊遊戲</td><td colspan="3">VR 射擊遊戲開發程式與相關素材</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td>其他促進教學之成果說明</td><td colspan="6">✓ 受培訓的同學們參與了與社區的 AR 實務開發，提昇實作開發經驗。
✓ 衍生「防災教育遊戲開發」產學合作計畫。</td></tr>
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