香港教育大學
The Education University of Hong Kong

ICLT 2023

Proceedings of International Conference on Learning and Teaching for Future Readiness 2023

Learning and Teaching in the Eve of Metaverse

17 - 19 May 2023

CENTRE FOR LEARNING TEACHING AND TECHNOLOGY 教學科技中心
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Proceedings of
International Conference on Learning and Teaching for Future Readiness 2023

17-19 May 2023
Hong Kong

Publication of The Education University of Hong Kong
10 Lo Ping Road, Tai Po, New Territories, Hong Kong

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基於線上教學設計構建中學英語教師 TPACK 的行動研究

An Action Research on Building TPACK for Secondary School English Teachers Based on Online Instructional Design

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【摘要】 新冠肺炎疫情對廣大教師在線教學提出了新要求，整合技術的學科教學知識（TPACK）對教師顯得尤為重要。鑒於此，本文采用合作型行動研究方法，以一名新手型初中英語教師為研究對象，探究以優化線上教學設計為切入點的中學英語教師 TPACK 構建路徑。經三輪研究的深入觀察和數據分析，本文提出，教師可通過課前把握學情，準備線上教學資源；課中利用平臺軟件改良常規教學方法，增強調控和師生互動，監督學生學習動態；課後加強評價，督促學生增加學習投入來構建自身的 TPACK。此外，通過合作行動建立的專業共同體有利於推動教師 TPACK 持續發展。
【關鍵字】行動研究；線上教學設計；整合技術的學科教學知識；TPACK

Abstract: *This paper adopts a collaborative action research approach to investigate a novice middle school English teacher's TPACK construction pathway that takes the online instructional design as the entry point. After three rounds of in-depth observation and data analysis, this paper proposes that teachers can build their own TPACK by grasping the learning situation and preparing online teaching resources before class; using the platform software to improve conventional teaching methods to enhance regulation and teacher-student interaction and monitor students' learning dynamics during class; and strengthening evaluation and urging students to increase their learning engagement after class. In addition, the professional community established through collaborative action facilitates the continuous development of TPACK for teachers.*
Keywords: Action Research, Online Instructional Design, Technological Pedagogical Content Knowledge, TPACK

1. 問題的提出

在信息化時代背景下，互聯網技術在教育教學中的應用愈益頻繁，加之新冠肺炎疫情的不斷反復，以互聯網和多媒體為載體的線上教學逐漸成為教學常態之一，學校紛紛開展並深入實踐線上教學或線上線下教學相結合的模式。教育部（2018）發布《教育信息化 2.0 行動計劃》，要求「大力提升教師信息素養，推動教師主動適應信息化、人工智能等新技術變革，積極有效開展教育教學」。中共中央、國務院（2019）印發的《中國教育現代化 2035》明確指出，「建設高素質專業化創新型教師隊伍」是面向教育現代化的十大戰略任務之一，要求「夯實教師專業發展體系，推動教師終身學習和專業自主發展」。可見，運用信息化技術縱深推進教育教學改革，更新教師專業教學知識，提升教師技術整合素養是必然趨勢。因此，整合技術的學科教學知識（Technological Pedagogical Content Knowledge，簡稱 TPCK；後期為便於拼讀，改為 TPACK）在信息化時代教師專業發展中顯得尤為重要。

Koehler&Mishra（2005）在「教學學科知識」（PCK）的基礎上提出「整合技術的學科教學知識（TPACK）」概念，旨在促進教學內容、教學方法和技術的深度融合。如圖 1 所示，在這兩位學者看來，TPACK 框架包含三個知識要素，即學科內容知識（CK）、教學法知識

（PK）和技術知識（TK）；四個復合要素，即學科教學知識（PCK）、整合技術的學科內容知識（TCK）、整合技術的教學法知識 （TPK）和整合技術的學科教學知識（TPACK）（何克抗，2012）。

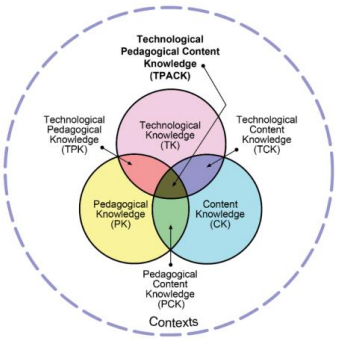

圖 1 TPACK 框架圖

（資料來源： http://tpack.org，經 tpack.org 許可轉載。）

TPACK 概念自提出以來便受到了國內外研究者的廣泛關註，從以往研究來看，基於實證測量探究 TPACK 本質及結構是研究重心，關於 TPACK 測量方法和測量工具的開發逐漸從單一走向多元（張哲，張海和王以寧，2015）。此外，部分文獻關註教師 TPACK 現狀與發展策略，以此實現理論與實踐的結合，如王春麗（2012）從學習內容、學習過程、學習支持三方面設計了一個教學幹預系統，並在當地境脈中施行推廣，結果表明該幹預系統能夠有效地促進職前教師信息化教學設計能力的發展。鄭誌高和張立國（2019）開展分組實驗證實「設計學習」在促進師範生 TPACK 發展上有更好效果。隨著研究的不斷深入，TPACK 理論促進教師信息化專業發展逐漸從宏觀轉向微觀，在具體領域探討如何推動教師 TPACK 的發展成為了研究熱點之一。如將 TPACK 中的技術知識（TK）具體化為操作慕課教學平臺技術、使用交互式電子白板等、將教學知識（PK）具體化為問題驅動式教學和深度學習等，以及將學科知識（CK）具體限定在英語、物理等學科領域（張哲，張海和王以寧，2015）。例如，魏誌慧等（2021）通過案例研究總結生成了慕課教學情境下高校教師 TPACK 發展機製。筆者在研究前期通過課堂觀察以及教師訪談，發現教師線上教學設計水平有待提高，然而，少有研究在這一具體領域深入探討教師如何發展 TPACK。其中，新手教師作為教師隊伍的新興力量，是未來引領教育信息化發展的核心力量，具有較強的 TPACK 發展韌性和潛力，具備示範性作用。

有鑒於此，本文試圖通過與一名新手型中學英語教師進行合作型行動研究，以線上教學設計為著力點探索構建其 TPACK 的有效路徑，以期為教師信息化專業發展提供具體參考。

2. 研究設計

2.1. 研究對象

研究對象為一名新手型初中英語教師（R 教師），教齡三年，碩士研究生，暫無獲獎情況。本研究所基於的課程類型為北京某中學初三年級英語學科的復習課，課程主題是閱讀理解與完型填空。

2.2. 研究方法

本文采用行動研究方法，並沿用美國學者勒溫的「螺旋式」研究模式。該模式包括計劃、行動、觀察、反思四個環節（Lewin, 1946），本文按其順序展開具體研究過程。首先，筆者在研究前期通過對 R 教師的課堂觀察以及訪談溝通，總結出其線上教學問題如下：課前學生準備不充分，課堂消極沈默時間較長，師生互動深度受限；課中教師無法實時掌握學生學習狀態；課中教師較難調控好教學時長和節奏，教學進度慢；課後學生知識鞏固不紮實，遺忘

較多。基於此，筆者經過與 R 教師的充分溝通以優化線上教學設計為切入點製定行動計劃。接著，R 教師實施行動方案，筆者進行非參與式課堂觀察，最後在課後交流，進行反思並調整。本文開展三輪行動研究（圖 2），以期解決 R 教師教學困惑並探索 TPACK 構建路徑。

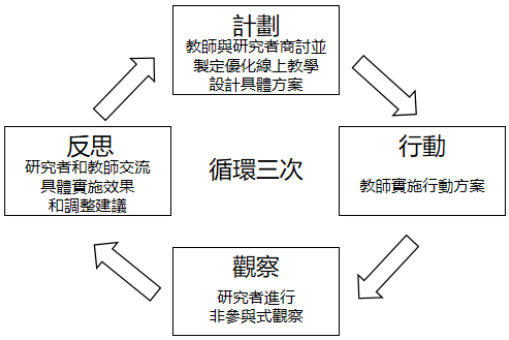

圖 2 行動研究流程圖

3. 研究過程

三輪行動研究分別於 2022 年 5 月 17 日-21 日、2022 年 5 月 31 日-6 月 2 日和 6 月 9 日-10 日三個階段開展實施。本部分將重點呈現優化線上教學設計的具體行動方案，通過觀察與訪談商討得出的行動過程中存在的問題，以及下一輪的調整方案。

3.1. 第一輪行動研究

3.1.1. 教學計劃與行動

第一輪行動研究涉及的課堂學習內容是閱讀理解。教學設計優化主要體現在課前利用平臺技術增加學生自主學習，課中提高互動效率並實時監測學情，課後鞏固學習內容。

具體方案為以下三點：首先，課前設計導學案，通過問卷星/釘釘群發布導學任務，引導學生進行自主學習，幫助學生回顧做過的內容，節省時間，提高課堂時間利用效率。導學案內容可以包括閱讀整體框架，部分單詞短語中文釋義等基礎內容。其次，課中先讓學生展示講解導學案內容，教師引導學生互評互答，增加學生主動學習。教師再基於此展開更高階的重難點講解。教師可利用思維導圖等軟件展示文本架構，還可以通過釘釘答題卡、互動消息區功能實時了解全體學生答題情況和線上學習情況。最後，課後或課程快結束的時候設置一些相關題目以釘釘答題卡/問卷星形式發布，監測學生上課情況，幫助學生鞏固該課知識點。

3.1.2. 教學觀察與反思

通過對該堂課的錄像分析，教師雖然結合了相關技術優化教學設計，但整體效果不佳，還是存在較多的低效時間，教學進度拖沓。

經過教師溝通以及查看教師課後反思後，筆者總結為以下四點問題：（1）教學設計不貼合學習者特征。教師反映學生學習積極性不高，課後學習投入不足，如部分學生作業和課後小測不能按時完成。課上情況可見大部分學生課前未能做好準備，課堂消極沈默較多，且在此類時間中其余未被點名的學生註意力容易轉移。（2）教師在把握教學節奏和分配教學時間上合理性欠佳。時間分配不平衡，未能有效完成教學目標和具體任務。（3）教師教學策略未能體現教學重難點，通篇講解方式的教學效果差強人意。（4）教師技術運用水平有待提高。教師未能提供學生實操機會，部分技術操作不當影響了教學流暢度。

3.2. 第二輪行動研究

3.2.1. 教學計劃與行動

第二輪行動研究的學習內容是閱讀理解和完型填空。本輪行動研究整體上延續第一輪行動研究方案，並在此基礎上，我們對教學活動設計進行了部分修改。

首先，教師將導學案改為課堂學習清單，其中包括思維導圖和知識點，要求學生課上邊

聽講邊完成。教師留出部分時間給學生自行完成思維導圖並檢測完成情況，以此代替教師講解段落大意，提高課堂時間利用效率。其次，教師將課中檢測題放在 PPT 內，提高教學流暢度並節省操作時間。再次，教師針對學生答題情況對閱讀文本的重要知識點進行講解，做到有所側重。最後，對未完成課中檢測的學生進行反饋，提醒學生完成測試內容；在課上留出一定時間發放課後小測並要求學生完成。

3.2.2・教學觀察與反思

通過第二輪行動研究，筆者發現低效時間相對減少，完成小測的學生人數也相對增加，教師在運用技術優化教學效果更佳。R 教師反饋道，

「學生課堂積極性有明顯提高，他們更清楚該堂課的學習目標和重難點。我在課前也能夠更加明確該課的重難點和時間分配，以及因為要提前設計問題，我自己也更容易聯想起知識體系幫助學生系統化復習知識。」

但是，我們發現在教學過程中依舊存在以下問題：（1）線上師生互動次數依然較少，互動方式僅限教師點名學生回答問題，學生的積極性不高。接下來的行動方案還需在互動方式上進行優化，繼續摸索面向全班學生，提高學生在各教學環節的參與度的具體方法。（2）學生線上學習資源較少，只有電子版習題和課本。後續還需根據學生需求提供相應的教學資源。（3）在線平臺使用親和度較低。釘釘平臺屏幕展示區域有限，學生不能同時看到閱讀內容和文章選項，需要來回切換，不方便回答問題。教師在課後反思中指出可以在製作幻燈片時克服該局限。

3.3. 第三輪行動研究

3.3.1・教學計劃與行動

本輪行動研究整體上延續了前面兩輪的優化教學設計行動方案，並增加了一些教學活動的細節管理。主要體現在教師課前通過微信群與學生互動，在直播教學中充分利用語言表達的感染力、模擬課堂互動、開展復習講解。

首先，R 老師在課前通過釘釘群與學生互動，詢問學生對作業難度的感受，對學習者進行各種「花式鼓勁」，並提前發送課程提綱預告該課的重難點。由於無法與學習者面對面交流，缺少肢體語言等的支撐，R 教師改變在線語言表達，通過較高的語言表達能力吸引和帶動學習者，此外，R 老師還借鑒采用「扣 1」等模擬課堂互動的方式來替代線下課堂教學中的學生回應，加強與學生的互動。課後 R 教師也會積極詢問學生課上感受和教學建議。其次，R 教師在製作課件時盡量將題目和閱讀文本整理在同一張幻燈片上，便於學生觀看。最後，R 教師將課上講到的知識點串連起來，以思維導圖的形式呈現並將文件發送給學生，提高學生課後復習鞏固的效率。

3.3.2・教學觀察與反思

通過對本堂課的錄像分析，筆者發現師生互動明顯增多，教師在前兩次的優化基礎上運用技術更加得心應手，教學順暢度提高，整體教學節奏松弛有度。R 教師反饋說，

「上線上課更需要教師調動學生情緒，把自己展現得像『主播』一樣，學生在評論區回復扣 1 的會增多一些，也更方便我了解學生是否掌握這些知識點了。課後還會有學生完成課程提綱之後主動發給我檢查的，雖然線上課看不到學生的臉，但這些方式可以方便我了解到學生學習之後的效果如何。」

第三輪行動研究克服了前兩輪教學中學生參與度不夠，師生互動有限的問題。可見，管理細節的增加是必要的，也是有效的。R 教師也在逐漸建立起自身的 TPACK 信念，不斷熟悉使用信息技術提高線上教學效果。

4. 研究結果與討論

前三輪的行動研究可見 R 教師對教學技術的適應與創新，在此過程中，R 教師在研究者的支持下逐漸構建並發展 TPACK。本部分將提出基於線上教學設計的 TPACK 構建路徑（見表 1），並探討合作型行動研究對教師 TPACK 發展的支持作用。

4.1. 具體路徑：以優化線上教學設計為抓手

4.1.1・課前設計：把握學情，準備線上教學資源

由於線上教學具有特殊性，教師需充分了解和分析學習者特征和需求，以及學習者學習環境，基於以上信息再準備相應的教學資源，選擇適宜的線上教學平臺。鑒於本文選取的研究對象 R 教師教授初三年級學生，並且該學生群體自主學習能力較弱，學習投入不充分，筆者與 R 教師則根據教學目標、課型和學情，將用於自主學習的導學案調整為學生課上同步完成的學習清單。清單內容較為系統、整體地展現知識點，引導學生構建知識體系，觸類旁通，拓展閱讀資料。同時提前在釘釘群內發布相應公告，進行課堂預熱。對於其他年級、學科教師，還可以利用高質量、多樣化的慕課、微課資源，補充豐富視頻圖像資料，配設硬性設備（如手寫板、電容筆等）提高線上教學設計質量。在這個階段，教師確定通過何種技術手段展現具體教學內容和采用教學方式，把已有的 PCK 遷移至線上教學情境中，逐步搭建 TPACK 知識框架。

4.1.2・課中設計：改良方法，監督學生學習動態

針對線上教學過程中學生自覺主動性低、師生互動低效等問題，教師應充分利用技術強化互動，增加調控，以活躍學生思維。線上課中設計優化主要從以下三方面入手。首先，利用軟件平臺功能強化互動。教師可通過引導學生語音連麥、評論區打字回復，以及發布選擇題答題卡的方式增加師生互動，同時監測到班級學生上課情況。其次，豐富在線語言表達。教師應發揮語言的魅力，堅持情感原則，彌補線上教學組織形式帶來的不足。最後，優化常規教學方法，例如采用思維導圖呈現閱讀文本框架和知識體系；教師先精講重難點，再給學生部分時間自行完成學習清單。在本次行動研究中，R 教師嘗試線上教學工具新功能，不斷地探索線上教學新方法，構建自己的 TPACK，提升課堂互動效率，改善教學效果。

4.1.3. 課後設計：加強評價，鞏固課上所學內容

為解決學生課上掌握知識不紮實，課後遺忘較多的問題，教師可利用平臺軟件等為學生提供電子版相關資源和評價檢測，幫助並督促學生增加學習投入，鞏固知識。如在本次研究中，R 教師課程快結束或課後會發布問卷星，檢測學生重難點掌握情況，對未完成的同學委婉提醒，及時監管學生。其他學段和學科老師還可結合課中和課後評價，即課中學生個人表現和課後作業完成情況，或結合教師評價、學生自評和同伴互評的方式，註重評價過程性和多主體，提高評價質量和信度。在此階段，教師優化線上教學設計的同時也在提升 TPK，使用技術幫助教師得到及時反饋，便於對下節課的教學內容做出調整。

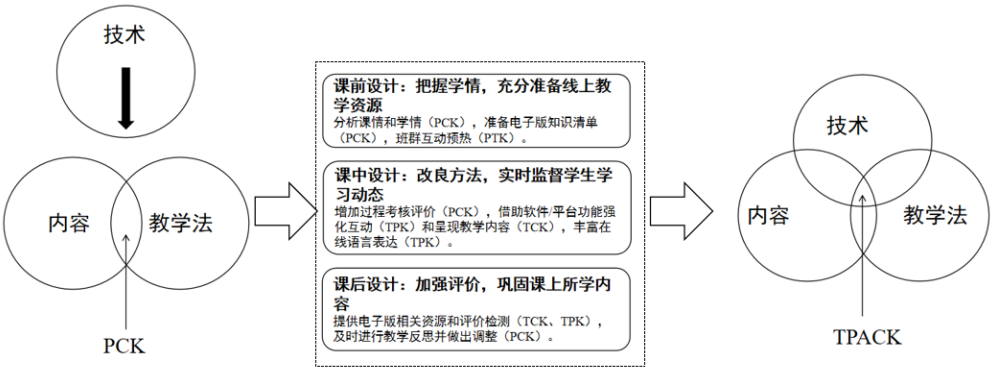

圖 3 基於線上教學設計的 TPACK 構建路徑

4.2. 合作行動：專業共同體推動教師 TPACK 持續發展

陳向明（2019）指出，行動研究的目的在於求善，改善教師教學實踐現狀，解決教師真實困惑。跨界合作型行動研究更能拓展教師的學習情境和視野，多渠道建構知識，促進教師專業發展。在本次行動研究中，研究共同體在推動教師 TPACK 發展的貢獻體現在兩個維度。第一是 TPACK 腳手架支持。研究者協助教師理解 TPACK 概念、細化 TPACK 提升路徑、習得 TPACK 發展循環並實現 TPACK 常態化發展。第二是外部監督協助。研究者督促和幫助教師觀察、審視並反思教學實踐，以補充、調整並完善教師自身教學經驗。

教師在三輪行動研究過程中，其 TPACK 總體呈現螺旋式上升發展態勢，TPACK 狀態從概念化發展到動態化，再進入常態化。研究前期，通過和研究者的協商互動，教師初步了解 TPACK 理論知識。研究中期，教師在真實教學情境中運用技術，嘗試整合學科內容、教學方法和技術，逐漸激活 TPACK，並適應以 TPACK 理論作為指導。研究後期，經過多輪 TPACK 概念轉化和經驗重組，教師逐漸可以內化、探索並提升 TPACK。教師循環往復地經歷困頓、挫折和失誤，也收獲了新知、經驗和感悟。可見，教師和研究者平等合作，構建專業共同體，針對線上教學中遇到的真實問題深入研究，有利於教師 TPACK 持續發展。

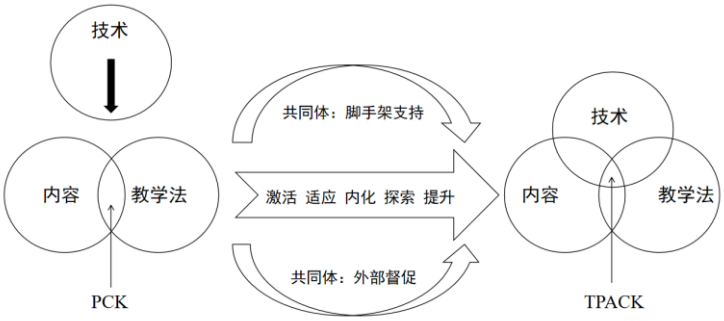

圖 4 跨界合作型行動研究教師 TPACK 發展路徑

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Developing Experiential Virtual Teaching and Learning Materials: Video-Based Learning in Leadership Education

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Abstract: *Videos are important virtual teaching and learning tools, particularly under the pandemic when synchronous and asynchronous online learning as well as blended learning commonly take place. With the support of the University Grants Committee, we have developed videos in a subject entitled "Tomorrow's Leaders" which are taken by 2,000+ students each year. Experienced teachers developed 15 animated videos on theories and 9 scenario-based videos based on real-life issues. We have developed the videos with reference to the positive youth development constructs, including self-awareness and self-management, psychosocial competence, resilience, moral competence, life meaning, law-abiding leadership, cultural competence, communication skills, and ability to resolve conflicts. To date, we have conducted three evaluation studies on students' perceptions of the videos. First, we conducted subjective outcome evaluation on 900+ students in Semester 2 of 2021/22 academic year using two client satisfaction scales, one for the animated videos and the other one for the scenario-based videos. Results showed that these measures possessed good psychometric properties, including support for their factorial validity using confirmatory factor analysis. Besides, students generally showed positive perceptions of the videos developed. In the second study, we are collecting student feedback in Semester 1 of 2022/23 academic year again. Similarly, findings showed that students had positive views of the videos. Finally, we conducted a qualitative study via focus group interviews with 48 students. Results showed that the students perceived the animated videos and the scenario-based videos to be helpful for their study.*

Keywords: Confirmatory Factor Analysis**,** Focus Group Evaluation, Leadership Education, Subjective Outcome Evaluation, Video-based Teaching and Learning,

1. Introduction

1.1 Videos in Virtual Teaching and Learning

In the early days of the COVD-19 pandemic, school lockdown was common. Hence, online teaching and learning played an important role. Online teaching offers synchronous (e.g. the delivery of lectures through video conferencing platforms) and asynchronous (e.g. pre-recorded lecture videos) learning environments through the use of electronic device and internet (Zhu & Liu, 2020). While some studies argued that online learning was well-accepted by students because it was flexible and time-saving (Hasan & Khan, 2020), other studies suggested students in developing countries faced various technical and financial issues (Adnan & Anwar, 2020).

Studies on online teaching under the pandemic suggested that educational videos are important tools. Educational videos could be combined with different teaching and learning activities to meet diverse learning objectives. For example, in dental schools, Van Doren et al. (2021) asserted the importance of providing different kinds of educational videos (e.g., dental procedure videos) when students learned remotely during the pandemic. Another study revealed that video-based online labs, including pre-recorded online videos, PowerPoint slides, readings, and face-to-face practical tutorials, could be effectively used in teaching a college-level data science course (Doudesis & Manataki, 2022).

Besides, scholars have discussed how videos could be combined with flipped learning approach in higher education courses to enhance students' motivation and learning outcomes. Flipped classroom setting requires students to self-study specific course content before attending lectures, so that other teaching and learning activities could be implemented during lesson time. There are studies showing that the combination of flipped learning and animated videos promoted student academic performance, learning satisfaction and enthusiasm, and self-learning and problem-solving abilities (Wikandri et al., 2021; Wu et al., 2022).

1.2. Videos in Leadership Education

Leadership qualities are important for university students because they are leaders of tomorrow. To uphold this belief, students at The Hong Kong Polytechnic University are required to fulfill the Leadership and Intrapersonal Development (LIPD) graduation requirement by taking a 3-credit course. We have developed and implemented a subject entitled "Tomorrow's Leaders" which is offered to more than 2,000 students annually. Many evaluation studies suggested that the subject was able to promote leadership qualities and well-being among students. The subject also received the Silver Award (Ethical Leadership) and Gold Award (Nurturing Student Well-Being and Purpose) in the QS Reimagine Education Awards in 2017 and 2021, respectively, and the UGC Teaching Award (Team Award) in 2018.

In contrast to traditional lecture format inherent in other courses, "Tomorrow's Leaders" emphasizes experiential learning, reflective learning, and collaborative learning. Besides, high quality teacher-student and student-student interactions are strongly promoted via in-class activities, such as group sharing, group discussion, group projects, games, debates, and simulation exercises. Obviously, with reference to the constraints as well as the flexibilities of virtual teaching and learning, there was a strong need to develop relevant pedagogies, teaching and learning activities and materials when the leadership subject was conducted online. This need was particularly strong under the pandemic when teachers were forced to deliver online or hybrid teaching.

2. Animated Videos and Scenario-Based Videos in "Tomorrow's Leaders"

With the financial support of the University Grants Committee, we have implemented a research project to develop experiential learning materials on leadership development under virtual teaching and learning. Besides, we planned to evaluate students' perceptions of the quality and implementation of the developed materials and the impacts of the developed pedagogies and related programs on both students and teachers.

First, the "Tomorrow's Leaders" subject was developed based on the positive youth development (PYD) approach. The PYD approach is based on the premise that smooth childhood-to-adulthood progression requires the development of cognitive, emotional and social competences. It also constitutes developmental assets in the prevention of adolescent problem behaviors. 15 PYD constructs were identified in a review of PYD programs in the United States (Catalano et al., 2004). In addition, Benson et al. (1999) proposed the developmental assets concept, which refers to the positive effects of external and internal assets to young people's healthy development. Using a self-report scale on developmental assets, Scales et al. (2000)'s study found that adolescents' developmental assets significantly contributed to the prediction of their thriving behaviors. Based on these PYD studies, the "Tomorrow's Leaders" subject was developed to foster university students' intra- and interpersonal competences and holistic development (Shek, 2012). With reference to the changing requirement for success in the 21st century, seven intra- and four interpersonal competences were chosen as the topics in this subject (e.g., critical thinking, moral competence, resilience, social-emotional competence, conflict resolution, and self-leadership) (Dede, 2010; Yu et al., 2022). The 15 animated videos and the 9 scenario-based videos were developed in this project to facilitate the teaching of this subject.

Second, in terms of the design features of the videos, this project has produced both the animated videos and the scenario-based videos. The animated videos cover the main theories taught in this subject, and the scenario-based videos illustrate cases for students to analyze and discuss based on the theories or their life experiences. The production of these

videos utilized both 2-dimensional animation technology and video-filming skills. The animation technology was mainly used in the animated videos to explain theories. For video-filming, we employed university students to demonstrate and film the stories in the scenario-based videos (i.e., role-play videos). Because of the variety of effects that animation technology could provide, some cases in the scenario-based videos were also illustrated with animation. The details of the 15 animated videos are as follows:

1. Self-understanding and self-management: This video covers concepts and theories of self-leadership, including self-understanding and self-management.
2. Cognitive competence: This video introduces the concepts and examples related to misinformation, disinformation and propaganda.
3. Social-emotional competence: This video explains the definitions of social-emotional competence and the four-dimensional framework of social-emotional competence.
4. Social-emotional competence: This video covers the concept of egocentrism and related behaviors.
5. Resilience: This video introduces definitions of resilience and the concepts of internal and external resilient qualities (i.e., protective factors that guard ones against adversities).
6. Resilience: This video covers Richardson's Resiliency Model and the process of resilience development.
7. Moral development: This video presents the moral dilemma (i.e., Heinz's dilemma) with reference to the Kohlberg's Theory of Moral Development.
8. Moral development: This video is about the phenomenon of hiring ghostwriters among university students. The definitions of ghostwriting and contract cheating and related examples are presented.
9. Spirituality: This video introduces the Spiritual Leadership Model and its components. It also explains why spiritual development is the fundamental need of both leaders and followers.
10. Law abidance leadership: This video introduces the basic concepts and theories related to law-abiding leadership and socially responsible leadership.
11. Law abidance leadership: The video highlights the importance of law-abiding leadership from the individual and organizational perspectives.
12. Cultural competence: The video introduces definitions and models of cultural competence and the importance of cultural competence to leaders nowadays.
13. Effective communication: We introduce the six steps in the REPAIR strategies for resolving interpersonal conflicts in this video.
14. Team building: In this video, we highlight the five conflict-handling modes in the Thomas-Kilmann Model of Conflict Management.
15. Team building: This video introduces the four steps to reach a win-win situation in the Conflict Resolution Model as well as the four typical win-win solutions.

The details of the 9 scenario-based videos are as follows:

1. Self-leadership: The video presents a conflict between two good friends over their lifestyle choices. Students are invited to analyze the case and share their experience.
2. Cognitive competence: The video presents two distinct views towards the MMR vaccine, with contrasting arguments expressed by scientists.
3. Social-emotional competence: The role-play video uses storytelling technique to present a conflict between a mother and a daughter over the choice of television program at home.
4. Resilience: The video uses storytelling technique to describe the challenges faced by Eric Ma, who suffers from a rare disease that affects his normal functioning and appearance.
5. Spirituality: In the video, three students with different experiences of betrayal and forgiveness are interviewed. The three students discuss their experiences in forgiving others.

6. Cultural competence: This video is based on an interview with an ethnic minority family in Hong Kong who share the difficulties faced by their family in Hong Kong.
7. Effective communication: The role-play video presents a case about resolving conflict with peers with reference to face-enhancing strategy and face-detracting strategy.
8. Team building: This role-play video presents problems in a dysfunctional team where students work separately and have not agreed on a work distribution plan.
9. Team building: This role-play video presents problems in a dysfunctional team. A group of students is working on a group project but there is a free rider in the team.

Third, since the launch of the "Tomorrow's Leaders" subject in 2012/13 academic year, both qualitative and quantitative evaluation strategies have been employed to evaluate the teaching and learning effectiveness of the subject. Subjective outcome evaluation through the client satisfaction approach was one of quantitative evaluation strategies we have applied to measure students' perceived effectiveness of and their satisfaction with the "Tomorrow's Leaders" subject (Yu et al., 2022). Client satisfaction approach has been used in the field of education and social work to measure service recipients' self-perceived need satisfaction after an intervention (Brestan et al., 1999). The study by Shek (2010) also found that subjective outcome evaluation could reflect objective outcomes. Additionally, focus group studies have been conducted to evaluate the "Tomorrow's Leaders" subject, with the emphasis on examining teachers' and students' subjective experience in teaching or learning in this subject (Shek et al., 2014; Shek et al., 2017). Tümen-Akyıldız and Ahmed (2021) stressed that focus group discussion could create positive interactions among participants and generate high quality data. It is effective for examining a particular issue in which a group of participants have experienced together. Therefore, to evaluate the educational effectiveness of the 24 videos, subjective outcome evaluation and focus group studies were implemented in this project.

3. Evaluation Methods

We adopted a mixed-method evaluation design to evaluate the quality of the developed materials based on views of students and teachers. Primarily, we used subjective outcome evaluation (via the client satisfaction approach) to assess students' perceived quality of the designed teaching materials and effectiveness of the new unit on their learning. For the 15 animated videos, we developed a 12-item measure assessing views of the students, such as whether the videos were interesting, well-designed, and easy to understand, and whether the teachers used them effectively. For the 9 scenario-based videos, we developed a 14-item measure to understand perceptions of the students, including whether the videos could increase student engagement, student-student interaction, and teacher-student interaction. Besides, we conducted focus group interviews with the students to understand their learning experience. Finally, we conducted qualitative evaluation based on teachers' focus group interviews to evaluate their experiences in using the designed teaching and learning materials and the impact of the developed pedagogies on both students and teachers. In this paper, we presented findings based on three evaluation studies in this project.

4. Results of Evaluation Studies

In the first study, we collected subjective outcome evaluation in Semester 2 of 2021/22 academic year when the subject was conducted via online synchronous teaching (900+ students). Results showed that the measures possessed good psychometric properties, including factorial validity via confirmatory factor analyses (CFA). The two scales showed very good reliabilities with the Cronbach's alphas from .96 to .99 for the 15 animated videos and .97 to .99 for the 9 scenario-based videos. A series of model fit indices of the CFAs showed that the one-factor model fitted the data very well for both the animated videos and the scenario-based videos. Especially, the one-factor model of the 12-item measure showed a good model fit with CFIs $\geq$ .94, NNFIs $\geq$ .92, SRMRs $\leq$ .04, and RMSEAs $\leq$ .08 for the 15 animated videos. We also found very good AVEs $\geq$ .65 and CRs $\geq$ .96 for the 12-item measure. The one-factor model of the 14-item

measure also showed a good model fit with CFIs ≥ .93, NNFIs ≥ .92, SRMRs ≤ .04, and RMSEAs ≤ .07 for the 9 scenario-based videos. Good AVEs ≥ .66 and CRs ≥ .96 were also found for the 14-item measure. In short, all model fit indices supported the establishment of the one-factor model of the subjective outcome evaluation scale for both the animated videos and the scenario-based videos. Regarding students' perceptions of the animated videos, more than 90% of the students perceived that the videos were able to promote their interest in the study and benefitted their development. For the scenario-based videos, students similarly showed positive views of the videos, with more than 95% of the students regarded the videos as well-designed, easy to understand, stimulating, helpful to their understanding of the subject matter, and promoting their reflection of the subject matter (Li et al., 2023).

In the second study, we collected data on the views of students in Semester 1 of 2022/23 academic year when there was face-to-face teaching (900+ students). We conducted this study to replicate the findings of Study 1 and to examine the perceived effectiveness of the 24 videos in face-to-face teaching. We applied the same methodology used in the first study. Similar to Study 1, students' perceptions of the animated videos were positive. For example, for the animated video on the topic "cognitive competence", 98% and 98% of the students gave positive responses to "the teacher used the animated video effectively" and "the animated video has enabled me to understand related concepts", respectively. Besides, 96% and 98% of the students agreed that the video benefitted their development and they were satisfied with the video, respectively. For the scenario-based video on "cognitive competence", results were also positive, with 98% of the students agreed that the video deepened their understanding of the topic. Most of the students (96% and 97%) also agreed that the video aroused their interest and promoted their reflection of the subject matter.

Finally, we conducted a focus group study to understand students' views of the videos. 48 students who took the subject in Semester 2 of 2021/22 academic year were interviewed in eight focus groups. They were asked to express their perceptions of the arrangement of these videos in pre-lesson learning, general learning experiences, and perceived benefits and difficulties when watching the animated videos and the scenario-based videos respectively. Preliminary analysis of the focus group interview findings demonstrated that students had positive attitudes towards the video arrangement, their learning experiences and the benefits gained from watching the videos. They expressed that the videos were able to help them gain basic understanding of lecture content before lessons, which improved their attention and interactions with instructors during lessons. The videos could also serve as revision materials for students. Besides, students expressed that the visual design and animation effect in the videos were interesting, which could increase their attention to the videos and help them better understand the video content. Many students appreciated animated videos' clear structure and detailed explanations of theories, and scenario-based videos' innovative format.

5. Discussion and Conclusion

With reference to the lack of educational videos for college-level leadership education, there are several contributions of this study. First, we successfully developed 15 animated videos and 9 scenario-based videos which can be used in different teaching contexts, particularly online teaching and learning context. Second, we developed a 12-item measure to assess animated videos and a 14-item measure to assess scenario-based videos. Results showed that these two measures have high reliability and factorial validity. In view of the paucity of evaluation tools for educational videos in the Chinese context, this is an interesting addition to the literature. Third, we used different evaluation strategies to understand the views of different stakeholders on these videos. Using the client satisfaction approach, we have examined the views of students on these videos in two semesters. The findings showed that students had positive perceptions of the animated videos and the scenario-based videos. In the focus group study, we also found that the students had positive views of the videos. As evaluation studies are not commonly done on educational videos in the Chinese context, this is a useful contribution to the literature. The present findings suggested that educational videos could be profitably used in online and face-to-face contexts, particularly under the pandemic.

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疫情對香港小學生學習和成長的影響

The Impact of the Epidemic on the Study and Growth of Primary School Students in Hong Kong

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【摘要】 新冠肺炎疫症(COVID-19)於 2020 年 3 月被世界衛生組織宣佈為大流行，對各地教育造成影響。在新常態教學下香港學童有時需要網上學習、有時要分階段復課、有時只能上半日課，為了解小學教師和家長就疫情對小學生學習和成長的影響，香港初等教育研究學會於 2021 年底開展「新常態對香港小學生學習和成長的影響」研究。本文將運用此研究結果，結合學術文獻及本地機構的相關發現，深入討論和分析香港教師與家長看疫情對小學生的影響，包括：新常態教學下小學生的學習困難和小學生在疫情的學習轉變、新常態教學對小學生成長的影響及小學生在疫情的整體學習表現等四方面。

【關鍵字】 疫情對香港小學生的影響；疫情下學生的學習困難；新常態對學生成長的影響

Abstract: *The coronavirus disease (COVID-19) was declared a pandemic by the World Health Organization in March 2020, affecting education everywhere. Under the new normal teaching, Hong Kong students sometimes need to study online, sometimes they have to resume classes in stages, and sometimes they can only attend half-day classes. At the end of 2021, a study on the impact of the new normal on the learning and growth of primary school students in Hong Kong be launched. This article uses the results of this research, combined with literatures and relevant findings from local institutions, to discuss and analyze in depth the views of the impact of the epidemic on primary school students by teachers and parents in Hong Kong, including: the learning difficulties of primary school students under the new normal teaching and the learning changes of primary school students during the epidemic, the impact of new normal teaching on the growth of primary school students, and the overall learning performance of primary school students during the epidemic, etc.*

Keywords: Students' Learning Difficulties Under the Epidemic, The Impact of Hong Kong Primary School Students in Pandemic, The Impact on the Growth of Students in New Normal

1. 肺炎疫症大流行影響各地教育

新冠肺炎疫症(COVID-19)自 2019 年 12 月被發現後，在全球各地蔓延並於 2020 年 3 月被世界衛生組織(WTO)宣佈為大流行 (pandemic)，對世界各地教育造成了有史以來的破壞。聯合國於 2020 年 8 月發表「政策簡報：COVID-19 疫期教育及展望」指出，截至 2020 年 4 月中旬，全世界 200 個國家 94%的學生都受到疫情的影響；各地應對學校停課的能力隨著發展水準而產生差異，如在人類發展水準偏低的國家，2020 年第二季度小學兒童失學率為 86%，而在人類發展水準很高的國家失學率只有 20%。根據經濟合作與發展組織（OECD）的教育特別調查，新冠肺炎疫情期間全球學校大範圍停課；各國 2020 年資料顯示小學平均停課 54 天，初中停課 63 天，高中停課 67 天(戴宜楠等編譯，2021.9.23)。據全球教育機構培生的 2020 年《全球學習者調查報告》，在適應「新常態」的過程中，全球 70%受訪者認為新冠疫情加劇

教育資源的不平等，尤其表現在年輕學生的教育中，88%受訪者希望學校在解決教育資源不平等方面付出更多努力。

2. 內地與香港對疫情影響教育的研究

因應疫情的影響，內地有學者進行對學生學習和成長影響的相關研究，其中較值得香港小學同工關注的有：「新冠肺炎疫情期間廣東省小學生視屏行為現狀及影響因素」研究顯示，廣東省小學生平均單節網課時長為(26.07±9.62) 分鐘。網課之外，分別約有 1/2(學習日：50.7%，週末：43.0%)和 1/4(學習日：27.0%，週末：21.3%)的學生每日使用電子設備學習的時長達到 1 和 2 小時。該研究發現兒童娛樂性視屏時間過長的風險隨其在電子設備學習上所花時間的增加而相應增加；再者，並發現父母文化程度較低的兒童娛樂型視屏時間過長的發生率更高及父母的娛樂型視屏時間≥2 小時是兒童娛樂型視屏時間過長的危險因素。而楊思帆和龐貞艾(2020)一文則稱：為滿足疫情期間的線上教學需求，教育部精選出了 22 個線上課程平台、15 個線上課程資源平台和技術平台。豐富的線上課程平台滿足了包括小學教學在內的多種需求。此外，有研究顯示疫情期間廣東省 6～17 歲中小學生情緒行為問題檢出率為 14.8%，其中小學低年級、小學高年級、初中生和高中生情緒行為問題總檢出率分別為 21.0%，14.4%，7.3%和 10.1%；並提示長時間居家限制對中小學生的心理行為有潛在影響，應予以高度重視(阿爾孜古麗·喀喀爾等，2021)。因應疫情造成小學生學習心理的諸多變化，鄭麗敏(2020) 提出「在防疫前提下，盡可能安排學生的小組活動，促進學生之間直接交流、共同完成某些簡單的需要協同完成的任務，強化學生學習的社會化互動」。此外，在「後疫情時期：家庭體育對小學生體育鍛煉態度的影響研究」指出，家庭成員參與體育鍛煉頻率越高，小學生對體育鍛煉態度得分均值越高，表明小學生鍛煉態度也越積極，並會促進其體育鍛煉行為的參與(陳志斌等，2022)。從上述研究可見疫情促進了線上教學的發展，但對內地部份學童的身心健康和學習有負面的影響，並提出了一些應對之法。

在香港，2020 年年初冠狀病毒病疫情反覆，自從教育局於 2020 年 1 月 27 日宣佈延長農曆年假以來，因應平衡學生學習與防疫抗疫的需要，教育局曾分別宣布全港學校停課、局部進行面授課堂及進行半日面授課堂等安排，期間香港學校上課日數大幅減少，影響了學生的學習。面對疫情及停課等難以預計的事情，不少學生感到壓力和困擾而情緒波動。教育局早於 2020 年 4 月便推出一系列心理教育短片，讓教師及家長掌握協助學生及子女處理負面情緒和精神壓力的技巧。與此同時，多個民間團體先後開展相關調查研究，向公眾反映情況並期影響政府措施。當中包括：香港小童群益會於 2020 年 5 月發表「兒童及家長在停課期間的狀況調查」，指出有 73.8%的家長在停課期間更多時間留在家中，但相處時間多可能引致更多親子間的問題，有 17.0%家長就表示親子關係較疫情前差，亦有 30.8%表示親子衝突比疫情前多。香港婦聯社會政策研究委員會則於 2021 年 2 月 8 日發表「疫情下學童學習情況如何受影響」問卷調查報告，發現 87.5%被訪者表示擔心子女在疫情過後，將會追趕不上學習進度。至於，浸信會愛羣社會服務處兒童、教大特殊學習需要與融合教育中心等聯合進行「分析疫情下初小學生的學習挑戰及心理調適情況」調查，於 2021 年 8 月 27 日發表稱普遍初小學生在家學習期間出現負面情緒，逾四成受訪學生對於在家上課感到煩躁不安及有孤獨感，且無法按時完成功課。而香港社區維繼協會及兒童權利關注會於 2021 年 10 月 17 日發表「貧窮兒童在疫情開學限制下面對的學習困難問卷調查報告」，發現持續的網上學習，對學童身體帶來不少影響，包括：難以長時間專注上課(82.3%)、長期對著電子屏幕學習，影響健康及視力(80.3%)、眼睛不舒服(76.8%)、加深近視和散光等眼部問題(69.8%)、出現寒背(50.4%)等。在生活/心理/精神方面，過半受訪學童表示學習不到擔心日後學習落後(76.6%)、天天在家更煩悶(69.8%)、沉迷打機(65.1%)、不願出街(57.4%)、心情差了(56.9%)、常無故發脾氣(56.1%)等。

3. 香港小學教師和家長對教學新常態影響的看法

為了解香港小學教師和家長對疫情下教學新常態對小學生學習和成長的影響，香港初等教育研究學會成立研究小組，於 2021 年 11 月利用網上問卷邀請小學教師和家長填答「新常態對香港小學生學習和成長的影響」調查問卷，分別有 262 位小學教師及 440 位小學家長的回應。為了三角對照量性的統計資料，研究小組於 2022 年 1 月 18 日邀請來自 8 間小學 25 位關心議題的教師、主任、副校長、校長家長以線上會議形式進行三節聚焦訪談。經量性數據和質性資料的分析與討論，研究小組於 2022 年 3 月 17 日在線上舉行記者會發表「新常態對香港小學生學習和成長的影響」研究報告，其中較受媒體關注的研究數據是：有八成受訪教師及一半家長認同網課擴大學生之間的學習能力差異及七成教師及六成家長指部分小學生追不上課程進度。本文將運用此研究結果，結合學術文獻及本地機構的相關發現，深入討論和分析香港教師與家長看疫情對小學生學習和成長的影響。

3.1. 新常態教學下小學生的學習困難

在小學生學習困難方面(下表 1)，分別有八成和七成小學教師認為新常態教學下「小學生學習差異擴大」和「部份小學生追不上課程進度」。其次，約六成教師認為「小學生自主學習能力不高」及「新常態教學的學習成效差了」。值得留意的是，有過半小學家長認同子女在上述四項的學習困難同時，也認為「教學時間大減，不少教材無學過」，比小學教師的 41.2%認同率為高。其中「追不上課程進度」憂慮一項，與香港婦聯 87.5%被訪者「擔心子女在疫情過後將會追趕不上學習進度」的雷同。與此同時，小學教師/主任在聚焦訪談更進一步指出：「低班學習情況差些，感有些散漫」、「有高年級生習慣家長在旁支援上線學習，依賴性強」。正如上文「分析疫情下初小學生的學習挑戰及心理調適情況」調查發現，逾四成初小學生無法按時完成功課，小學教師和家長需對學習能力稍遜初小生有更大的耐心和更多的支援。再者，因為上網課已有一段長時間，衍生了有些高小生依賴家長在旁支援上線學習。上一述在疫情後小學生新的學習困難，至今仍困擾着不少小學生、小學教師和家長。

表 1 教師與家長看新常態教學下小學生的學習困難

教師看法(次序)	教師率	家長率	家長看法(次序)
1. 小學生學習差異擴大	80.9%	50.2%	4
2. 部份小學生追不上課程進度	70.6%	60.2%	1
3. 小學生自主學習能力不高	64.5%	59.8%	2
4. 新常態教學的學習成效差了	59.9%	51.8%	3
5. 教學時間大減，不少教材無學過	41.2%	50.2%	4

3.2. 教師與家長看小學生在疫情的學習轉變

在新常態教學下小學生學習的轉變方面(下表 2)，超過四分之三回應的小學教師與家長均認為經常在線上學習後的小學生：「在線上學習期間難以專注」和「長時間望視屏影響小學生眼睛健康」。這兩點與上文「貧窮兒童在疫情開學限制下面對的學習困難問卷調查報告」，回應者對學童身體帶來影響的最高兩項：難以長時間專注上課、長期對著電子屏幕學習影響健康及視力是一致的。與此同時，有過半的小學教師與家長均認為在新常態教學下「需家長協助子女上網學習」，這呼應了上文質性訪談曾提及「有高年級生習慣家長在旁支援上線學習」，看來提昇中低能力學生的自主學習能力，是各校高低年級教師與家長的必修課。

表 2 教師與家長看新常態教學下小學生學習的轉變

教師看法(次序)	教師率	家長率	家長看法(次序)
1. 在線上學習期間難以專注	82.1%	78.2%	2
2. 長時間望視屏影響小學生眼睛健康	77.5%	80.5%	1
3. 需家長協助子女上網學習	69.1%	56.8%	3
4. 提高了電子學習的能力	67.9%	24.8%	6
5. 家中沒有電腦或相關上網器材欠佳，影響了進行線上學習	50.8%	10.0%	9

3.3. 新常態教學對小學生成長的影響

在新常態教學對小學生成長的影響方面(下表 3)，最多小學教師與家長認為對學生成長的三個影響分別是：「康樂活動減少，運動量不足」、「花在打網上遊戲和看電視等消閒活動時間較長」及「實體上課不多，與同學社交互動機會減少」。首兩項有關學童運動和用視頻過長也是內地研究的關注點。至於，半數以上香港小學教師發現學童「與同學社交互動機會減少」、「不大適應學校常規」和「自理能力不强」，這與香港學校曾半天復課多月有關。因應疫情造成學生學習心理的變化，上文有內地學者提出「在防疫前提下，盡可能安排學生的小組活動，促進學生之間直接交流、共同完成某些簡單的需要協同完成的任務，強化學生學習的社會化互動」(鄭麗敏，2020) ，值得香港小學教師參考。

表 3 教師與家長看新常態教學對小學生成長的影響

教師看法(次序)	教師率	家長率	家長看法(次序)
1. 康樂活動減少，運動量不足	80.2%	77.0%	1
2. 花在打網上遊戲和看電視等消閒活動時間較長	78.2%	59.8%	3
3. 實體上課不多，與同學社交互動機會減少	75.2%	71.6%	2
4. 少回校上課，不大適應學校常規	68.7%	24.5%	7
5. 衞生意識提高，學懂帶口罩等防疫措施	64.9%	58.6%	4
6. 較多時間在家，自理能力不强	54.6%	35.7%	6

與此同時，在質性聚焦訪談，有小學教師/主任組提及新常態教學下：「學生兩極化，自律強學生的學習影響不大」、「動機低學生線上不敢作答，學生學習差異拉大」；也就是說，低能力學生脫節更大，而教師輔導弱生的需求亦更高。正如上文培生的 2020 年《全球學習者調查報告》，88%受訪者希望學校在解決教育資源不平等方面付出更多努力；香港小學和同工實需對此關注，花更多的資源和力氣去照顧疫情下表現更弱的同學。另一方面，有教師/主任同工分享指出：「學生線上學習能力如上網搜集資料、入線上系統及匯報技巧均有提昇」，可見新常態教學下不少學生的資訊科技能力提高，有能力在線上自如地學習，這算是疫情後對小學生成長的正面影響。

3.4. 教師與家長看小學生在疫情的整體學習表現

在整體學習表現方面(下表 4)，最多的小學教師(73.3%)與家長(61.6%)均認為新常態教學下「學生運動量少，體能差了」；其應對之法可參考內地陳志斌等(2022)研究發現：「家庭成員參與體育鍛煉頻率越高，小學生對體育鍛煉態度得分均值越高，表明小學生鍛煉態度也越積極」。在這個研究中，小學教師與家長回應反差最大的一項是：「學生的科技能力增强」(教師 70.6%；家長 36.8%)，這點值得雙方進一步理解和關注。在質性聚焦訪談中，有小學家長在聚焦訪談表明子女回校上實體課比在家上網課為佳：「較喜歡子女回校上實體課，有紀律；子女整天在家，磨擦多了」、「覺得上實體課學得多些，子女較聽話」，可見有小學家長

期待子女復課已久，而上實體課後子女整體學習表現較佳。正如上文香港小童群益會調查指出「有 17.0%家長就表示親子關係較疫情前差，亦有 30.8%表示親子衝突比疫情前多」，疫情中學生經常在家上網課，有家長全天候督促子女學習，惡化了部份家庭的親子關係。另一方面，有小學教師/主任組在質性聚焦訪談提及：「9 月復課，學生與同學相敍開心；改變學習模式，可提升學習興趣」，這與家長觀察子女表現是相近的。然而，有小學教師/主任組稱「回校復課後，同學間的衝突磨擦比以往多了些」，這與量性統計中有過半小學教師認為「學生與人互動、社交能力沒有進步」的發現是一致的。

表 4 教師與家長看新常態教學下小學生的整體學習表現

教師看法(次序)	教師率	家長率	家長看法(次序)
1. 學生運動量少，體能差了	73.3%	61.6%	1
2. 學生的科技能力增强	70.6%	36.8%	4
3. 聽課學習機會減少，學生整體學習表現差了	64.1%	55.5%	2
4. 學生與人互動、社交能力沒有進步	51.1%	36.8%	4

4. 小結與啟示

在 2019 冠狀病毒病第 5 波疫情襲港之際，特區政府於 2022 年 2 月 22 日公布要求學校提前放暑假，幸運地減少了在確診個案大幅飆升下對學生的影響。第 5 波疫情於今年 3 月初在港達到高峰，每天有 7 萬多宗新確診個案，而當時 3 至 11 歲的學童的疫苗接種比率偏低，若沒有實施這項嚴格果斷的防疫措施，說不定有大批香港小學和幼稚園學童染疫。及後，鑑於疫情緩和及政府放寬社交距離措施，教育局於 5 月 19 日公布修訂的學校防疫抗疫措施安排，放寬學校舉辦活動的規定，容許學生參與半日而無須除口罩的活動及可在周六參與非學術性的課外活動，以加強學生的身心發展。教育局於 2022 年 8 月 5 日發出的《全港學校 2022/23 學年面授課堂的安排》通告，既強烈呼籲學校充分利用政府提供的不同途徑安排學生接種疫苗，又明示各校全體教職員及學生在每天回校前必須完成一次快速抗原測試，以保障學生在疫情大流行未退的情況下回校上實體課的健康和安全。

截止 2022 年 8 月，冠狀病毒病疫情已影響了全港 80 萬名中小幼特學生，在新常態教學下學童不能正常地在校學習，有時需要網上學習、有時要分階段復課、有時只能上半日課，甚至在第五波疫情中提早放暑假。在香港初等教育研究學會這個「新常態對香港小學生學習和成長的影響」研究中，小學教師和家長共同參與調查研究，發現兩者理解疫情對小學生「學習困難」、「學習的轉變」、「成長的影響」和「整體學習表現」等四方面整體上有相近的看法。而這個研究發現: 教師和家長認為小學生學習困難是疫情下學習差異擴大、並憂心部份追不上課程進度，學習轉變則有在線上學習期間難以專注和長時間望視屏影響眼睛健康，小學生的成長影響為運動量不足、花在網上遊戲和看電視時間較長及與同學社交互動機會減少。上述疫情對香港小學生的影響與內地學者及本地相關機構的研究互為引證；寄望香港小學教師和家長活用上述研究發現，更好地支援小學生在疫情中得到更好的學習和成長。

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Improving Task Authenticity and Personalisation for Self-directed Speaking Practices Through Virtual Reality: The Development and Implementation of the VR Mobile Application, *I'm IN – HKUST*

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Abstract: *It has long been a challenge for teachers to provide personalised speaking training for students with limited class time and space in a physical classroom, and the pandemic has made the issue even more pronounced, under which in-person, teacher-student practices were implausible. As part of the post-pandemic new normal, the implementation of e-learning technology, particularly, Virtual Reality (VR), has become a viable solution with higher task authenticity and personalization for language and communication training. This paper begins by depicting the hurdles of teaching and acquiring communication skills for HKUST business students; the present project showcased the development and implementation of the VR mobile application, I'm IN – HKUST, in a business English course. The application encompasses 2 main functions, providing communication practices, corresponding to the needs and the majors of the business students, by VR trainers and introducing job-seeking related topics (in the form of mini-lessons). It also provides standardised feedback based on self-reported performance levels, integrated as a blended reflective learning task. Users' surveys, field observations and focus group interviews were conducted within HKUST, and the results indicated that the introduction of VR technology enhanced the teaching and learning of business communication successfully.*

Keywords: *Business Communication, Higher Education, Personalisation, Self-directed Learning, Virtual Reality*

1. Introduction

The catalysts of this project emerged from the teaching and learning of business communication. This project primarily targeted Business students studying in a business English course, *LABU2060 Effective Communication in Business*, the last required language course of the Business School's program. The course has adopted a simulation approach, with the first module focusing on job-seeking. *One* lesson has been particularly assigned for the purpose of job interview practices, yet it is certainly far from enough for what students actually need. Students could only continue to prepare for their job interview assessment outside class, but, in reality, it was difficult for students to find a partner to practice together – This is even more so during a pandemic (being one of the main catalysts of the study). Teachers, too, with their current teaching load found it daunting if they were to provide additional out-of-class mock practices for students. VR, an emerging technology, as opposed to a web-based solution, was selected due to its three-dimensional nature coupled with its authenticity, interactivity and wide applications in education and training, enhancing administrative efficiency as well (Fabrisa, Rathnera, Fonga, & Sevigny, 2019). A VR job interview trainer, in lieu of a class teacher, was designed to fill the current gap in teaching and learning of business communication in a job interview setting.

2. Literature Review

The theoretical underpinning of the project includes experiential learning. The VR job interview application was designed to create immersive learning experience, a reflective, whole-person learning process. When learners have the autonomy to learn through actively interacting with the application in their own time and pace with minimal stress (i.e., the absence of a teacher and formal/ informal assessments) and through reflecting on their experience, they are engaged in a meaningful learning process.

2.1. Experiential Learning

We create meanings through experience.

Experiential learning theory (ELT) which sees experience as the pivot to learning is supported by six propositions (as cited in Kolb & Kolb, 2005, p.194):

1. Learning is best conceived as a process, not in terms of outcomes. To improve learning in higher education, the primary focus should be on engaging students in a process that best enhances their learning - a process that includes feedback on the effectiveness of their learning efforts. As Dewey notes, "[E]ducation must be conceived as a continuing reconstruction of experience: . . . the process and goal of education are one and the same thing" (Dewey, 1897).
2. All learning is relearning. Learning is best facilitated by a process that draws out the students' beliefs and ideas about a topic so that they can be examined, tested, and integrated with new, more refined ideas.
3. Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world. Conflict, differences, and disagreement are what drive the learning process. In the process of learning one is called upon to move back and forth between opposing modes of reflection and action and feeling and thinking.
4. Learning is a holistic process of adaptation to the world. Not just the result of cognition, learning involves the integrated functioning of the total person - thinking, feeling, perceiving, and behaving.
5. Learning results from synergetic transactions between the person and the environment. In Piaget's terms, learning occurs through equilibration of the dialectic processes of assimilating new experiences into existing concepts and accommodating existing concepts to new experience.
6. Learning is the process of creating knowledge. ELT proposes a constructivist theory of learning whereby social knowledge is created and recreated in the personal knowledge of the learner. This stands in contrast to the "transmission" model on which much current educational practice is based, where preexisting fixed ideas are transmitted to the learner.

3. Implementation

The project was conceived for increasing students' out-of-class job interview opportunities and their self-awareness of their own communication skills when answering job interview questions. The project deliverables have been duly achieved within the 1.5-year project period. A VR job interview application (VR app, thereafter) with mini-lessons on job-seeking has been implemented in *LABU2060 Effective Communication in Business* in Spring and Fall 2022 in HKUST. The application staged in the mobile application market, with job interview questions pertain to specific jobs and industries. The project website containing the user menu and a data bank storing users' performance recordings has been established. The immersive learning experience was designed to revolve around elements, i.e., virtual reality, personalization, self-directed learning, and gamification.

The niche of our project is presented as follows: The job interview mobile application operates in both VR and 2D mode. Three practice time frames (5, 10, and 15 mins) and 3 challenge levels for our student users (the higher the challenge level the more behavioral, technical and unexpected questions are asked) have been incorporated. Fifteen sets of job

interview questions (up to 200+ questions for one job set) pertain to the most sought-after jobs by HKUST students are available on the application, as a result of the close collaboration with the HKUST Career Center. A 'replay' and 'skip' option in the practice session, i.e., the virtual interview room, is available (to further lower students' stress in practicing). Students can receive some standard verbal feedback by the VR trainer tailored to their self-declared performance levels after the practice. Training sessions, i.e., the mini-lesson resource, are provided – there are 13 mini-lessons (YouTube videos with subtitles) in both 3D and 2D form, featuring 3 HR directors/ managers from the industries and teachers of LABU2060 Effective communication in Business.

4. Methods

We invited students of various disciplines to participate in the evaluation of the project to assess the effectiveness of the VR features of the practice application. Students, enrolled in *LABU2060 Effective Communication in Business*, *LANG2030 Technical Communication I* and *LANG2010 English for Science I* (HKUST language courses), were invited to partake in a field observation from 15 June to 16 July 2022. The total number of valid responses was 17. The field observation consisted of three parts: **(1) VR App experience and short evaluations**, during which students were asked to wear VR goggles provided by the project team and undergo an interview practice in the VR mode, **(2) individual interviews**, and **(3) focus group interviews**. During the field tests, students were assigned a 15-minute interview practice at a specific difficulty level, but they could choose any industry and job they were familiar with. After the practice interview, students completed a short self-evaluation on the VR app, and they received instant verbal feedback from the VR trainer based on their self-evaluation. Students were asked, after the VR app experience, to provide their self-reported performance ratings during the short self-evaluation on the VR app in written form. Meanwhile, the observer in the same evaluation noted the students' performances. An individual interview was conducted after students watched the mini-lesson of their own choosing. The individual interview focused on students' experience with the VR app and their engagement during the interview practice. It aimed to investigate the utility and usability of the VR app. Students continued to join a focus group interview to discuss the potential usage of the VR app, such as job interview training, blended learning, etc. The groups were formed by 2 to 3 students in the same discipline, e.g., *LABU2060* students being in the same groups. The field observations, individual interviews and focus group questions were specifically designed together with an Educational Evaluation Officer, Center for Education Innovation, HKUST, for this project. Based on the objectives of the project, the research tools aimed to investigate 3 aspects, that is, the physical aspects, content, and the students' perspectives.

4. Results

The research findings in regard to the users' experience with the interview practice, in terms of their engagement levels, stress experience, perceptions of the interview questions, learning effectiveness and feedback are reported below.

4.1. Engagement

Students were asked to review their engagement levels during the interview practices in a 3-point Likert scale. The results showed (c.f., **Error! Reference source not found.**) that students could engage in the interview practice (M=2.28; S.D.=0.669). The observers also thought that students could engage in the interview practices (M=2.50; S.D.=0.618). According to the observers, most students could engage in the interview practice overall, and students were interacting with the VR app. A student was reported slightly nervous at the beginning, but he/she became comfortable over time.

Table 1. Students' engagement levels as reported by the students and the observers.

Engagement Level	N	Min	Max	Median	Mean	Std. Deviation
Students	17	1	3	2	2.29	0.686
Observers	17	1	3	3	2.47	0.624

*Scores on a 3-point Likert scale

4.2. Stress Level

According to students' interviews, most students felt low-stress levels. They attributed these to the fact that they could repeat any of the questions and they could respond to questions as practices. The interviewer being "not a real person" (as framed by a student) was also pivotal to their ease when practicing. Students reported they would not be affected by the interviewer verbally or non-verbally as what usually happened in actuality. Meanwhile, they claimed they could be more engaged in the VR mode than practising in the 2D as they did before, because they could be fully immersed and not distracted by the environment.

4.3. Questions in the Interview Practice

Generally speaking, students were satisfied with the job interview questions in the practice. A student stated the VR trainers would immediately ask the next question which "made the interview real". To end the interview practice, it was commented that the VR app could ask *"Do you have any questions?"* which is usually asked in a real job interview so students could also prepare for that kind of question.

4.4. Learning Effectiveness of Interview Practices

Overall speaking, students claimed that the interview practice was useful for them to improve their communication and interview skills. They had more opportunities to practise answering job interview questions than they would have had without the VR app, as it was flexible and convenient (not constrained by time and space). Students also reported they could "get into the interview mode easily/ really having an interview", and thanks to the VR goggles, it enables students to focus on the task (the interview). One student indicated they "would like to try 100% (perform at their best)" in the VR interview. Some of them were able to reflect on their own performances and improved from previous feedback on the VR app. One student stated "if you repeatedly do the same questions, you will build a way to answer them in a more organized way". A student claimed they would "try to use it again, especially when I'm having a job interview soon. I can listen to some questions from the interviewers. I will be able to practise more and also get more well prepared before the real job interview." In addition, the VR app could provide an authentic experience ("it was really close to reality when I was having my interview. The App was really similar.") for the learners to practice answering potential questions in a real job interview. Students who have ultilised the VR app in the 2D mode, in contrast, complained they were distracted by the surroundings and discontinued with the practice after a short time span.

4.5. Experience with Feedback

To investigate whether the feedback was appropriate, students were required to evaluate their own and teachers the students' performances during the interview practices with the same rubric (3-points scale) in the VR app. The results (c.f., **Table**) showed the observers rated slightly higher than the students' self-evaluations. *Related Sample Wilcoxon Signed Rank Test* comparing observers' and students' evaluations was conducted to check if there were statistically significant differences in the median score. There were no significantly differences in task fulfilment (p=0.052), fluency, stress and pausing (p=0.132), and energy and enthusiasm level (p=0.380). Nevertheless, in the use of language (p=0.029),

observers' ratings were significantly higher than students' ratings. It indicated that the feedback could generate slightly 'harsher' responses based on users' self-evaluations.

Table 2. Related Sample Wilcoxon Signed Rank Test on the Observation.

Observer - Students	N	Median		Positive Differences	Negative Differences	p-value (2-tailed)
		Observers	Students			
Task Fulfilment	17	3	2	10	3	0.052
Use of Language	17	2	2	9	2	0.029^
Fluency, Stress and Pausing	17	2	2	6	2	0.132
Energy and Enthusiasm Level	17	2	2	4	3	0.380

*Scores on a 3-point Likert scale

^Lower than significant level 0.05

To further explore whether the feedback was useful, students were asked about their opinions on the feedback given to them. Most students claimed that the VR app has given constructive and accurate feedback to them. The feedback was easy for them to understand. However, it was hard for them to remember and recall, as, currently, it was in a paragraph form. It was, hence, suggested the VR app emphasize important points and highlighted them with visuals. To further improve, some students would like to have specific feedback.

5. Discussion

The aim of the paper was to gain an understanding of the conceptualisation and development of the VR job interview self-directed speaking programme. The focus in the analysis was on the student users' experience, and, hence, the learning effectiveness of the VR programme (in the form of a mobile application). Given the results, the merits of VR trainers, learning through self-reflections, and lower stress in the VR environment will be discussed below.

5.1. The Merits of VR trainers

The pedagogy behind the VR job interview program is based on experiential learning. Our VR app operates in both the VR and the 2D mode. As compared with the 2D mode, students preferred the VR mode due to its immersiveness – it is authentic, engaging, and interactive which helps learners to perform to the best of their ability. Students complimented the proximity of the VR and a real-life interview experience. The sense of presence and the absence of disruptions and distractions in an interview contribute to the learning effectiveness. The VR trainer and the environment mandate "the integrated functioning of the whole person - thinking, feeling, perceiving, and behaving" (c.f., Literature Review). The VR app appears a superior platform for experiential learning, which the researcher of the project did not expect before. It was thought that the VR and the 2D was as effective as it could be.

5.2. Learning through Reflections

Learning as a continuous process as opposed to a composition of individual lessons might be conducive to students' learning. Often enough, teachers conduct lessons to teach various topics, and, hence, learning is one-off. What students might in fact need are repetitions, which are not feasible in a classroom setting as it might be boring to students if teachers teach them identical subjects over an extended period of time. A student commented "even with the same set of questions, if you repeatedly do the same questions, you will build a way to answer them in a more organized way" (c.f., Results). What the student has reflected is "learning is re-learning" (c.f. Literature Review). (c.f. overused?) In addition,

Experiential Learning Theory (ELT) can be described as an engaged learning process where students learn not by learning but by performing/ acting and, as essentially, by reflecting on the experience (Moore, 2010). As the VR app invites students to reflect as they learn (c.f. Methods) and empowers them to take charge of their own learning and development by providing the options and flexibility, or, in short, personalisation, effective self-directed learning could be achieved.

5.3. Lower stress in the VR Environment

Students stated they felt less stress using the VR app to practise. A student reported "mistakes were allowed" and the VR app is not "as awkward as practising by self-recording where one often paused due to frequent errors made". The less-stress VR interview environment is favorable with reference to brain-based teaching-learning approach (with a construct of Orchestrated Immersion, Relaxed Alertness, and Active Processing). Students preferred practising with the VR app, and they were motivated to "use it again, especially when there was a job interview soon". Maximising self-directed learning, the VR app allows students to practise according to their own preferences (time, pace, and challenge/ difficulty level). In addition, the VR trainers are emotionless/ without any facial expressions and would not interfere the student users or ask follow-up questions – they pose minimal threats to the students. Hence, students were more composed, performing more naturally and spontaneously in the interview practices – they know the VR trainers are not "real persons". Interestingly, teachers, being real persons, might cause strain to students.

6. Conclusion

The educational potential of VR is of growing interest for education practitioners, researchers, and institutions. This technology is particularly valuable in a pandemic situation and will continue to be so in the post-pandemic era since it saves time and effort for students and teachers, in particular – the involvement of a teacher is much less than that in a traditional classroom. The immersive VR app has yielded positive results in increasing students' job-interview sum speaking practice opportunities and in improving the learning experience for students. It is evident that this VR learning tool was thoughtfully created and carefully implemented. Further development, e.g., upgrading the VR program to an Oculus version, would, hopefully, generate more useful advantages for learners.

Acknowledgements

I thank Mr. Eric Yeung, Center for Education Innovation, HKUST, for the preparation of the research results of this paper.

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Inquiry-based Science Learning in ODL from the Lens and Experiences of Millennial Teachers

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Abstract: *The realization of continuous education amidst the COVID-19 pandemic signifies the importance of the learners' continuous learning despite the crisis. It is of interest to explore how millennial science teachers sustain inquiry-based learning (IBL) as they shift from face-to-face classes to online distance learning (ODL) in the school year 2020-2021. This study was conducted to determine their preparations for shifting to online teaching, the inquiry-based learning strategies, and tools they employed, their experiences, and suggestions to enhance IBL in ODL. This study utilized a narrative approach with millennial teachers interviewed online. Based on the participants' extracted narratives, they perceived the shifting to online teaching as challenging, necessitating them to upskill and reskill themselves through webinars in preparation for the new modality. Despite the shift to a new modality, the participants recognized the importance of sustaining IBL and learning processes. Hence, identified inquiry-based learning strategies and tools employed by the participants were contextualized, minimized, and guided inquiry-based activities; questioning; utilizing online simulations and virtual laboratory; and home-based experiments. The findings of this study can serve as inputs to enhance inquiry-based science learning in ODL in the Philippine context and further provides pedagogical insights to other science teachers who teach in the same modality.*

Keywords: COVID-19, Inquiry-based Learning, Millennial Teachers, Online Learning, Science Education

1. Introduction

The COVID-19 pandemic has prompted unprecedented changes (Alzueta et al., 2020), challenges, and opportunities (Arrieta, 2020; Gonzales, 2020; Wilkins, 2020) in every aspect of human life, from health to industry to education. The pandemic has tested the human quest for education. Continuous education amidst the pandemic changes the education landscape in the country (Tria, 2020), resulting from emergency remote teaching (ERT) that is temporarily shifting from face-to-face teaching to an alternative mode of instructional delivery due to the threat of COVID-19 (Ferri et al.,2020). Of the learning delivery modalities (LDMs), online distance learning (ODL) is commonly adopted by schools with teachers and learners having access to the internet for online instruction, especially in urban areas in the Philippines.

Science education in the Philippines aims for developing scientific literacy among learners, which significantly emphasizes learner-centered and inquiry-based approaches (DepEd, 2016; Gutierrez, 2015). The inquiry-based approach is grounded in Dewey and Bruner's ideas that support active learning (Constantinou et al., 2018). Studies reveal significant effects of an inquiry-based approach to student engagement (Mirowsky, 2020) and student achievement in a science course (Abdi, 2014). These imply the importance of sustaining inquiry-based science learning in the shift to ODL for its positive effects on student science learning. Behind the positive effects of inquiry-based in science education, inquiry-based teaching is undoubtedly challenging for science teachers (Constantinou et al., 2018; Edelson et al., 1999) as teachers have to be well-prepared and skilled in planning and implementing inquiry-oriented science lessons and also in supporting students' inquiry (Constantinou et al., 2018). If IBL is to sustain in the ERT, adapting and employing new teaching strategies is needed.

Meanwhile, the teaching force is notably increasingly populated by the millennials as Baby boomers and Generation Xers are on their retirement (Bartz et al., 2017). According to Layton (2015), millennials have all the essential traits of a great teacher, for they are 'highly educated, willing to learn, technologically advanced, and socially conscious.' Accordingly, millennials are confident, digital thinkers, entitled, and needy (Sladek & Grabinger, 2014). Hence, it is of interest to determine how millennial teachers adapt to the ODL, given they are described as digital thinkers and technologically advanced. The purpose of this study was to identify the preparations of the participants for shifting from face-to-face to ODL; the tools and strategies they employed that reflect inquiry-based science learning in ODL; and the participants' experiences in teaching science via inquiry-based learning in ODL. Also, recommendations were generated from the participants' narratives and suggestions for enhancing IBL in ODL.

2. Methods

This qualitative study utilized a narrative approach conceptualized by Clandinin and Connelly (2000). The participants were four science teachers aged 27 to 31 years from different public high schools in urban areas in the Philippines. Participants 1, 2, and 3 were identified as Proficient teachers, while Participant 4 is highly proficient based on the DepEd's Philippine Professional Standards for Teachers (PPST). For data collection, an individual semi-structured online interview via Google meet guided by open-ended questions was used. The open-ended questions asked to the participants were the following: (1) What are your preparations for shifting from face-to-face to ODL?; (2) Knowing that Philippine science education advocates an inquiry-based approach, is it still emphasized in ODL?; (3) What are the considerations, tools, and approaches you have in your lesson planning, modules, and synchronous online class that reflects inquiry-based science teaching? (4) What are your experiences in inquiry-based science teaching in ODL?; and (5) If you can improve inquiry-based science teaching, what can you suggest to improve them? The participants' narratives were transcribed and translated and then thematically analyzed. Ethical consideration was observed throughout the study; hence, *P1, P2*, *P3, and P4* were used for the participants' confidentiality and anonymity.

3. Results and Discussion

3.1. Preparations for shifting to ODL

Adopting a new teaching-learning modality requires new sets of skills, like, ODL necessitates teachers to upskill and reskill themselves about online teaching. Teachers' upskilling and reskilling are crucial for achieving quality education. Upskilling and reskilling are fundamental for teachers to be innovative and upgraded in their teaching; hence, they are necessary for equipping themselves with new teaching modalities. With this drastic change, creative ways of teaching are of utmost importance. Lansangan & Gonzales (2020) mentioned science teachers had re-equipped and retooled themselves with the demands of the new modality before the opening of SY 2020-2021. Similarly, all participants attended various webinars about online teaching tools, ODL, and LMS offered by different organizations and institutions. Further, part of their preparations was writing science modules. Besides webinars, reading printed and online resources about online teaching and learning was also mentioned as one of the preparations to learn more about ODL.

3.2. Inquiry-based Science Learning Strategies and Tools

Science as an inquiry-based discipline requires well-thought strategies (Edelson et al., 1999) aligned with the learning objectives. Participants believe that science is an inquiry-based discipline; as stressed, "the heart of science teaching lies in IBL (P3)." Immense literature depicts the positive effects of IBL on science learning (Abdi, 2014). Despite the teaching-learning processes change, participants believed the need to sustain and maintain inquiry-based science even in ERT, as emphasized in developing science self-learning modules. As argued, IBL in ERT is possible through teachers' efforts, time, preparation, and familiarity with the available materials. IBL enhances students' critical thinking skills, as stressed

by P2: "Yes, inquiry-based is proven that it can enhance critical thinking, communication, and other learners' skills through it. Hence, it should be continued." Similarly, P4 profoundly contended the benefits of IBL to learners, which resonates with Gholam's (2019) assertion that there has been an obvious need for instructional practices that encourage "critical thinking, reflection, questioning, collaboration, communication, and research" to ensure that our students are adequately prepared to meet the demands and expectations of the future. And one instructional approach to do so is IBL.

3.2.1. Contextualized, minimized, and guided inquiry-based activities

Indisputably, IBL requires the teacher's guidance and facilitation. The participants recognized that independent learning is not yet developed among their learners; thus, they should be guided, especially when alone learning at home. Adapting to the changes incurs changes in how things should be done. The participants pointed out that minimizing inquiry-based activities attuned to the learners' capability while learning independently at home and considering the limited time and contextualizing learning are encouraged. This corresponds to Baraquia's (2018) claim that inquiry-based and contextualized teaching approaches heighten student learning. Further, contextualization augments learners' involvement and performance as they become interested and engrossed in learning things relatable and relevant to them.

3.2.2. Questioning

Part of IBL is problems or questions to be answered or investigated by the learners to generate scientific information. Questioning is one of the inquiry-based strategies mentioned by one of the participants in ODL. Picture and video analysis were used, in which learners had to answer guide questions related to the picture and the video presented. Tawfik et al. (2020) argued that asking meaningful questions is vital for knowledge construction during problem-solving. Further, asking meaningful questions is an initial step of the inquiry process as it arouses learners' curiosity (Byker et al., 2017). Nevertheless, there are challenges encountered in questioning as an inquiry-based strategy. Some participants found it challenging to elicit learners' answers during synchronous sessions. Moreover, teachers should know that not all questions are considered inquiry-based. As P3 argued, "Not because you ask a question, it does mean it is inquiry. You ask the question until you draw learners' answers, and then, of course, you teach your learners the proper way of doing investigations."

3.2.3. Online simulations and virtual laboratories

Many online simulations and virtual laboratories can be used in science teaching and learning processes; some are free, and some are subject to subscription. "A virtual laboratory is an interactive environment for creating and conducting simulated experiments (Larbi-Apau, 2020)." Participants used free online simulations and virtual laboratories for their learners' activities. "Virtual lab, PhET Simulation, especially when I taught electricity as we cannot perform it for having no available materials (P1)." The PhET Interactive Simulations are readily accessible online and developed by the University of Colorado Boulder, comprising more than 30 simulations used for teaching and learning chemistry concepts (Moore et al., 2014). Furthermore, the participants encouraged collaborative and cooperative learning by doing inquiry-based activities instead of individual to ease the learners.

3.2.4. Home-based simple experiments

Simple experiments can be done at home with available household materials and technological devices (Andrews et al., 2020; Caruana et al., 2020; Destino & Cunningham, 2020). As shared by P1, they have done home-based experiments in their synchronous session. However, home-based experiments need caution for health and safety, including waste concerns (Destino & Cunningham, 2020). As mentioned by P3, they are advised not to do the home-based experiment as part of the learners' safety concerns.

3.3. Teaching Inquiry-based Science Learning in ODL

As most say, we should not take this COVID-19 pandemic as just a health crisis but as an opportunity (Arrieta, 2020; Gonzales, 2020; Wilkins, 2020). And this resonated with the participants who encountered different challenges but new

experiences and learning. "This pandemic, this new modality offered in school is also an improvement for us that [proves that] not only face-to-face can we do (P2)."

3.3.1. Adjusting teaching strategies

Part of the adaptation process is having adjustments (Ladum & Burkholder, 2019), and this is obvious to all participants as they shared their experiences in teaching through ODL. Not only did they adjust their lessons and teaching strategies but even their personal lives

> At first, in the first quarter, there were many adjustments. Like, even though you prepare, you don't know what will happen. Maybe my adjustments in the second quarter— I limit the number of activities. Concerning inquiry-based, the module we used is an IDEA model (Introduction, Development, Engagement, Assimilation). I tried all parts to be performed by the learners, but time was not enough. It became very tasky for the learners. It cannot be done during the first quarter (P1).

3.3.1. Validating learner's works

Aside from adjustments, participants recounted how limited the interaction between them and their learners is in ODL compared to face-to-face. And they found this as a concern for limited learners' participation during their synchronous session, as identified by Arrieta (2020) in their study. In contrast, Smith & Hardaker (2000) and Alexander (2001), as cited by Kemp & Grieve (2014), argued that because online learning assumes self-directed learning, it may have the potential to instigate in-depth discussions and encourage broader student participation. Hence, validation of the learners' work is another concern mentioned due to limited interaction. As Gonzales (2020) underscored, an online assessment may jeopardize students' integrity, questioning their honesty and credibility as no one is watching them while having the online assessment.

3.4. Suggestions for Enhancing Inquiry-based Science Learning in ODL

Participants recognized the significance of inquiry-based teaching in ODL; hence, they enumerated some suggestions and needed improvements in enhancing inquiry-based science learning in ODL. Accordingly, the provision of appropriate learning resources is crucial. Appropriate and adequate equipment, facilities, and educational materials are elements of good learning resources crucial for the teaching-learning process (Okongo et al., 2015). Learning management systems (LMS), devices, the internet, online tools such as online applications, simulations, and virtual laboratories are now the teachers' and learners' new learning resources in the ODL. Rodriguez (2020) concluded that online technological tools utilized in the online learning environment could empower science pedagogy and the learning process. The millennial participants being digitally skilled and technologically advanced, were cognizant of those online learning resources. Hence, providing an appropriate online learning environment and resources to learners and teachers is of the utmost importance. Enabling Teachers' resourcefulness is also of use.

As suggested, in improving inquiry-based science learning in ERT, one group of writers should be tasked only to design and develop inquiry-based activities for Alternative Delivery Modules, which science teachers can select for their classes based on their respective contexts. Meanwhile, P4 suggested the importance of including student reflection in inquiry-based activities. Reflective thinking cannot be separated from IBL. Verawati et al. (2021) expounded on the positive impacts of the reflection process in inquiry learning to the learners, which includes improving critical thinking and solving problems.

Also, one of the participants pointed up the need for science teachers as facilitators to revisit or reorient themselves about the inquiry-based approach. This is because teachers have different understandings about doing inquiry-based for having no established standards. Hence, guidelines or a framework for an inquiry-based approach may be developed.

4. Conclusion

This study confirmed the manifestations of inquiry-based science learning during emergency remote teaching, specifically in ODL. The transition to new learning delivery modalities evinces the resiliency of the education system in the country. Albeit the participants perceived how challenging the transition to ODL was, they still recognized the opportunities it offers and so did not hinder them from fulfilling their responsibilities as teachers. In so doing, upskilling and reskilling themselves to online teaching by attending webinars. Different teaching strategies aided by online learning resources reflect the prevalence of inquiry-based science learning in ODL that sustain the inquiry-based approach during ERT. Participants were exposed to new experiences and challenges while transitioning and adapting to the new teaching modality. It can be inferred from this study that relevant and proper training as part of teachers' preparation in response to new policies and practices and teachers' upskilling and reskilling are crucial, thus, should be continuously provided and supported by the school heads and administration. To sustain and effectively implement inquiry-based science learning in ODL, the school administration must ensure the provision of appropriate learning resources, organize expert writers for developing inquiry-based science activities, and issue proper guidelines for the inquiry-based approach.

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A Visual-Performing Arts Collaborative Online International Learning (COIL) Project Between a Hong Kong and Australian University

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Abstract: *Virtual teaching and learning bring about opportunities for collaboration across continents for global education. Through technology like video-conferencing, image and video software on nearly every smartphone, and online content-exchange platforms like Padlet, one can easily set up opportunities for students from different parts of the world to have online exchanges. This presentation highlights an innovative Collaborative Online International Learning (COIL) project between a course at the Education University of Hong Kong (EdUHK) and another at the Queensland University of Technology (QUT) that has run for two Semesters. The collaboration involves early childhood education preservice teachers in a visual arts course in Hong Kong and primary (elementary) education preservice teachers in a performing arts course in Australia. Preservice teachers from Hong Kong create visual artworks which are shared with preservice teachers from Australia who respond to them through music, drama, and dance performances. In this conference paper, we share the reasons behind this collaboration, including the two lecturers' teaching pedagogy, examples of preservice teachers' work, and results of their feedback. We argue that such cross-national teaching collaborations are powerful for helping students discover how different experiences, processes, and perspectives are expressed through different arts languages. And they hold significant potential for expansion into more elaborate online cross-cultural exchanges.*

Keywords: Collaborative Online International Learning (COIL), Innovative Pedagogy, Performing Arts, Virtual Teaching and Learning, Visual Arts

1. Introduction

Virtual teaching and learning bring opportunities for collaboration across continents for global education. Through technology like video-conferencing, image and video software on nearly every smartphone, and online content-exchange platforms like Padlet; one can easily set up opportunities for students from different parts of the world to have online exchanges. These opportunities allow students to develop international and intercultural knowledge and abilities within their home university (Nilsson, 2003). They present the prospect of nurturing cultural humility through interacting with diverse individuals from different countries. By designing activities where students from two countries can engage in collaborative learning, students can recognise and understand their own worldview by relating them to those of students from another country. This can prompt awareness of one's biases and misconceptions while inspiring respect for those who think differently (de Castro et al., 2019).

This paper highlights a Collaborative Online International Learning (COIL) project between Mr. Eugene Lau, who teaches "Visual Arts Education in Early Childhood" at the Education University of Hong Kong (EdUHK), and Dr. Susan Chapman, who teaches "Performing Arts for Primary Education" at the Queensland University of Technology (QUT) in Australia. In their COIL project, preservice teachers from Hong Kong create visual artworks on paper, take photographs of their art, and upload them on Padlet for preservice teachers from Australia. Preservice teachers from Australia then analyse these artworks, respond to them through music, drama, or dance performances, and video-record and re-upload

their performances on Padlet for the Hong Kong preservice teachers. In this paper, we will share the reasons for this collaboration, the two lecturers' teaching pedagogy, examples of preservice teachers' work, and preservice teachers' feedback. We argue that such cross-national teaching collaborations are powerful in helping students discover how different experiences, processes, and perspectives can be expressed through different arts languages. Moreover, they hold significant potential for expansion into more elaborate online cross-cultural exchanges.

2. Lecturers' Teaching Pedagogies and Reflections

The two lecturers' teaching pedagogies in the COIL project were akin to the process of language translation. Eisner (2005), whose work has provided a seminal influence in arts education, describes language as "the use of any form of representation in which meaning is conveyed or construed" (p. 342). This project used an Arts Immersion pedagogy building on Eisner's (2055) definition of language and can be described as "the process of using the Arts as the purposeful medium through which enhanced learning occurs across disciplines to inform mutual understandings" (Chapman, 2015, p. 93) The arts comprise a unique set of languages with an expressive capacity that goes beyond the power of words. Each arts subject involves symbols, techniques, processes, and skills and comprises elements that are the building blocks for developing arts literacy. Developing literacy in each arts subject requires manipulating subject-specific arts elements to make meaning. The table below indicates the elements of the arts subjects involved in the 2022 COIL project, according to the Australian Curriculum (Australian Curriculum and Reporting Authority, 2022).

Table 1. Elements of visual art, music, drama, and dance.

Arts Subject	Elements
Visual art	Colour, form (3D shapes), line, shape, space, texture, and value/tone.
Music	Dynamics and expression, form and structure, pitch, rhythms, texture, and timbre
Dance	Dynamics, relationships, space, and time
Drama	Audience, focus, language, mood, movement, relationships, role and character, situation, space, symbol, tension, time, and voice

The EdUHK lecturer created a task where preservice teachers were required to depict an issue familiar to them using the language of visual art through the two-dimensional media of painting and drawing. In the lesson, the EdUHK lecturer first taught his preservice teachers the visual art technique of continuous contour line drawing. This technique uses a single, unbroken line to develop an image. The strength of the technique is that it can help build confidence in beginning artists by helping them focus on the process rather than the outcome, reducing tentative sketchy work and removing the need to erase mistakes (Colella, 2022). Hence, it is a good technique that visual art teachers in training can teach to young children. Thereafter, preservice teachers created their individual contour line drawings as practice. The EdUHK lecturer then invited the COIL Coordinator for the Department to explain the rationale for the collaboration, introduce the QUT lecturer, and share exemplars of preservice teachers' work from the previous year to create excitement for the current cohort.

Next, the 45 preservice teachers were divided into 12 groups and asked to create a group contour line drawing. The task was designed based on a constructivist approach and required preservice teachers with no background in art to experience using a new technique to create artworks through discussion with their peers in groups. The use of group work is rooted in the constructivist approach, where it is posited that learners do not acquire knowledge and understanding by passively receiving it from a teacher; instead, they gain new understanding and knowledge through experience and social discourse, integrating new information with prior knowledge (Applefield et al., 2000). This was indeed the case for the EdUHK preservice teachers, as within their groups, they were observed sharing and explaining their ideas, before coming to a group consensus. They also had to learn to compromise, negotiate, respect one another's views, and work on the

same visual artwork together. In addition to creating the visual artwork together, preservice teachers also recorded a group video introducing themselves and explaining their art creation process. These group artworks and videos were then uploaded onto a Padlet for QUT preservice teachers: https://padlet.com/schua5/l2l2tufwkzyn9d9a. Some examples of group artworks are shown in Figure 1.

Figure 1. Examples of EdUHK preservice teachers' visual artworks.

By using the EdUHK preservice teachers' visual artworks as a stimulus in this collaborative creative process, the QUT lecturer gave her preservice teachers the task of translating these visual artworks into performing artworks – music, drama, and dance. To do this, the QUT preservice teachers first needed to respond to the original visual artworks by considering the message or story that is conveyed, the mood of this artwork, and how it made them feel. This response was then justified by analysing how the visual art elements had been manipulated to make meaning and how this showed the perspective of the artists (the EdUHK students). Of course, interpretation is subjective, with preservice teachers having various responses. Arts pedagogy acknowledges that there does not have to be one "right" interpretation of an artwork. However, the process of interpreting and expressing ideas, stories, feelings, and topics in artworks can be strengthened when a justification is provided. A deeper analysis of the elements of an artwork can assist in justifying an interpretive or expressive opinion or process.

For instance, the use of strong primary colours in a visual artwork could suggest joy, playfulness, youth, or energy, and the dominant use of the colour, red might suggest a warning, a sense of urgency, or speed (an object moving at a fast rate). Muted and pastel colours could suggest gentleness, peace, or a harmonious situation, while darker neutral colours might suggest sadness, frustration, or a sombre mood hinting at feeling overwhelmed or hopeless. A predominant use of the colour, green, might show strong connections with an outside environment and the natural world or by contrast, could refer to the COVID-19 virus and sickness. Consideration can be given to whether colours are primary (yellow, red, or blue), secondary (combinations of two primary colours – orange, violet, or green), or tertiary (combinations of three colours), and how these colour choices contribute to making meaning. Meaning in a visual artwork can be further nuanced by noting that each colour has hue (colouration – different versions of a colour e.g., cobalt blue or egg yolk yellow), value (which can also be called tone and refers to the lightness or darkness of a colour) and intensity (the brightness of a colour) (Dinham, 2020). The way colours are combined also contributes to meaning making which can be conveyed through complementary colours (opposite each other on the colour wheel) to create contrast, analogous colours (near each other on the colour wheel) to create connection, warm colours (reds, oranges, yellows, and browns) to create cosiness or danger, and cool colours (blues, greens, purples, and greys) to create relaxation or bleakness.

Similarly, other visual arts elements can suggest a range of meanings. As paint or drawing materials were the media used in these two-dimensional visual artworks, texture was conveyed as an implied representation of the artwork's surface. Texture can combine with shape to depict layers of meaning in response to a complex topic such as living with COVID-19. Texture and shape can also contribute to the mood of a visual artwork where similar fluid shapes representing a smooth texture may lead to feelings of harmonious balance and serenity, or jagged shapes that imply roughness might suggest tension and discomfort. Whether shapes are organic, geometric, regular, irregular, distinct, amorphous, natural, or human-made can determine the mood of an artwork and the artist's response to the message being communicated. These qualities can invite the viewer to consider the reasons behind the artistic choices made, for example, whether amorphous, natural shapes have been used to depict a harmonious environment or the creeping dread of an invading virus. The element of

line has length, width, direction, and texture (Dinham, 2020), and can be used separately or in conjunction with shape to highlight an object, thereby separating or connecting it to other objects (Russell-Bowie, 2015). This connection or separation can create meaning by suggesting the impact of an object and its relationship to other objects in the visual artwork. Line can also imply texture or value (using different methods of shading) and suggest movement (energy, restlessness, or tranquillity), all of which can influence the mood of the artwork with sharp, angular lines possibly suggesting conflict or confidence, and fluid, curving lines suggesting stability or equilibrium. Meaning-making is also influenced by several design principles such as balance, rhythm and repetition, proportion and scale, and contrast and emphasis, all of which can highlight the visual artwork's most important focus, leading the viewer's eye to key points of the visual message.

It is important to realise that individuals can have different emotional or analytical responses to the same artwork and may create different artistic responses to a given artwork or creative task. Collaborative class discussions can support preservice teachers in developing an appreciation of different perspectives, which they could also encourage in their future students. Similarly, workshopping ideas that incorporate individual and collaborative creativity, problem solving, and critical thinking can develop preservice teachers' respect for their peers' perspectives and prepare them to facilitate this process in their future classrooms. The pedagogical process outlined in Figure 2 explains how the Padlets facilitated collaborative learning between the EdUHK and QUT preservice teachers, and Figure 3 shows the process in action.

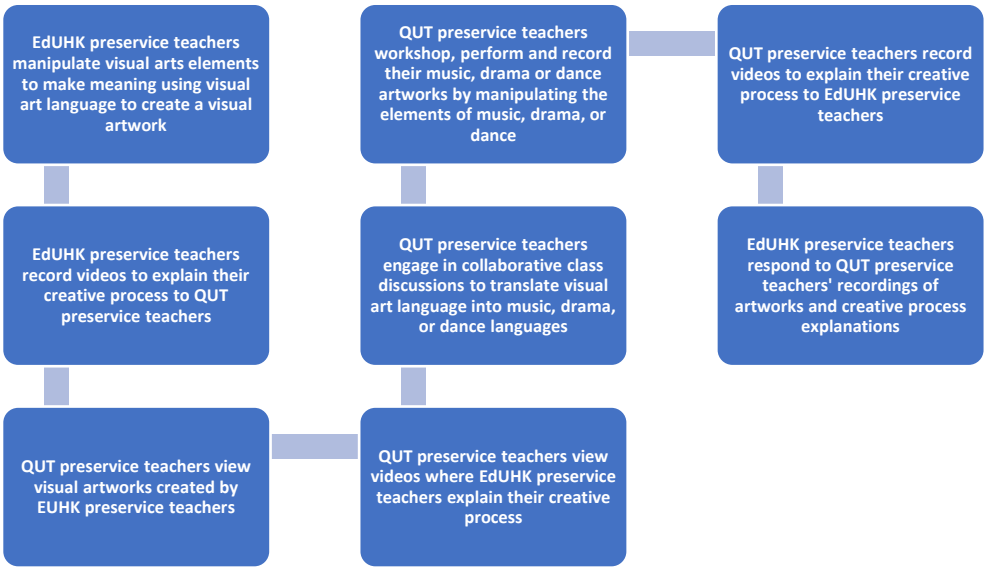

Figure 2. Pedagogical process supporting this COIL project.

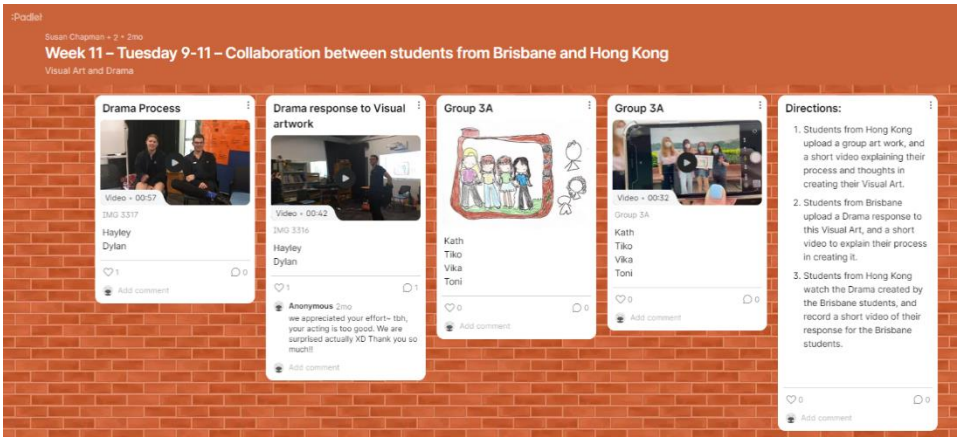

Figure 3. A Padlet screenshot of a visual art-drama collaboration.

The process of translating meaning from one arts language (visual art) to another (music, drama, or dance) was facilitated by the QUT lecturer using dialogic pedagogy with questions to prompt deeper thinking and experimentation from the QUT preservice teachers. Examples of these open-ended questions are provided below.

- How can you create music to reflect the mood of this visual artwork? How can your music's pitch (higher or lower sounds) or rhythm (patterns derived from different combinations of sound and silence) reflect this mood? Would the dynamics (volume) vary in your music? How would the expression (how the music is played or sung) reflect this mood? How will you construct the layers that form the musical texture reflecting this mood? Which instruments/voices will you use and why? When will these layers enter, and for how long will each layer be present in the musical piece (the texture of the music will reflect the relationship between the layers of music that are created)? How will you establish the mood at the beginning of your musical piece? Which timbres or tone colours will you choose to reflect this mood, and which instruments or voices will be most effective? How can visual colour be represented by tone colour/timbre? Does the mood change in your musical piece? Will you need someone to conduct your piece? Can your music also tell the story of the visual artwork?
- How can you develop dramatic action to show the narrative arc in the story that reflects this visual artwork? Who are the characters in the story? What are their backstory, history, opinions, and motivations, and how will you show this? Will you choose both spoken and body language to tell this story or just body language? How will you create the mood of your story, and does the mood change? Is there an aspect of tension that propels your story forward, and what type of tension is this? How will you show the relationships between the characters involved, and how does this influence their status? How will you portray your character using voice and movement, gesture and stance? What situation have you chosen for your story – how are these details evident in the visual artwork? What is the focus of the visual artwork, and how will you translate this to the focus of your story? Are there any visual symbols in the visual artwork that can be translated into dramatic symbols? Who is your target audience? How will you use time and space to frame your story? Is the story chronological, thematic, or a short episode in a larger story? Does your use of space represent different locations, settings, or time periods? Will your story: take place in real-time, use fast forwards or flashbacks, move at the same pace, or change pace?
- Can you create a dance to reflect the mood and/or tell the story of the visual artwork? What types of movement will you choose to reflect the mood or tell the story – how will you use dynamics by selecting the appropriate weight, force, and energy of your movements? How would you describe the quality of the movements to represent the visual artwork? Does the movement quality change at any point in your dance piece? Will your movements be fluid or disjointed, heavy or light, explosive or with gently extended momentum? As dancers, will you be representing different characters – will they be human or non-human, animate or non-animate? Will you focus on particular parts of the body? How can you show the connections between different parts of the body when you move, and how might this reflect connections in the visual artwork? Will your movements be heavily grounded on the floor or move lightly across this surface – what does that reflect in the visual artwork? Will the relationship between the dancers in your group mirror the relationship between different objects, animals, plants, or people in the visual artwork? Does this mean you will have some joint and individual movements? How will you reflect the use of space on the page of the artwork through your use of performing space – how will you use different levels, directions, planes, and pathways? How will the visual artwork be represented in terms of time – how will you plan the sections of the dance? How will your choice of tempo (speed) reflect the message of the artwork? How might you represent visual patterns with movement patterns? What music will you choose to portray the mood and/or story of the visual artwork? How will you use stillness and respond to the beat of your chosen music to bring the visual artwork to life?

The translation of meaning from visual to performing artworks required students to identify the heart of meaning-making and consider what this might look or sound like in a different arts language. For example, QUT preservice teachers needed to consider what a peaceful visual artwork featuring fluid lines and organic shapes, including dolphins might sound like

in music, be enacted through drama, or brought to life through movement in dance. This was a challenging but valuable task to extend preservice teachers' understanding and skills, using cross-modal interpretations to portray the sound of the colour, "red," the story of a group of amorphous shapes, or the movement of living life with COVID-19.

3. Student Feedback and Analysis

To help us understand preservice teachers' experience of this COIL project, a feedback survey was distributed to 45 preservice teachers in the EdUHK lecturer's class, and 40 responded. Overall, the EdUHK preservice teachers were generally positive about the collaborative activity, giving an average rating of 4.1 (Table 2). When asked if they liked working together as a group to create their painting, the rating was 4.45 (Table 3). This suggested that students enjoy group work.

Table 2. How would you rate your experience of this collaborative activity?

Stars	1	2	3	4	5
Frequency	0	1	9	15	15
Average Rating			4.1		

Table 3. How was the experience of working together as a group to create your group painting?

Stars	1	2	3	4	5
Frequency	0	1	4	11	24
Average Rating			4.45		

Open-ended questions were also asked to seek students' thoughts and feelings about the collaborative activity. Generally, preservice teachers felt that the activity was fun and used many synonyms to describe their feelings about the activity, including entertaining, funny, exciting, surprising, intriguing, unique, special, amazing, wonderful, fascinating and interesting. They felt so because of the chance to share a creative experience, to see their artwork become transformed into another form, and to interact with students from another country.

Some preservice teachers also mentioned that it was "surreal" that "someone from so far away responded through an act of drama" to their painting, and they appreciated the opportunity to communicate with people from a different culture to "hear about opinions outside the classroom" and "see different perspectives and points of views." The transformation from visual to performance act was also instructive for the preservice teachers who realised that "creativity can be described in actions," which is a significant outcome considering that Hong Kong early childhood arts education is heavily visual and often lacking in performance-type activities (Yeung et al., 2022). Another student added, "seeing an art piece inspire a musical piece made her feel inspired to teach future children a similar aspect."

Overall, these positive feelings towards the COIL project reflects those of Garcia-Portillo and Lopez-Morales (2019) who reported that their students appreciated interacting with people from different cultures and found the experience new and enlightening. To improve the activity, EdUHK preservice teachers suggested that more time could be given to the activity as it was "rushed" and "hurried". Many of them would have liked to interact more and in real-time with the Australian preservice teachers over Zoom or even in person.

4. Limitations

A limitation of our collaboration design was that EdUHK and QUT preservice teachers did not interact in real time. This was owing to limitations in timetabling as the QUT academic semester started earlier. A study by Tanghe and Park (2016) has shown that face-to-face video conferencing helped students feel more connected with the project and their

international partners, leading to higher levels of satisfaction and involvement and the development of more and stronger personal relationships. Hence, we hope to incorporate this element in the future and encourage others to do the same. Yet, despite this limitation, our project showed that using only asynchronous methods, it is still possible to hold an enriching collaboration between two localities.

5. Conclusions

In this COIL project, EdUHK and QUT preservice teachers discovered how different experiences, processes, and perspectives were expressed through different arts languages. This also reflects similarities and differences between two the different countries and their education systems. The process of language translation through an Arts Immersion approach deepened QUT preservice teachers' understanding of a broader concept of language which is embodied and not limited to words. The process of articulating their process for responding to a visual artwork through discussion and creating a new artwork using a performing arts language assisted in clarifying their ideas and extending their capacity as preservice arts teachers. This opportunity was only possible because of the COIL project, which used Padlets to exchange pedagogical practice between the EdUHK and QUT lecturers, and create collaborative learning opportunities between students from two different countries.

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Digital Wisdom and Embodied Presence as Enhancers of Pervasive Learning in the Metaverse and Beyond

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Abstract: *The crisis in sensemaking that has emerged as our information systems have gone increasingly online, and as traditional media systems have declined in relative size and in perceived trustworthiness. As means of addressing this crisis, the Anthony makes a case for the retention of embodied presence in future metaverse/virtual reality learning environments, and how this might help facilitate digital wisdom. Technology, including virtual and metaverse-like spaces, can be employed to cultivate such wisdom, but we need to honour our authentic selves as means towards that end. Finally, an argument is made for the concept of pervasive learning, which incorporates multiple online and offline formal and informal learning contexts. The probable driver for that shift in education and learning will be rapid changes in societies, technologies, economies, work and education. The Anthony's conceptual and philosophical arguments emerge from the discipline of Critical Futures Studies.*

Keywords: Embodiment, Futures, Metaverse, Mindfulness, Technology

1. Introduction

A crisis in sensemaking has emerged as our information systems have gone increasingly online, and as traditional media systems have declined in relative size and our institutions have weakened in terms of perceived trustworthiness (Brenan 2019; US adults under, 2022). We are struggling to find a unified, coherent set of values and trusted narratives to help us establish stable, meaningful futures. Further, we have become less connected to the physical world, to our bodies and to our inner lives. Logically, the issue will become more pronounced as we enter the age of virtual reality and the metaverse. This relative shift from a more grounded interoception towards technology-mediated exteroception has likely exacerbated the crisis in sensemaking and made us more susceptible to misinformation and manipulation (Addressing the sensemaking crisis, 2021).

How might we begin to address this civilizational emergency? This paper suggests one possible approach, which is to move beyond simplistic regulation of technology and information media, and instead implement a deeper, multi-faceted approach: the cultivation of digital wisdom. This may assist us in the retention of embodied presence in both the physical world and in future metaverse/virtual reality living and learning environments. Technology itself, including virtual and metaverse-like spaces, can be employed to cultivate such wisdom. It shall be argued below that there is a need to honour our Authentic selves and to cultivate embodied presence. Finally, the likely development of pervasive learning within the next few decades may be utlised to help develop digital wisdom. Pervasive learning incorporates multiple online and offline formal and informal learning contexts, and the probable driver for that shift in education and learning will be rapid changes in societies, technologies, economies, work and education by the year 2050.

2. Critical Futures Studies

The theoretical approach used in this paper is inspired by the discipline of Critical Futures Studies. Beginning in the 1970's, Critical Futures Studies arose from critical theory and poststructuralist thought, with Michel Foucault and Jacques

Derrida being especially influential (Inayatullah, 2018). Critical Futures Studies moves beyond prediction and trends analysis and seeks to question deeply the way we think about the future, and to create preferred and alternative futures.

One very prominent futurist is UNESCO Chair in Futures Studies, Sohail Inayatullah (2018). Inayatullah has outlined "the six pillars of futures studies," which indicates the scope of the discipline: mapping, anticipating, timing, deepening, transforming and creating alternatives. This brief paper contains aspects of anticipation, deepening, creating alternatives and transforming the future.

A relevant and simple dichotomy developed by the author for futures discourse is that of Deep Futures, juxtaposed with Money and Machines Futures (Anthony 2010, 2023). Respectively, these are utopian and dystopian representations of future societies, and emerge from two different worldviews: the techno-utopian, and the green-progressive. The purpose of this two-tier model is to help frame discussions of preferred and undesirable futures. The idea of the crisis in sensemaking (below) can be viewed as emerging from the proliferation of Money and Machines Futures in recent times, and the diminishment of Deep Futures.

3. The Context: The Crisis in Sensemaking, the Metaverse and Embodiment

Since early 2021, we have seen an acceleration of the development of virtual and augmented reality spaces, including the metaverse. The most publicized competitor has been Meta; but rivals include Microsoft, Roblox and Epic Games. Central to Meta's vision are Horizons Workrooms and Horizons Worlds, which will eventually encompass relationships, work, business, education and training, and entertainment. Meta's plan is to engineer a virtual future where physical, augmented, and virtual realities blend into an enhanced reality, and where economy and media become unified (Zickraf, 2021). In 2021, Mark Zuckerberg promised to turn Meta into a full metaverse company within five years. He set the goal of users feeling "present… in an embodied internet, where instead of just viewing content - you are in it." His vision is of an all-immersive, all-inclusive, monetized 3D internet where future humans work, socialize, play and learn all on the one platform. The Meta CEO believes that it will become increasingly difficult to distinguish the real world from digital worlds, and that there will be no "logging off" (Zickraf, 2021).

Yet the past two financial years have been disastrous for Meta, and in 2022 it lost $3.7 billion dollars, then fired 11 000 staff (Ferrier, 2022). Other tech giants like Amazon and Twitter have also downsized. It is generally agreed that the Covid-era tech boom is over and that the industry now faces a period of austerity. Further, the development of metaverse technologies has been far slower than predicted by Zuckerberg. Meta's metaverse problems include:

- Clunky usage, limited haptics and tactile engagement;
- The system requires expensive VR glasses, while some software is also expensive;
- Virtual eye contact is basic, while hand and finger gestures lack pixel depth;
- Users often experience disorientation, motion sickness and poor depth perception (Mark Zuckerberg, 2022).
- Criticisms that the metaverse's all-pervasive nature will make it highly addictive, and compound the current problems found in today's web (Zickraf, 2021).

Yet given the massive financial incentives involved, it is probable that there will be continued expansion of virtual and augmented reality in the foreseeable future. It is expected that by 2028 the metaverse will be valued at more than 800 million dollars, while Meta has already invested 10 billion dollars (Bogart, 2022).

The race for meta-space can be viewed as occurring within a broader context. In the current era, humans are becoming more disembodied as more and more time is spent online (Garcia, et al., 2021; Gomez, 2010; Kang, 2007), and our gaze is increasingly screen-mediated and exteroceptive. Humans are losing connection with the somatic body, which includes both strong emotions and more subtle intuitions (Paul, 2021a). This disconnection from the body may be depleting our emotional and intuitive wisdom. For example, there is a strong correlation between social media use and increased rates of depression, anxiety and suicide in the young (Haidt, 2022).

A further context is that this is happening amidst the crisis in sensemaking. It is becoming more difficult to make sense of the world and what it means to be human, as information, perception and reality itself become increasingly virtual (Addressing the sensemaking crisis, 2021; Rebel Wisdom, 2019;). There is much uncertainty regarding what is real or true. This has coincided with a rise in conspiracy theory culture (Rocha, et al., 2021) and declining trust in traditional media and institutions (Brenan, 2019; Haidt, 2022), while governments and institutions are struggling to influence and control populations (Schwab, 2020).

One possible way to approach this context is to go "deeper", to examine the problem at the worldview level, as well as shift our consciousness structures via practicing alternative ways of knowing. The focus taken here speculates upon the potential value of establishing a more authentic self via the cultivation of embodied presence (Anthony, 2023). This approach is not mutually exclusive from other hypothetical interventions, such as the technological, legal, educational and so on.

The wisdom of embodied presence is expressed via the somatic body and "integrated intelligence," which is an enhanced intuitive acuity (Anthony, 2023).[1] Modern cultures have already damaged the relationship between mind and body (Anthony, 2008, 2015, 2021; Kang, 2007). To further diminish that relationship in a metaverse-centred, Money and Machines Future may represent the perpetuation and deepening of a major civilisational error, one that arguably underpins the crisis in sensemaking (Anthony 2008, 2021).

As humanity approaches the possible dawning of a more democratic web 3.0 and the metaverse, our burgeoning IT systems, cultures and dominant ways of knowing are increasingly emphasising exteroception at the expense of interoception (Paul, 2021). Most notably, in an era of surveillance capitalism (Zuboff, 2019), exteroceptive stimuli are now typically mediated by invisible third parties and artificial intelligence, where the drive for profit and power is typically obfuscated. The values of the system optimise Big Tech profits by maximising clickability of content (Consilience Project, 2022; Haidt, 2022; Zuboff, 2019). The system does not encourage the development of the interoceptive gaze required for human beings to develop the mindful wisdom which could help them establish their authentic selves and to lead potentially more meaningful lives.

4. Pervasive Learning

The increasing proportion of our time spent online, combined with the rapidly changing nature of our virtual worlds may eventually require an expanded perspective on learning and education. Lifelong learning is learning extended across time. However, pervasive learning as defined by the author is learning that expands not only across time but also across multiple online and offline spaces. Thus it is likely that in future expressions of the internet, and especially if metaverse-type technologies evolve, "learning" will continue to expand beyond formal education and training, encompassing all of professional life, relationships, health and well-being, finances and entertainment. And in the context of teaching for digital wisdom (below), that may include expanded ways of knowing, incorporating interceptive acuity and embodied presence. Yet for that to occur a worldview shift is required and a re-valuing of our interoceptive experiences.

A shift towards pervasive learning could be rapid because online spaces are far more changeable and malleable than offline spaces. Secondly, even the concept of offline spaces may become increasingly redundant as mobile technologies improve, alongside augmented reality and the internet of things.

Other drivers of pervasive learning will likely include disruptions to work, society and information technology. We are living longer lives, and populations are aging (Aging and health, 2022). There has also recently been staggering

[1] The integrated intelligence model that suggests intelligence comprises a range of cognitive acuities, including: the rational/linguistic; the extended mind that emerges from the brain's intimate relationship with the body and the environment; and finally via the more contested claim of the non-local properties of cognition and intuition (Anthony 2008, 2023).

innovation in cheap and user-friendly AI systems such as ChatGPT and Bing AI; and with the mobility revolution and the future development of the metaverse, older and less agile citizens will be able (and perhaps needed) to perform non-labour intensive work well into old age, and from home. Yet this will require greater adaptability and creativity as societies age.

Thus far this paper has outlined three related and emerging trends: our increasingly online, disembodied lives; the crisis in sensemaking; and the likely need for pervasive learning. Yet how might we address these?

5. The Need for Digital Wisdom

Digital wisdom (Anthony, 2022, 2023) may help us develop preferred Deep Futures of the web and metaverse. Digital wisdom indicates the degree to which a person is in conscious relationship with digital environments and technologies. Digital wisdom thus comprises three parts.

5.1. Know thyself

This domain relates to being aware of how one's mind functions. It involves being conscious of our trigger points and personal psychological issues, and possibly our trauma. Ideally, this includes being able to bring ourselves to mindful attention at will, which is the foundation which establishes an internal locus of control.

5.2. Know the humans

Know the humans is understanding how human beings function biologically and culturally, including our tendencies toward tribalism, projection and various forms of bias (negativity bias, fundamental attribution error, cognitive dissonance etc.). Another important principle includes knowing what a bad faith actor is (Anthony, 2023). Armed with this kind of knowledge, we can be better prepared when we encounter misinformation/disinformation, and various forms of manipulation and bullying on the internet.

5.3. Know the machines

This domain incorporates an essential awareness of how the internet and communications technologies function. This includes concepts like echo chambers, algorithmic behavior and information feeds, the limitations of large language models like ChatGPT, tech giant profit models, the pitfalls of long periods spent online and in front of computers, and so on.

Digital wisdom may be achievable via changes in our technological systems (hardware and software), and in nurturing our own offline experience, including self-awareness. Ideally, we may foster awareness of the relationship between mind/body and technologies. The internet can become an inculcator of personal, social and civilizational development via a Mindful Metaverse (Anthony, 2022, 2023). However this will necessitate addressing current antithetical cultures and technologies that have led to the collapse of sensemaking, and development of effective policies and strategies that create preferable futures.

6. Embodied Presence

Cultivating greater embodied presence is part of the first domain of digital wisdom (know thyself). When cultivated across populations it may help address the problems outlined above. Embodied presence is the state of having one's attention focused in the present moment, while retaining a strong sense of felt connection to the body and its somatic wisdom (Anthony 2021, 2022, 2023).

A recent body of literature discussing somatic awareness and its relationship to neural synchronization suggests that human intelligence cannot be thought to occur only at an individual level, and that humans possess an "extended mind."

(Paul, 2021). Our brains are constantly synchronising with the people and environments we engage. Further, by learning to notice bodily intuitions, we can enhance somatic wisdom (Paul, 2021).

A related but more marginalized concept is that of the non-local mind, which can be found in many indigenous, spiritual and awakening traditions. The scientific study of the non-local mind occurs predominantly in parapsychology (Sheldrake, 2013), while the concept is also referenced in several modern alternative and philosophical discourses (Anthony, 2023).

Though the extended mind and non-local mind discourses have notable distinctions and typically draw from disparate bodies of literature, they have much overlap in theory and practice. They suggest that human consciousness is more expansive than has traditionally been represented in mainstream science, and that there is greater knowledge and wisdom accessible to human beings when they are more deeply grounded in embodied presence and where non-ordinary ways of knowing are incorporated into our sensemaking (Paul, 2021; Sheldrake, 2013). Notably, the cultivation of embodied presence can be fostered even within digital and online cultures.

7. Technology as an Enhancer of Embodied Presence

Online environments and digital technology are not necessarily antithetical to embodied presence merely because online engagement typically encourages imbalanced exteroception. Though online cultures tend to undervalue interception, engagement in metaverse-like environments can be experienced in states of embodied presence. In particular, improvements in haptic technologies in the future may help render a more embodied online experience - as is the stated objective of Meta (Mark Zuckerberg, 2022). With the probable arrival of a vastly more "natural" metaverse and a more democratized Web 3.0, online environments may feature greater embodied presence and cognitive responsibility (witnessing the mind and assuming responsibility for behavior and choices - Anthony 2021, 2022, 2023). Towards this end, the Anthony (2022, 2023) has developed the Mindful Metaverse scenario, which describes a preferred future society and internet where online experience strongly mirrors the mindful self-awareness found in traditional wisdom traditions. Such a society might develop where interoceptive wisdom is seen as a value worth preserving right across society, including online.

8. Conclusion

In this short paper it has been argued that pervasive learning will likely be a requirement of human futures into mid-twenty-first century. Within this context, developing digital wisdom and embodied presence may be part of the solution to the collapse of sensemaking in the digital society, and in turn may help create a Deep Future of the metaverse and web 3.0.

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The Feasibility of Physical Education in Metaverse

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Abstract: *Technology backed by chip technology, network communication technology, VR/AR/MR/XR technology, game technology (game engine, game code, multimedia resources), and blockchain technology is referred to as "metaverse" equipment. Augment Reality and Virtual Reality both have a wide range of potential applications. As the social metaverse's degree of accessibility increases, more practical components should be found. Some people think that using technology to solve issues is least necessary in the field of physical education. However, there are still several problems in the subject of physical education. such as the dearth of sports facilities, the disparity in access to educational resources and the standard of physical education. I believe that covering physical education in the metaverse is now popular. To overcome the limitations caused by the lack of venues, physical education in the metaverse is extremely important. This paper examined the viability of physical education in the metaverse as well as the factors affecting physical education's effectiveness. To assess the viability, we would use the definitions of metaverse technologies, examples of how the technology has been used in sports, and the meaning of the term "metaverse." Through network research and fieldwork, educational occurrences and metaverse knowledge are gathered. The information's findings suggested that Metaverse Applied to Physical Education would be highly advantageous to pupils. The significance of metaverse technologies as they relate to education is highlighted in this paper.*

Keywords: Metaverse, Physical Education, Virtual Reality

1. Introduction

In the coronavirus or corona-variant age, physical education in the Metaverse is a novel and cost-effective way to use Metaverse technologies to remove barriers to learning. Face-to-face communication has virtually disappeared in modern culture as a result of the COVID-19 epidemic. However, numerous innovative approaches to teaching and learning were used and found, such as learning in the Metaverse, which opened up new opportunities for both. This essay will outline the use of Metaverse courses and explain physical education in the Metaverse. This essay's goal is to assess the Metaverse course's viability.

2. Definition of Metaverse

Metaverse is a compound word comprising “meta” and “universe”. Meta is a Greek word meaning “transcendence or more”. Meanwhile, “universe”, which means “world”, refers to the actual world we live in. With the recent development of artificial intelligence-based technology, the imagined goals of mankind from about 30 years ago are being made into realities that we can experience, and the metaverse continues to develop as an expanded integrated space that connects the real world and the virtual world(Yu, J.-E. 2022)

it is defined as “a 3-dimensional (3D) virtual space where social and economic activities like the real world are used”, or “a new world and digitized earth contained in digital media such as smartphones, computers, and the Internet that cannot be limited to the virtual world” (Yu, J.-E. 2022).

Users of the Metaverse will likely receive a single avatar or digital identity that gives them access to a cohesive digital world. The ecosystem is supported by chip technology, network communication technology, VR/AR/MR/XR technology, game technology (game engine, game code, multimedia resources), blockchain technology, AI artificial intelligence, and technology for virtual reality. This is the fundamental reason why it might have its own money, assets, and things. This could be a digitally modified version of reality, a brand-new virtual environment, or a hybrid of the two.

Despite the emphasis on virtual experiences and technological advantages, Metaverse seems to have many similarities to the internet in its core. This implies that Education may be applicable to the Metaverse.

3. Definition of Physical education

Physical education is a cultural activity that uses physical exercise as an essence to promote physical and mental development.

Activities in P.E. include football, netball, hockey, rounders, cricket, four square, racing, and numerous other children's games. Physical education also teaches nutrition, healthy habits, and individuality of needs.[]NCHS pairs a P.E. class that incorporates cardiovascular exercise, core strength training, cross-lateral movements, as well as literacy and math strategies which enhance learning and improve achievement.（Mitchell, Stephen 2016）

4. Research Background

The present data was taken from a lot of papers taught by the network. It is worth noting that these four technologies both were the essence of Metaverse, which is widely used in the world. The objective of this research is to demonstrate that Metaverse technologies should be used to sports in physical education Accordingly, the following research questions will guide this study

What kinds of Metaverse technology should be applied to Physical education, and how does metaverse apply to sports instruction?

Based on the study *The Future of Immersive Teaching & Learning: Metaverse in Education.* presented by Senarith, P., Wachirawongpaisarn, S., & Phakamach, P. (2022). & *Rezzil Player 22 Review: Stay Fit In VR While Learning Sports!* made available by Skarredghost. (2021). The metaverse application has a few notable features. which the new features might affect how we teach physical education. The goal of this essay is to illustrate how they apply to physical education.

How much potential of Metaverse and which educational gap could benefit from Metaverse technologies applying?

According to PricewaterhouseCoopers' study of the US Metaverse for 2022. (2022). With the Action Plan for the Integration and Development of Virtual Reality and Industry Applications (2022–2026), the researcher will examine surveys that show the metaverse can close the educational gap in the current essay.

The primary goal of the current article is to examine the viability of physical education in the Metaverse. In order to achieve this goal, a mixed design that depends on the stage of the review was thought to be more effective.

5. Metaverse Technologies

5.1 .Virtual Reality (VR)

Virtual Reality is a computer-generated environment where users feel that they are in the real world even though they are interacting in the virtual world. The video gaming industry has one of the more remarkable examples of VR, where players wear VR headsets and glasses to let themselves enter the virtual gaming world. Gamers can hit, run, and feel all the activities depicted in the storyline.[3]The VR industry still has far to go before realizing its vision of a totally immersive environment that enables users to engage multiple sensations in a way that approximates reality. （Sheldon, R. 2022）However, the technology breeds unprecedented business modes and learning modes. This concept will

stimulate the production and consumption of educational content, giving birth to new educational models and generating a wealth of new entrepreneurial and investment opportunities.

Figure 1. Virtual Reality

5.2. Augmented Reality (AR)

Augmented reality (AR) is an interactive experience that combines the real world and computer-generated content. The content can span multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory. AR can be defined as a system that incorporates three basic features: a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects. The overlaid sensory information can be constructive (i.e. additive to the natural environment), or destructive (i.e. masking of the natural environment). This experience is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment.(Wikipedia Contributors. 2018,) In this way, augmented reality alters one's ongoing perception of a real-world environment, whereas virtual reality completely replaces the user's real-world environment with a simulated one.Moreover,Augmented reality is a chance that it will become our 'senses' through AR equipment and its excellent experience will even be accepted and defaulted by the brain.

5.3. Multisensory Extended Reality (XR)

The fields of virtual reality and augmented reality are rapidly growing and being applied in a wide range of ways, entertainment, marketing, real estate, training, and remote work (Chuah, Stephanie Hui-Wen 2018)

More especially, Multisensory extended reality is a kind of commixture, which combine Virtual Reality(VR), Augmented reality(AR), and Mixed reality (MR). This technology Integrates the five traditional senses to realize the rapid connection between actuality and virtual reality and enhances a variety of users' senses in virtual reality.

Due primarily to the COVID-19 pandemic, When events are regularly constrained by practical factors. It is not convenient for citizens to cheer each other at the stadium that tedious process of exercise is the inability to get feedback timely, and that is the reason why many people find it difficult to stick to them. Metaverse Technologies are the new way to break all barriers and make exercise more fun for them.

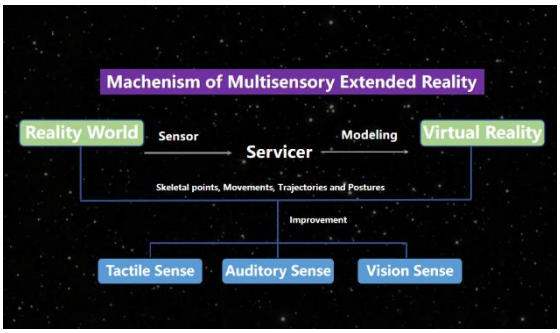

Figure 4. Mechanism of Multisensory Extended Reality (XR)

6.Metaverse Applied to Physical Education

Instructional methods for using Metaverse were continually uncovered as it was being developed. More Metaverse technologies are currently being used in the Education sector to overcome the numerous restrictions. This idea is known as "(Technology + Education)" in the academic world.

6.1. Virtual Reality (VR) in Physical Education

Academic field has been emphasizing on Virtual Reality since Instructional techniques of utilising Metaverse were continuously dug up.Virtual reality in education has been incorporated into national strategy in China.
Currently, there are some video game applications that use virtual reality to teach professional athletes.
Four separate training modes are available in games like Rezzil Player 22: Headers, Hoops Vision, Reaction Wall, and Blockz.Each practice or gaming session is highly influenced by a certain sport and can be used to prepare for that sport. The game also collects some statistics on your performances and shows them to you at the end of each session, also highlighting if you are improving with regards to your past performances. For instance, in Reaction Wall it shows your shortest and longest reaction time, while in Headers it shows your accuracy in hitting the ball, or in Hoops Vision the longest streak of circles that you have correctly hit. This encourages you to improve always more. (Skarredghost. 2021)

According to the former study, it demonstrated that A computer-generated simulation of a hands-on demonstration taking place in a digital setting. Training sessions on risk management, for instance, that focus on the management of fires and flight training for airplanes.（Phakamach, P., Senarith, P., & Wachirawongpaisarn, S. 2022).

Headers Hoop vision Reaction wall Blockz

Figure 5. Training Modes in Rezzil Player 22

Figure 6. User of Rezzil Player 22

I assume that what the first example showed also applies to physical education. Sports like football, tennis, and golf have training restrictions due to location issues, and it might be challenging to reserve a field in advance. This is the fundamental reason why Physical Education programs are rarely implemented widely in developed regions. In

Guangzhou, for instance, there is a lack of sports fields, which makes it expensive to conduct physical education classes there. However, some foundational football courses can be held outside of these locations with the help of a coach, and online courses cannot cover the physical education subject due to the fact that physical education entails participation in sports.

6.2. Augmented Reality (AR) in Physical Education

The augmented reality technology have three sectors:Head-mounted displays,tracking system,Computing Capacity on the Move.These sectors create a digital illusion in three- dimensional world. Users are able to investigate a variety of applications of the metaverse for educational purposes or for learning in augmented reality by utilizing educational impact.it is mean that everyone using AR could have digital images in their vision .on the other words, AR technology could benefit our referee training in Physical Education. For instance, there are a lot of controversial penalties in the Football World Cup. Offside or onside are always the Spotlight of the football match which could determine the validity of goals. but it is difficult for referees' naked sight to judge offside 100% correctly.AR could solve those problems, we can use AR digital images and calculations to identify offside. In daily referee education, Augmented reality can be used to power in-depth material overviews. due to this, it is easy for learners to absorb and comprehend the study case. Moreover, it could motivate the interest of learners and inspire their spirituality.

(Explain of the erroneous judgement) (Vision of FIFA World Cup Qatar 2022)

Figure 8. Controversial Offside in FIFA World Cup Qatar 2022

6.3. Lifelogging in Physical Education

Lifelogging is a recorder that could capture and preserve your living life by devices. It would automatically document and share your life whatever you use and collect your life's data. With intellectual wearable devices and lifelogging smartphone applications, you don't need to record every single thing that happens to you to log your life. This data could be analyzed to render them onto smartphone applications. on the other hand, pupils are enabled to overview their sports progress by lifelogging as it enables pupils to see where and why they made a mistake or somewhere needs improvement. so that these can be avoided or accurately changed in future.

6.4. Potential of metaverse in Physical Education

Accuracy of Physical Education: VR technology can help physical education in tertiary education majors to instruct students with more accuracy as well as the development of their interests,

Venue Shortages of Physical Education: Metaverse simulation of sports venues would widen the range of physical teaching and instructional methods.

Imbalanced Resources of Physical Education : Metaverse Applied to Physical Education using VR/AR/XR to break down the educational barriers between urban and rural.

7. Conclusion

The conclusions are summarized as physical Education in the Metaverse has a lot of real-world viability. Even with the limitations of the technologies, the potential is still astounding. The fact that Metaverse has been used to socialize and play games, both of which are fundamental components of physical education. It might be evaluated in terms of its contributions to enhancing the effectiveness of physical education instruction and addressing the venue's limitations. It is unclear what mechanisms impact performance disparities between virtual and real worlds.

I could only come up with two options. One is that the foundation of sports technique is emphasized in Metaverse physical education courses. The other possibility is Metaverse could establish a new field of Physical Education that is something like a mixture between Physical Sports and E-sports.

Despite its drawbacks, I believe that Metaverse Applied to Physical Education would benefit students greatly. Future developments could increase the application of metaverse to physical education.

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Metaverse Enhanced Project-based Learning:

Experiences from an Interdisciplinary University

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Abstract: *The development of metaverse educational software and platforms has been widely explored in the context of blended learning and has sparked discussion about whether metaverse is a boon or a bane for higher education. However, little research has been done on how the Metaverse should empower higher education when used as a pedagogical tool for student project work. In this paper, we approach this problem from a practical standpoint: We supervised an interdisciplinary Metaverse research project from the perspectives of scholarly communication, design thinking, technical skill building, and pedagogical considerations. Results show that project group members acquired skills in metaphorical embodiment, creative writing, user needs analysis, and technical design in 2.5 months. We therefore suggest that metaverse education for graduate students should pay more attention to creative perception of the world, individual sense of presence, and awareness of teamwork.*

Keywords: *Cinematic Game, Computational Media and Arts, Design Thinking, Metaphor, Science Communication*

1. Introduction

The Metaverse is more than a technology, but a vision that anticipates the future (Pan Hui et al., 2021). Metaverse in education has been widely discussed in at least two scenarios: the first is how the Metaverse redefines the conventional means of education by engaging learners in hands-on activities that are risky and difficult to accomplish in the real world; the second is how metaverse ideas reshape teaching and learning in a post-COVID -19 world. In both cases, metaverse concepts and frameworks have been explored. However, studies have rarely linked their discussions to the pedagogical implications of the Metaverse, i.e. How can the Metaverse expand students' perceptions of the world? How might individual sense-making be reconciled with teamwork? How would the roles of teachers and students change in a student-centered metaverse project?

Our research tries to bridge the gap by integrating pedagogical and educational considerations with real teaching situations by addressing the following topics:

- What elements have we considered when the Metaverse meets graduate education?
- What teaching methods have we used in developing student-centered metaverse projects?

We expect our experiences will illuminate considerations of pedagogical practice as the Metaverse evolves. As the first university to launch a plan to establish a digital twin metaverse campuses to enhance teaching and learning, we have embedded metaverse elements in multiple contexts. Technically, our foundational work in augmented and virtual reality dates back a decade and has been complemented by research in computer networks, data science, and social networking. In addition, all six technological areas of the Metaverse, i.e., blockchain, human-machine interaction, electronic games, artificial intelligence, computer networks, and digital twin, are hot research areas with a solid foundation derived from the research heritage of the host university. Finally, our interdisciplinary academic framework enables us to develop a new pedagogical idea by helping students create integrative metaverse projects that reflect the belief that "collaboration and communication are important values for the Metaverse" (Zackery et al., 2016).

The existing education system and the pedagogical frameworks in higher education need to be reformed to provide the current and future generations with timely awareness of new technologies. In addition, the grand, meta-narrative style of science communication needs to be reconsidered. Educational professionals engaged in the Metaverse need to reflect on the quality of its presence, its character, and narrative style, and its impact on the real world.

This paper describes how science communication, design thinking, computational media and arts education are integrated into a 2.5-month challenge project. We will explain our experiences with a student-centered, inquiry-based teaching method in metaverse education that focuses more on balancing individual and collective perceptions of the world than on skill development. We will also outline our teaching philosophy and rationale, describe the research project and its findings, and finally reflect on the pedagogical implications.

2. Teaching Philosophy and Rationale

Two levels of teaching philosophy and rationale inform our practice: the university level and the curriculum level.

2.1. At the University Level

As a brand new university, we “adopt the enquiry-based cross-disciplinary active learning model which blends enquiry-based and problem-focused learning to prepare our students to be future leaders and technology entrepreneurs”. Students explore new topics with their hands-on projects rather than simply following advisors' research ideas. Leadership skills, communication skills, and JIT (just in time) learning skills are practised. Students are also expected to develop a shared vision and support each other with their expertise.

The university's exercise in Maker Education sheds light on metaverse education. Maker Education was originally associated primarily with STEM (science, technology, engineering, and mathematics). Today, it can be found in various disciplines to demonstrate learning while creating something meaningful, group-based, and proactive (Hwang, 2023). Given recent trends in creative convergence education during the Industry 4.0 revolution (Kettler et al., 2021), much of the research recommends educational strategies that foster students' creative and critical processes of meaning making. This is a teaching method that highlights students' interests and guides them to create something meaningful, unique, and tangible (Hsu et al., 2017). The so-called Maker Space is our university's flagship for Maker Education. With a total area of more than 9700 m^2, it provides space for 450 students to work collaboratively. The Maker Space enables student-centered teamwork by breaking down physical and disciplinary boundaries. With more than 260 master's students from diverse academic backgrounds, we apply the project-based learning (PBL) approach and encourage students to explore real-world problems together.

2.2. At the Curriculum Level

The Challenge Project for master’s students is a good example of our impact-driven leadership development initiatives. It offers students 2.5 months to work in teams to discuss, propose, rethink, and prototype a research project. This exploratory phase, later described by students as "self-directed, self-disciplined, self-monitoring, and self-correcting," begins with students committing to the project, recruiting team members, and managing project progress. Project leaders must learn to lead, collaborate, seek resources, and ask for help when needed.

Two integrated courses support Challenge Project progress. Effective Academic Communication and Design Thinking, the two Common Core courses for all master's students, are taught jointly by 3 English teachers and 3 Design Thinking teachers. Effective Academic Communication aims to enable students to reach the widest possible audience using simple language. Design Thinking emphasizes user needs exploration and recognizes that "Metaverse emphasizes a new level of user experience between the physical and virtual worlds and therefore requires simultaneous efforts of network, system, and user-centered aspects" (Pan Hui et al., 2022).

Students may also seek advice from faculty members or other engineering-based project mentors from industry. The teaching team discusses regularly to review the rationale for presenting a particular class topic. Based on the idea that Metaverses are "fictional constructions in which participants interact through self-created avatars that attempt to replicate participation or real life in an environment of virtual metaphors without spatial and temporal constraints" (Acher, 2022), a metaphorical design thinking philosophy was proposed and applied on the part of the language teachers. The use of metaphorical expressions in representing scientific or abstract concepts is embedded throughout the semester and was the main topic of two separate lectures. Students are encouraged and guided to put themselves in the perspective of the audience rather than using a linear and top-down expert model when communicating with non-experts. Symbolic expression and visualization are also strongly encouraged for communicative purposes. Examples of SAM (storytelling, analogies, and metaphors) in science were given. These "SAM" skills are taught extensively to students, and they are encouraged to think of metaphorical or analogical expressions for scientific concepts.

In addition to regular lectures, language instructors also hold individual "communicative sprints" to address students' communicative goals. The teaching and learning process brings creative writing, esthetics, and linguistic viewpoints into play. This combination is intended to increase the focus on students' creative communication skills and analytical abilities based on an understanding of user needs.

During the recruitment roadshow, we found that many students were eager to try out projects related to the Metaverse. Over the 13 weeks, students worked together through the 5 steps of Design Thinking: Empathize, Define, Ideate, Prototype, and Test - half of them developed prototypes. We gave them instructions on four aspects: how to use symbolic and metaphorical thinking and language throughout the project; how to design the project based on the needs of the users; how to implement pedagogical goals with interactive activities; how to implement technological requirements to achieve the goals. It was found that students with a background in fine arts tend to use metaphorical means more systematically, and we decided to discuss an art technology based metaverse project in Section 3.

3. Project Design and Results

The metaverse project “Plume Tale: The Poetic Rhetoric of Meta-narrative” is both an interactive film and a cinematic game with a theme of the new university’s history. An interdisciplinary team designs it with five members with different backgrounds in *New Media Art, Film and Literature*, *Computer Science*, *Linguistics and Interaction Design*, and *Social Politics*, as is shown in Figure 1. The students “share the same aim of the humanistic spirit of the new era through research and practice of cutting-edge media and content” by poetically delivering individual stories about the university through mixed reality (MR). Everyone has different roles and contributions in the project, such as writing the story and proposal for the project, solving technological issues, visual and user interface design, and preliminary research historical footage collection.

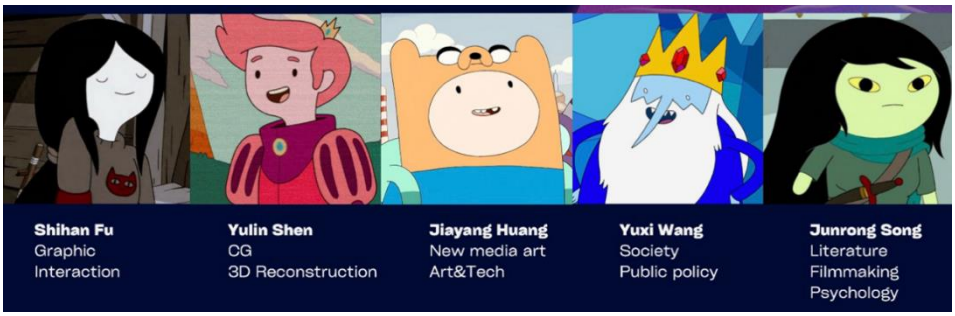

Figure 1. Comic images of team members used in project roadshow.

3.1. Implementation

The Metaverse is being developed primarily using Unity3D to run on Meta Quest 2 with hand tracking capabilities. The project involves three subtasks: 3D modeling, animation, and interaction design. First, students have to create a virtual environment modeled after the real world, which motivates them to learn some 3D modeling skills. Animation is another task. Students use Mixamo's open-source motion library to select and tune custom animations in Unity3D's animation control system so that different characters can play with different animation behaviors. The final part is the interaction design that allows the application user to play in the virtual world. The interaction design allows users to play in the virtual world, and completing these three subtasks requires interdisciplinary knowledge that can enhance student learning.

3.2. Project Storyline and Level Design

As a cinematic game, the project sets the player's mission to trigger the miracle about a red bird by helping the little girl find the missing feather. The story is revealed through a little girl's eyes when she observes how her parents open a wasteland and build a new world. A view of the virtual design is given in Figure 2.

Figure 2. View of the designed virtual scenario.

The story is a continuum of metaphors based on the history of the new university being a realistic reference blueprint. It takes the "Red Bird" as an invisible symbol, and the player searches for lost memories in the campus space interwoven with virtual and the real world. The prototype of the little girl is a teacher who has a close relationship with HKUST, and her image represents a composite character to express a shared experience and memory. Maritime elements represent the undiscovered 'blue ocean' of knowledge. At the same time, the two campuses are connected by the ocean, and the ocean represents the birthplace of original life. After experiencing and searching for memories represented by a red feather, viewers enrich their emotions, and the environment changes from gloomy to colorful.

Historical documents, materials, and archives are referenced throughout the visual style and design. Dark blue and golden yellow are used as the color scheme, and the color coordination comes from the school's emblem, which is interpreted as a blue ocean and golden brain. In the design of a virtual magic campus, the ocean and knowledge are used as design elements. On one side is the ocean, which symbolizes the origin of life, with many sea creatures and elements. On the other side is the ancient Greek sculpture of the "Academy of Athens", symbolizing the beginning of wisdom and representing the noble mind in the pursuit of morality, intelligence, health, and esthetics.

4. Pedagogical Discussions

Below we propose the following 3 pedagogical suggestions for metaverse education in the higher education context, especially for graduate students. They are based on the regular classroom meetings and discussions held by the teaching team. We also asked students for feedback after the end of the semester.

4.1. Metaverse education should focus on balancing the individual and collective sensemaking of the world

In a world where well-trained AI language models are increasingly common, only new and individualized perceptions of the world can continue to push the boundaries of knowledge. In science classrooms, sensemaking is a collaborative practice in which students share initial ideas with peers and identify disagreements or gaps in their shared understanding of the causes of phenomena or solutions to problems (Odden and Russ 2019).

Our efforts to develop students' ability to tell stories and use analogies and metaphors to reach the widest possible audience have sparked a spirit of innovation among students. Although this metaverse project has a large and rigorous theme of restoring the history of the college, it uses a different approach than the traditional meta-narrative style of science communication: a personalized and poetic worldview. Storytelling leads to more sustained and meaningful engagement with science. The metaverse environment assists a academic narrative shift from totalizing beliefs to individualized expression. In the metaverse context, living or embodied stories provide users with access to highly personalized experiences. Paradoxically, the designer and the player/viewer also foster a sense of community through interaction and interpretation of the metaphorical meaning of the story. This expands the boundaries of interactive film and the audience's experience of “being on the Internet."

The use of metaphorical concepts and symbols also allows students to better present ideas for solving real world problems. It is well known that metaphor is a fundamental component of human cognition and not just a poetic, rhetorical device (Gibbs, 1994; Lakoff & Johnson, 1980, 1999).Students develop their own interpretations of new concepts or theories rather than adopting what is considered authentic in a particular discipline. They also develop new scientific ideas and find a shared space for understanding with the audience by using metaphorical symbols.

4.2. Metaverse education should encourage peer tutoring or students as partners

What we do at the curriculum level offers an alternative to the current mode of graduate education: students as partners in creating teaching and learning content. They worked on a solid story for 2-3 weeks on its intertextuality, visual style, coherence, and interaction with the technology. With different understandings of the main character, plot, audience experience, and other issues, they were able to reach a consensus with the help of the teachers. In designing and creating such a metaverse project, students are brought to the center of education: they are the mastermind and the executive force as well. They become educators when they create. Instead of being gurus, teachers become the coordinators, coaches, and facilitators who must collaboratively find the most efficient way to make learning happen.

Student feedback indicates that they had a memorable time together through meaningful discussion, communication, and collaboration. The group consists of diverse members with different backgrounds. However, after agreeing on the goal of the project, they agreed on a leader. In this project, the lead student taught the other members software skills, and other members contributed filmmaking or data collection skills. They have found that a common goal, sound logic, and academic support are essential.

4.3. Future Work

With the rudimentary attempt to tell new academic stories from the perspective of poetic narrative, we have yet to engage diverse populations and empower them through the instructional process of scientific sense-making. If students have technical questions during project development, project mentors need to coordinate resources in a timely manner. How should teachers be involved in a metaverse project? Currently, we recommend students form a team of five to eight members with diverse educational backgrounds to encourage brainstorming. However, during the 2.5 months, some students in the group could not contribute because the task had to be more suitable for them and they preferred to work independently. Therefore, the coordinating role of faculty also presents new challenges for faculty and mentors.

The evidence is clear: to create metaverse education that contributes to students' creative perceptions of the world, an individual sense of presence, and an awareness of teamwork, new pedagogical perspectives must be fostered to move from teacher-centeredness to student-centeredness. If approached properly, the metaverse enhanced project-based learning can provide opportunities for interdisciplinary practices that help build hard and soft skills. Although this approach needs more time to flourish, in the long run it would be a significant step toward a resilient panorama of metaverse education.

Acknowledgements

We thank all the instructors, the interviewees, and students involved in this project.

Note:

All quoted sentences are from the student's project report unless otherwise specified.

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LCK：教師專業知識的新形態

Learnable Content Knowledge: A New Form of Teachers' Professional Knowledge

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【摘要】 順應全球教育教學改革趨勢，追溯中國對學習錯誤研究的歷史根源，可以從學生"學"的視角切入，提出"課目學習知識"這一新形態教師專業知識。該知識是課目知識和學生學習知識的特殊"結晶"，包含關於學生理解的知識、關於學習材料開發的知識和關於學生學習方式開發的知識。課目學習知識的建構有賴於中小學校本教學研究向校本學習研究轉型、教師教育課程轉型。課目學習知識的研究具有賦予教師知識創造者的新角色、推動學生的高品質學習和為造就一支高素質專業化創新型教師隊伍奠定知識論基礎等價值。
【關鍵字】 教師專業知識；課目教學知識；課目學習知識；教師教育；以學習為中心

Abstract: *With the trend of global education and teaching reform, tracing the historical roots of China's research on learning errors, a new form of teachers' professional knowledge called "learnable content knowledge" (LCK) could be proposed from the perspective of students' "learning". LCK is the special "crystallization" of CK and the knowledge about student learning, mainly contains knowledge about students' understanding, the development of learning materials and student learning approaches. The construction of LCK relies on the transformation of school-based teaching research to learning research and the reform of teacher education curriculum. The study will endow teachers with new role as knowledge creators, promote students high-quality learning, and contribute to create a high-quality, professional, and innovative teaching force.*

Keywords: Learnable Content Knowledge (LCK), Learning-centered**,** Pedagogical Content Knowledge (PCK), Teacher Education, Teachers' Professional Knowledge,

1. 引言

專業的一個關鍵特徵，是擁有能夠解決專業實踐問題的知識。"教師作為從事教學工作的專業人員，究竟應該擁有什麼樣'獨特'的專業知識？"這一問題，一直吸引著研究者加以探索。1985 年，舒爾曼（Shulman，L. S.）在他任主席的美國教育研究協會年會報告中首次提出"課目教學知識"（pedagogical content knowledge，簡稱 PCK）。[2]PCK 被視為教師專業知識的關鍵組成部分，能對教師的有效教學起決定性作用（Gess-Newsome, 1996），產生了廣泛而深遠的學術影響。2022 年 12 月 1 日，穀歌學術（Google Scholar）顯示舒爾曼根據報告內容發表在美國《教育研究者》刊物上的論文被引頻數已達 34,417 次。30 多年，學術界探討 PCK 的構成和基本原理，研製測量工具檢測職前與職後教師 PCK 的現狀，比較專家教師與非專家教師 PCK 的異同，進而給出相應的提升策略。

從研究視角分析，PCK 主要關注的是課目知識（課程細目知識，content knowledge，簡稱

[2] PCK 有學科教學知識和科目教學知識等多種譯法。本文將"content"譯為"課目"，系課程細目的簡稱，既指稱各分科課程的具體內容，也涵括活動課程和整合課程等非學科、非科目課程的具體內容。概念翻譯亦是一種概念建構，基於對"content"的譯法，本文將 PCK 譯為課目教學知識。

CK）與有效教學方式的融合，即課目知識的“有效教學化”，這實質上是從教師“教”的視角切入來分析教師應擁有什麼樣的專業知識，關注的是“教師如何教”相應的課目知識。但是，從國際國內教育教學改革整體發展看，以學習為中心、以學習為本、以學定教和為學而教等理念彰顯，迫切需要探察“以什麼樣的教師專業知識來支持為學而教”。為了解決這一新問題，就需要從課目知識與有效學習方式的融合層面即課目知識的“有效學習化”層面進一步深化 PCK 研究。這要求從學生“學”的視角切入觀照教師應當擁有什麼樣的專業知識，關注的是“學生如何學會”相應的課目知識。變易理論創始人馬飛龍曾在 1976 年就指出，關注學生所學內容的多樣性是非常重要的，不同學生在學習相同概念或原則等內容時的方式非常多樣。通過掌握關於學生如何學習的知識，我們無疑能夠獲得對教學最有成效的資訊。（Marton & Säljö, 1976）在這樣的背景下，本文提出“課目學習知識”（learnable content knowledge，以下簡稱 LCK）這一概念，闡述 LCK 何以成為教師專業知識的一種新形態。

2. LCK 的概念解讀

LCK，是課目知識和學生學習知識的特殊“結晶”，包含三層面的內容：一是學生關於某一課目內容的理解的知識，即關於學生理解的知識（特別是學生遭遇的困難）；二是怎樣基於學生的理解而開發最有用的學習材料的知識，即關於學習材料開發的知識；三是如何基於前兩項內容（學生理解和學習材料）設計出最有用的學習方案（過程、方式、方法等）的知識，即關於學生學習方式開發的知識。

LCK 是對 PCK 的發展，是以“概念化”的方式將 PCK 所孕育的對學生有效學習的關懷加以凸顯，啟發教師找出學生遭遇的困難並據此調整學習內容、方式與策略。當年舒爾曼正是基於對“課目知識（課程細目知識，content knowledge，簡稱 CK）和教學知識（pedagogical knowledge，簡稱 PK）這二者嚴重割裂”的批判而創造出 PCK 這一概念及其所代表的教師知識形態。舒爾曼對 PCK 的界定得到公認，即 PCK 是 CK 和 PK 的“結晶”，保證教師將需要教學的具體課目內容加以有效組織、呈現與改造進而轉化為易於理解的形式。（Shulman, 1986）教師在教的層面對 CK 進行理解和把握並用類比、例證、實例等有效教學方式加以呈現的過程，實質上創造了 PCK。LCK 不是否定 PCK，不是排斥 PCK，而是用涵括式超越的致思理路提出，教師的“教”要落實為學生有效的“學”，還需從學習層面去研究學生對 CK 的理解和把握，進而開展教學設計與實施。這個過程，實質上由師生共同創造了“關於具體課目內容的有效學習的知識”即 LCK。

由此，LCK 指引教師作為“識知者”（knower）去識別“學生對 CK 的理解”，這樣的識知（knowing）過程指向于經由促進學生的有效學習而不斷改善教師專業實踐並持續推動教師專業發展。學生的學習，一定是指向于某項要學的物件，即“學習內容”。在真實的課堂教學活動中存在三類學習內容，分別是教師設計的學習內容、教學實際運作中的學習內容和學生能夠體驗到的學習內容。PCK 主要關注到了前兩類學習內容，LCK 將以上三類學習內容都納入視野且尤其重視第三類學習內容。PCK 作為對 CK 的“有效教學化”加工，主要取決於教師對 CK 的理解和處理。而學生實際學到了什麼（這與教師設想學生能學到的內容並不一致），取決於其真正體驗到什麼。LCK 主要取決於學生對 CK 的理解和教師對“學生對 CK 的理解”的理解和處理。從 PCK 到 LCK，關鍵在於教師要去認識和把握“學生對 CK 的理解”並對 CK 進行“有效學習化”加工。這樣的過程，就是教師作為“識知者”（knower）去識別“學生對 CK 的理解”的識知過程，這是“在行動中識知”。教師的課目學習識知過程（learnable content knowing，簡稱 LCKg），就成為教師專業發展知識基礎的建構過程。基於 LCK 建構的教師專業發展，能夠改進學校和課堂中真實的教與學活動，成為能夠切實優化學生學習的教師專業發展，也才是有效的教師專業發展。

此處結合“製作渡河的工具”STEM 課程設計案例，說明 LCK 和 PCK 這兩類知識之間的區別。PCK 指引教師從教的角度出發進行有效教學。例如，教師將教學重心放在突破“影響浮力的因素”這一重難點上，為此，教師精心製作了輪船與同等質量的實心鐵塊在水中的視頻作為案例呈現給學生，引導學生通過對比分析發現浮力的大小與物體排開液體的體積有關。LCK 指引教師不僅從有效教的角度出發，還要從學生有效學的角度設計和實施教學。例如，教師發現學生在實操測試自己製作的渡河工具時，儘管能應用“影響浮力的因素”這一知識點製作出能浮在水面的渡河工具，卻常常會遇到工具不防水、易傾斜側翻等諸多問題。教師不僅沒有忽視這些問題，還將問題化為寶貴的學習資源。如，組織學生討論“渡河工具除了要能浮在水面上，還要考慮哪些因素”這一技術問題，額外提供尼龍布和塑料膜等防水材料供學生改造自己的渡河工具，並引導學生探究“為什麼這些材料能否防水”。由此，學生真實的學習需要得到珍視。

視角，決定研究視域。推動研究視角的發展，才能“見”已有視角之“未見”。教師教了，不等於學生學了，更不等於學生學會了。教學實施不僅是將教學方案付諸實踐，更要促進學生的學習。師生是教學實施的合作者，是學習成就的共同創造者。在學生完成合作前，教學實施並未完成。LCK 不是否定和排斥 PCK，而是將研究視域拓展至 PCK 所忽視的“學生如何有效學習”的維度、層面和意涵，為教師專業知識發展提供新方向，為解決“以什麼樣的教師專業知識來支持為學而教”問題提供新解答，有利於推動教學重心下移，切實關注和持續改進學生學習，進而為推動學生高品質學習和高品質教學提供新方略。

3. LCK 的建構路徑

校本學習研究和教師教育課程轉型，能夠支持教師 LCK 的建構與持續增長。

在已有的中小學校本教學研究中，存在著忙於“教的研究”而忽視“學的研究”等問題。LCK 的建構，要求教師重視和加強對學生學習的研究，即開展校本學習研究。主要包括“構建研究共同體-預備研究-正式研究”三階段組織結構和“學習研究準備-學習內容擬定（重點是挑選出對教師建構 LCK 具有範例意義的課目主題，診斷學生學習困難與學習不足，確定具體的學習目標、難點和重點，開發出適用的學習材料）-教學設計研討-教學實踐探索-研究評估回饋-研究成果昇華（將構成 LCK 的三層面內容加以顯性化、系統化，促使 LCK 在更多教師之間分享及大範圍傳播）”六步驟過程結構。

指向 LCK 建構的教師教育課程，需要課程理念、內容結構、實施策略及評估方式轉型。課程理念從重視教師（師範生）的知識獲得和情境參與走向關注知識創造；在知識創造理念的引領下，課程內容結構可以從開設專門的 LCK 課程和以 LCK 為導向適度重構已有課程兩方面加以完善；課程實施要加強院校協作，使得教師（師範生）直面“如何有效幫助學生解決課目學習困難”的問題，讓教師教育課程學習成為能夠促進 LCK 建構的過程；課程評估則將教師（師範生）的 LCK 建構與發展納入其中。

從深層次上說，LCK 不僅是新的知識概念，更代表著思維方式的變革。陶行知曾談到，在他回國後，看到國內學校裡先生只管教，便認定有改革的必要，並主張以“教學法”替代“教授法”。然而，在南京高等師範學校校務會議上辯論兩小時，都不得通過。因此，他不接受該校教育專修科主任之職。後來，陶行知撰寫《教學合一》一文，主張“教”的方法要根據“學”的方法，蘇州師範學校率先贊成採用“教學法”一詞，該詞才逐漸通行起來。（陶行知，1951）從 PCK 到 LCK，是“從教到學”的視角發展，也意味著“思維方式”隨之更新，即放棄“以教代學”等根深蒂固的習慣性思維方式，認識到“教並不等同於學，教並不必然導致學”，進而認同“為學而教”的重要性。這不是將教師邊緣化和學生主體性絕對化，而是走向師生主體間、他者關照和共生關係的新階段，並且洞察到學生在構建新知識、技能和態度的過程中承擔著最難的部分

（師生是教與學的合作者，是學生學習成就的共同創造者。學生完成有效學習，教學效果才會真實顯現。教學實施的成效，需要深達至學生學習的層面加以考察），教師要為學生的有效學習提供強有力的支援，LCK 這類知識則能有力支持教師為學而教。

4. LCK 的研究價值

4.1. 賦予教師知識創造者的新角色

LCK 作為教師專業知識的一種新形態，凸顯教師教育課程的知識創造價值，賦予教師知識創造者的新角色。教師不僅是已有教育教學知識的消費者與傳播者，更是 LCK 的生產者與創造者。概括而言，教師教育課程的發展過程中，經過了強調知識獲得、重視情境參與等階段。比如，強調讓教師盡可能廣泛地接觸、理解、內化教育教學知識以便形成相應的知識結構，這是知識獲得的定位，導致教師學而不用或學而難用，知-用脫節愈演愈烈，學習與情境割裂的問題也日漸突出。鑒於此，觀摩、跟崗和實踐等情境參與開始被重視起來，幫助教師“活化”所學知識。說到底，無論是知識獲得還是情境參與，教師都是在繼承和分享已有知識。為了促成 LCK 的建構，教師教育課程需要向前更進一步，說明教師既分享熟練教師反思形成的 LCK，更在教學情境中通過解決實際問題的“識知”行動來不斷創造 LCK。這樣，教師教育課程不僅是傳遞已有教育領域知識，更具有促成教師創造 LCK 的價值。由此，也才能真正突破有效教學的困境。因為教師面對的真實問題就是如何有效幫助所教學生解決課目學習困難，這有賴於教師擁有並持續創造 LCK 來予以支撐。

LCK 持續增長的關鍵在於教師“在行動中識知”，作為“識知者”去識別學生對課目知識的理解。這就凸顯出“行動者知識觀”（在教學情境中通過解決實際問題的“識知”行動來不斷創 LCK），超越了常見的“旁觀者知識觀”（只是去獲得已有的 LCK）。由此，教師成為知識創造者而不僅是知識繼承者，這就開拓出一條基於知識創造促進教師成長為高素質專業化創新性教師的新路徑。

4.2. 推動學生的高品質學習

高品質教育體系的建設，要能推動學生的高品質學習。擁有 LCK 的教師，能夠在深刻理解所教內容的基礎上，找出學生學習某一課目內容時遭遇的困難並據此調整學習內容、方式及策略等的設計與開發。以小學數學“兩位數乘兩位數”這一課目內容的教學為例可以直觀地反映教師具備 LCK 的重要性。例如，PCK 指引教師創新性地採取編口訣的策略幫助學生掌握兩位數乘兩位數的算法，通過在口訣中強調“積的數位要對齊”避免學生出錯，並以多道習題作為案例演示如何使用計算口訣。然而，一段時間後，學生遺忘這些口訣，計算錯誤率提升。LCK 指引教師針對這一問題展開深入研究，通過分析學生作業、向學生提問等方式，發現學生出錯的主要原因是沒有理解豎式中數位與數值的關係、對算理的理解不充分導致難以掌握算法。結合學生實際存在的問題，教師為學生補充回顧“乘法的意義”和“數位與數值的概念”等相關的學習材料，通過數形結合的方式幫助學生認識豎式計算中不同數位表示的數值，理解算理進而掌握算法。這有利於幫助每一位學生克服學習困難並提升學習勝任力，有利於滿足社會對“公平而有品質”的美好教育的需求。

4.3. 為造就一支高素質專業化創新型教師隊伍奠定知識論基礎

如何全面提升教師素質、專業化水準和創新能力已成為新時代教師專業發展決策者、研究者和實踐者必須回應的核心問題。專業知識，是評估一種職業專業化程度的重要指標，是專業人員確證自身專業地位的重要條件。LCK 這一概念的提出及這類知識的建構路徑，為教師

隊伍的專業發展提供了一種知識論層面的關鍵概念基礎，開闢了富有前景的命題“卓越教師需要具備 LCK 這類知識，而且要能在實踐中創造 LCK 這類知識”。這樣的教師不僅是已有教育教學知識的繼承者和消費者，更是新的教育教學知識的生產者和創造者。

而且，LCK 這一概念創新，為教師與學生開展 LCK 創新的行動研究建立起知識論的核心概念，為教師專業發展奠定知識論概念基礎，為校本學習研究和“院校協作”教師教育課程開發提供知識論概念基礎，有望在一定程度上促進教師教育學術研究。

5. 結語

概念是學術研究的關鍵節點。本文提出 LCK 概念並運用於思考有效教學、校本學習研究和教師教育課程轉型實踐，對豐富教師專業知識理論和推動高品質學習與教學實踐具有一定的意義。

基於 LCK 概念框架，可以繼續探討如何生成數學、化學、物理和歷史等學科類課目學習知識（相應類型 LCK 可用該學科英文首字母冠名，如 MLCK、CLCK、PLCK 和 HLCK 等）以及 STEM-LCK 等跨學科的課目學習知識，也可能探析如何幫助教師在現代教育技術支持下開發出更易於學生理解的學習內容材料以建構技術整合型的 LCK（如 TLCK、ICT-LCK 等），以及探索如何在人工智慧（artificial intelligence, 簡稱 AI）時代幫助教師運用 AI 技術診斷學生的理解狀況進而開發相應學習材料及學習方式以建構 AI 整合型 LCK（AI-LCK）。LCK 這類教師專業新知識的持續增長，可以有力支持教師成長為創造、擁有和應用能有效促進學生學習的專業知識的專家，推動中小學課程與教學成為真正以學生學習為本的課程與教學。

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Exploring In-service K-12 Teachers' Behavioral Intention of Utilizing Digital Games in the Classroom in China

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Abstract: *Educators and academics have paid significant attention to using digital games in the classroom over the past several decades. However, this application technology in China is still in its infancy. Teachers, as proponents of teaching reform and pioneers of technology integration, are essential in encouraging the implementation of digital educational games in China. This study aims to apply the modified Technology Acceptance Model (TAM) models to predict Chinese K12 teachers' acceptance of digital educational games by analyzing their behavioral intentions through a quantitative approach. A survey of 246 teachers was carried out. The study found that Chinese K12 teachers have high scores on behavioral intentions. In addition to Game Anxiety, there is a positive correlation between Perceived Usefulness, Perceived Ease of Use, Personal Innovativeness in the Domain of Information Technology, and Behavioral Intentions. Furthermore, Perceived Usefulness (B=.394, p< .001) is the significant influencing factor, which had a moderate positive relationship with behavioral intention. However, the connection between Perceived Ease of Use (B= .128, p< .05) and behavioral intention is the weakest in this study compared to the other variables. The result is inconsistent with the original TAM model, which assumed Perceived Ease of Use as a core factor. The findings filled in the gaps in K12 teachers' intentions of using digital educational games in the Chinese context.*

Keywords: *Behavioral Intentions, China, Digital Games, K12 in-service Teachers, Technology Acceptance Model*

1. Introduction

Employing digital games for educational purposes has been gaining traction worldwide. Numerous studies (Annetta et al., 2010; Callaghan, 2016; Cipollone et al., 2014) have demonstrated that teaching with digital games enhanced students' 21st-century skills, including critical thinking, problem-solving capabilities, and interdisciplinary competency, which has significant values for the cultivation of future leaders. Meanwhile, some characteristics of digital games, including competition, rewards, leaderboards, and levels, make them useful educational tools for improving students' motivation and classroom engagement (Kapp, 2012; Sailer et al., 2017). However, previous studies showed that digital games were not widely and frequently applied in the classroom by teachers (Denham et al., 2022; Evans, 2019). According to Hodges and Prater (2014), the majority of teachers selected games as the technology least likely to be adopted in the classroom. Scholars identified the reasons from external barriers, including lack of support, less equipment support, and unstable internet connectivity; as well as internal barriers, including stakeholders' negative beliefs and attitudes (Denham et al., 2022; Hew & Brush, 2007). Although the objective barriers exist, teachers' technology acceptance and related skills were seen as a longer-term issue for technology usage (Denham et al., 2022).

Teachers' individual traits play an important role in applying digital games in class. However, little research has been found on the relationship between Chinese K12 in-service teachers' individual traits and technology acceptance of digital games. Therefore, this study aims to understand and predict changes in Chinese K12 in-service teachers' technology acceptance of digital games by a modified model. Moreover, human's deliberate actual behavior is reflected in their

intentions (Davis,1989).In this study, teachers' acceptance of digital games was operationalised as teachers' behavioral intention to use digital games.

2. Literature Review

2.1. Teachers' Technology Acceptance

User acceptance describes the willingness of users to apply an informational system for particular goals, which can be modeled and predicted (Dillon, 2001). According to Hafiza Razami and Ibrahim's (2022) systematic literature review, Technology Acceptance Model (TAM), which was developed by Davis (1989), was frequently used to predict the acceptance of digital games. The reliability and validity have been fully proven. In this model, Davis (1989) analyzed and distilled two determinants of users' technology acceptance and named them Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). PU is whether users perceive a particular application to help them do their jobs better or not. A system with high PU is one in which users believe there is a positive relationship between usage performance. PEOU is the user's belief that using a system or application does not require too much effort. All else being equal, an application that is easier to use is more likely to be accepted by users. The outcome variables in TAM are Behavioral Intention (BI) and Actual Usage of Technology (AU).

In addition to the core variables listed above, TAM was typically supplemented with new factors and variables to enhance the validity of forecasts (Bourgonjon et al., 2013; Hafiza Razami & Ibrahim, 2022; Marangunić & Granić, 2015). De Grove et al. (2012) added three external variables to their research of teachers' acceptance of digital games: Game Experience, Learning Opportunities, and Curriculum-relatedness. The study showed that the model explained 68% of the variance in behavioral variance, validating the TAM model's capacity to predict behavioral intentions. The results demonstrated that Perceived Usefulness and Learning Opportunities were essential factors influencing the usage of digital games. Furthermore, in Bourgonjon et al.'s (2013) study of secondary school teachers, six external variables were added to the TAM model. According to the findings, Perceived Usefulness was the most influential variable on behavioral intention, and Learning Opportunities, Subjective Norms, and Personal Innovativeness In The Domain Of Information Technology were variables that influenced Perceived Usefulness. Marangunić and Granić (2015) suggested individual variables should be involved in future research because of their possible moderating effects, such as computer anxiety and other emotional factors.

2.2. Hypothetical Model

A modified model was developed to answer the research question, which is the relationship between teachers' individual traits and the behavioral intention of using digital games. The two key factors in the original TAM model, Perceived Usefulness (PU) and Perceived Ease of Use (PEOU), were selected as two independent variables of the individual traits. In this study, the PU was defined as the extent to which a teacher believes that adopting digital games for teaching and learning will improve their job performance and the learning of their students. The PEOU was defined as the extent to which a teacher believes that adopting digital games for teaching and learning will free from effort. The hypotheses for these two variables are as follows:

H1: Perceived Usefulness (PU) positively associate teachers' Behavioral Intentions (BI) to use digital games.

H2: Perceived Ease of Use (PEOU) positively associate teachers' Behavioral Intentions (BI) to use digital games.

Moreover, technology anxiety or technostress has been established to substantially influence in-service teachers' willingness to use technology and assessment of an application's curriculum relevance (Joo et al., 2016). It is an emotional disturbance or a personal feeling of unease when using technology (van Raaij & Schepers, 2008). The reasons for this anxiety can be a lack of infrastructure, training or support (Adukaite et al., 2017); a worry of losing important data or

making other mistakes, and a fear of looking stupid (van Raaij & Schepers, 2008). In this study, the researcher takes game anxiety as the norm of technology anxiety. Hence, the hypothesis for this variable is as follows:

H3. Game Anxiety (ANX) negatively associates teachers' Behavioral Intentions (BI) to use digital games.

Furthermore, previous studies have shown that Personal Innovativeness In The Domain Of Information Technology (PIIT) was an important factor in technology acceptance (Bourgonjon et al., 2013). The construct of PIIT was developed by Agarwal and Prasad (1998). It can be defined as "a person's willingness and attitude to try out any new information technology"(Agarwal & Prasad, 1998). Moreover, van Raaij and Schepers (2008) further explained PIIT as "a form of openness to change." Several studies (De Smet et al., 2012; Lewis et al., 2003; van Raaij & Schepers, 2008) demonstrated that PIIT is an essential feature and significantly influences technology acceptance in the educational field. The adoption of digital educational games in teaching and learning is a manifestation of teachers' technological innovation, which is significant to be considered in this study. Hence, the hypothesis for this variable was as follows:

H4. Personal Innovativeness in the Domain of Information Technology (PIIT) positively associates teachers' Behavioral Intentions (BI) to use digital games.

3. Method

This study adopted a quantitative research method. The data were collected through the questionnaire, which was adopted from the survey created by Davis (1989). The original survey's Cronbach's alpha coefficients exceeded .70. Except for demographic questions, all items used a five-point Likert scale as follows: 1-strongly disagree, 2-disagree, 3-neutral, 4-agree, and 5-strongly agree, which were converted into values of 0, 20, 40, 60, or 80, resulting in a score range of 0 to 80. This research recruited 263 Chinese K12 teachers through the snowball sampling method, while 246 valid data were obtained and analyzed by SPSS 27. The Cronbach's α of the questionnaire is greater than .7, indicating that the overall reliability of the questionnaire is relatively good and has good internal consistency. The results are shown in Table 1. A set of Ordinary Least Squares (OLS) regression with Behavioral Intention as dependent variables was conducted to answer the research question, and teachers' demographic items were designed as control variables in OLS regression. To prevent the problem of multicollinearity, all control variables were grand-mean centered before introduction into the model.

Table 1. Descriptive of the Scales and Items

Scales	Descriptive Results of Scales
Perceived Usefulness (PU) (Three items, e.g., "Using digital educational games can help me teach better.")	Mean: 70.27 Min: 20 Max: 80 Std. Deviation: 12.396 Cronbach's α：.901
Perceived Ease of Use (PEOU) (Three items, e.g., "Using educational games in the classroom would not require a great deal of effort from me.")	Mean: 46.61 Min: 0 Max: 80 Std. Deviation: 18.769 Cronbach's α：.787
Game Anxiety (ANX) (Three items, e.g., "Digital games make me feel uneasy.")	Mean: 27.97 Min: 0 Max: 80 Std. Deviation: 19.278 Cronbach's α：.886
Personal Innovativeness in the Domain of Information technology (PIIT) (Three items, e.g., "If I heard about new information technology, I would look for ways to experiment with it.")	Mean: 44.99 Min: 13 Max: 80 Std. Deviation: 14.282 Cronbach's α：.728
Behavioral Intention to Use (BI) (Three items, e.g., "I intend to use digital educational games in the classroom.")	Mean: 62.93 Min: 20 Max: 80 Std. Deviation: 13.818 Cronbach's α：.901

4. Findings

According to the OLS regression result in Table 2, the three independent variables, PU, PEOU, and PIIT, were significantly and positively correlated with BI. In contrast, ANX was significantly and negatively correlated with BI. The results are in line with the four hypotheses. In specific, the regression coefficient of PU was .394 (t= 7.648, p< .001), which means for every one standard deviation increase in PU, BI would increase .394 standard deviations, holding all other variables constant. The regression coefficient of PEOU was .128 (t=2.371, p< .05), which means for every one standard deviation increase in PEOU, BI would increase .128 standard deviations, holding all other variables constant. The regression coefficient value of PIIT was .186 (t =3.424, p< .001), which means for every one standard deviation increase in PIIT, BI would increase .186 standard deviations, holding all other variables constant. However, the regression coefficient of ANX was -.303 (t= -6.348, p< .001), which means for every one standard deviation increase in ANX, BI would decrease .303 standard deviations, holding all other variables constant.

The adjusted R^2 is .504, which means that PU, PEOU, ANX, and PIIT can explain 50.4% of the variation in Behavioral Intention. Moreover, the model has passed the F test (F (13,232) = 20.138, p< .001), which means that at least one of the scales would relate to Behavioral Intention. In addition, multicollinearity does not exist in this regression model because VIF values are all less than five. The D-W value is near two. Thus, there is no autocorrelation in the model and no correlation between the sample data. The model fits the data well.

Table 3. Regression Results of Individual Traits and Behavioral Intention

	Unstandardized Coefficients		t	*Sig.*	VIF
	B	Std. Error			
(Constant)	0	0.045	0.011		
PU	0.394	0.052	7.648	***	1.31
PEOU	0.128	0.054	2.371	*	1.441
ANX	-0.303	0.048	-6.348	***	1.123
PIIT	0.186	0.054	3.424	***	1.465
Gender (Female = reference group)					
Male	-0.112	0.178	-0.629		1.067
Prefer Not to Reply	-0.065	0.26	-0.251		1.051
Grade Level (Elementary = reference group)					
Kindergarten	0.175	0.147	1.193		1.109
Middle School	-0.02	0.114	-0.178		1.098
High School	-0.088	0.2	-0.438		1.064
Years of Teaching Experience (1 to 5 years = reference group)					
Less than 1 year	-0.288	0.238	-1.209		1.095
6 to 10 years	-0.124	0.119	-1.036		1.285
11 to 15 years	-0.014	0.136	-0.106		1.225
More than 16 years	0.265	0.132	2.006		1.224
R			.728		
R^2			.530		
Adjusted R^2			.504		
F			20.138***		

Note. *p <.05 **p <.01 ***p <.001, two-tailed. D-W= 1.850;
PU = Perceived Usefulness; PEOU = Perceived Ease of Use; ANX = Game Anxiety; PIIT= Personal Innovativeness in the Domain of Information technology; Dependent Variable = Behavioral Intention; Continuous variables (PU, PEOU, ANX, PIIT, and BI) were standardized prior to entry into the model.

5. Discussion and Recommendations

Per OLS regression analysis, the model in this study was able to explain 50.4% of the reasons for the change in behavioral intention. The findings of this study were consistent with all the research hypotheses. Three factors, namely Perceived Usefulness, Perceived Ease of Use, and Personal Innovativeness in the Domain of Information Technology, were positively associated with teachers' behavioral intentions to utilize digital educational games, respectively. However, Game Anxiety was negatively correlated with behavioral intention. The results indicated that if various stakeholders wish to encourage teachers' behavioral intention to use digital educational games, they should promote teachers' PU, PEOU, and PIIT. And reduce teachers' anxiety about the games.

Furthermore, the importance of these four factors varied. Specifically, Perceived Usefulness (B=.394, p< .001) was the significant influencing factor, which had a moderate relationship with behavioral intention. The result was consistent with previous research that found PU to be an essential indicator for testing behavioral intention (Bourgonjon et al., 2013; Hafiza Razami & Ibrahim, 2022) and was also consistent with the hypothesis of the original TAM model (Davis, 1989; Marangunić & Granić, 2015). Scherer et al. (2019) suggested that teacher education and professional development should enhance teachers' Perceived Usefulness as it was identified as a core factor in teachers' intention to use technology.

Moreover, Game Anxiety (B=.304, p< .001) was the other significant influencing factor, suggesting that teachers with negative emotions towards DEGs were less willing to employ them. The result aligned with Adukaite et al.'s (2017) research. However, the study found a weak association between PIIT (B=.186, p< .001) and BI, which showed teachers may incline to use digital games in the classroom even if their PIIT was not high enough.

Surprisingly, the connection between Perceived Ease of Use (B= .128, p< .05) and behavioral intention was the weakest in this study compared to the other variables. The result was inconsistent with the original TAM model (Davis, 1989), which assumed Perceived Ease of Use as a core factor, but was in line with Bourgonjon et al.'s (2013) study.

The addition of variables relating to the teachers' personal traits in this study increased the explanatory power of the TAM model. This study identified the importance of Perceived Usefulness and Game Anxiety in predicting teachers' behavioral intentions of using digital games. Therefore, to promote the implementation of digital games in the Chinese education context, school administrators should be aware of the importance of raising teachers' perceived usefulness, which is an effective way to increase teachers' willingness to adopt digital. Moreover, school managers should attempt to reduce teachers' game anxiety and assist teachers in enhancing personal innovativeness. To achieve these goals, relevant teacher education and training are essential (Gabriel, 2016).

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具身認知視角下桌游課程開發的原理與模型

Principles and Models of Boardgame Curriculum Development: From the Perspective of Embodied Cognition

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【摘要】 學習科學的發展，遊戲化學習等方式不斷產生，逼促教育變革。“如何將遊戲運用到課堂教學中”這一問題已深化為“如何將遊戲與教學有機整合，開發出系統且科學的課程”。本文將聚焦桌面遊戲，以具身認知為理論視角，觀照桌遊的特殊屬性，探尋桌游課程開發的原理與模型。桌遊的物質性表現為面板配件等提供的真實觸感啟動學習者的身體意識，為教學提供場域和媒介。桌遊的沉浸感通過玩法規則與遊戲敘事，為學習情境與多維互動提供條件。桌遊的物質經驗性則可幫助師生在體驗、經歷和共創桌遊課程中實現知識建構。
【關鍵字】 桌面遊戲；具身認知；課程開發；學習科學

Abstract: *With the development of learning science, gaming in education has emerged, which forcing the reform of education. The question of "how to use games in classroom" has been reframed to "how to integrate games and learning to develop a learnable curriculum". This study will focus on boardgame, using the lens of embodied cognition to reflect the characteristics of boardgame, then explore the principles and models of boardgame curriculum development. The materiality of boardgame can initiate learners' body and spatial awareness and serve as space and medium. Immersion in boardgame playing would enhance environment building and interaction through rules, gameplay and narratives. Knowledge building would happen when teachers and students co-created their curriculum and experienced it, and that is materials experience.*

Keywords: Boardgame, Curriculum Development, Embodied Cognition, Learning Science

學習科學的發展，遊戲化學習等方式不斷產生，逼促教育變革。“如何將遊戲運用到課堂教學中”這一問題已深化為“如何將遊戲與課程教學有機整合，開發出系統且科學的課程”。桌面遊戲作為遊戲的一種類型，與電子遊戲、普通玩具相比，具有“物質性”“沉浸感”和“物質經驗性”等特性。具身教育課程在批判傳統教育學身體與心靈分離的二元論基礎上，主張身體在課程實踐中的複歸，並構建身體與精神共同參與的整體課程實施模式，其內容主要關涉身體意識、學習情境、多維互動及知識建構四個部分（陳樂樂，2016）。本文以具身認知為理論視角，觀照桌面遊戲的屬性，探尋桌游課程開發的原理與模型。

1. 桌遊課程的物質性啟動學習者的身體意識

本論文受資助于中國博士後科學基金第 70 批面上資助項目“人機協同背景下師範生智慧化課目學習知識生成研究”（2021M701274）；廣東省哲學社會科學規劃 2021 年度青年專案“AI-LCK：AI 教師主講課程開發中知識增長研究”（GD21YJY13）

認知是基於身體的，也是根植於環境的。在這裡，“身體”並不僅僅指涉人的肉體，也包括了環境的“體”（body）。概言之，具身心智除了包含物理性身體外，也包括了環境和工具（葉浩生，2017）。桌遊的面板與配件提供的真實觸感，啟動了學習者的身體意識，為教學提供了場域和媒介。

1.1. 桌遊的物質性

桌遊的內在物質性（inherent materiality）是其與電子遊戲最為顯著的區分之處（Ambrosio, 2021）。電子遊戲的有趣體驗是通過螢幕和控制器來調節的，與之互動的是電腦或虛擬不在場的其他遊戲者，而桌面遊戲的趣味性在於具備“有形的物質物件”，玩家要與擁有相同物理空間的遊戲者互動。玩家和桌遊間的互動，並不局限於“規則如何塑造遊戲玩法和玩家表現”，還包括“玩家如何與它的物質元件（配件）進行互動”。桌遊配件提供的真實觸感，是玩家獲取沉浸感的前提因素，也是其優於數字電腦遊戲的關鍵因素（Kosa & Spronck, 2018）。

物質（materials）是由“屬性（如化學屬性、計算屬性等）”和“在真實應用情境中所體驗和表現出來的屬性（如物理習形式、時間形式、物質狀態等）”所表徵的（Giaccardi & Karana, 2015）。在桌面遊戲中，物質性具體表現為遊戲面板（game board）、遊戲配件（components）、規則說明書（rule book），以及玩家共用的同一物理空間。

1.2. 物質性在桌遊課程中的具體表徵

桌遊課程的物質性通過啟動學習者的身體意識實現具身認知，具體表現為兩個層面。

第一，面板決定物理空間。桌遊課程的互動主要是由遊戲面板創造的物理空間表現的。在某種程度上，遊戲面板本身就是桌面課程互動的物理空間，也是共用知識和具化遊戲狀態的中心介面，為教學提供場域和媒介。面板決定了配件間的位置關係以及參與者間的空間關係，進而影響學習者的身體運動及其對所處狀態的感知。

第二，配件規定互動方式。製作精良的桌面遊戲的觸感和愉悅感尤為關鍵，因為它能夠鼓勵學習者重複遊戲，進而反復接觸到遊戲裡蘊含的學習內容，並讓遊戲變得更加真實。與電子遊戲相比，桌遊的有形元素能夠讓遊戲更吸引人，更有趣也更容易上手（Fjællingsdal & Klöckner, 2020）。桌遊配件提供的真實觸感，啟動了學習者的身體意識，進而規定了學習活動的功能空間和課程參與者可以回應的互動空間，也體現了課程狀態和參與者間互動連結的方式。如圖 1 所示，A 通過屏風配件將玩家分為兩組，呈現出競爭關係，B 則通過共用的主面板和獨享的個人面板，定義玩家間互動連結的方式。

圖 1 桌遊配件決定物理空間與互動方式（Maurer & Fuchsberger, 2019）

2. 桌遊課程的沉浸感創設學習情境與多維互動

認知是嵌入環境中的認識主體的即時的適應活動，是一個系統事件，其發展是一個複雜的動力系統中的變化，它是諸多分散的與局部的交互作用的湧現的產物（李恒威和黃華新，2006）。換言之，認知既發生在身體內部各個部分之間，也發生在身體作為整體與環境（包含他人、情境、內容等）的碰撞、接觸和溝通之中。學習情境是具身認知的環境需求與條件保障，而多維互動是具身認知的過程要求。桌遊課程沉浸感的創設關鍵在於理解遊戲配件、玩法規則與敘事之間的關係。

2.1. 桌遊的沉浸感

沉浸感是桌游的天然屬性。相關研究主要從遊戲學（ludology）和敘事學（narratology）兩個視角展開討論，前者認為“能讓人沉浸其中的關鍵是遊戲玩法”，後者則指出“遊戲的沉浸感具體表現為玩家的體驗，即遊戲敘事”（Ang, 2006）。

在桌面遊戲中，遊戲玩法（Gameplay）是指在約定的規則框架內進行的活動，這些規則直接或間接地説明玩家實現遊戲目標。遊戲敘事（Narrative）則是對發生在某人身上的事情的敘述，它可能由“遊戲設置”“遊戲行動”“遊戲完成”等系列事件組成。換言之，遊戲玩法是玩家所採取的行動，而敘事則是關於這些行動的敘述（Ang, 2006）。遊戲玩法由規則（Rules）決定，玩法又定義敘事空間，而敘事事件（玩家體驗）也可能影響遊戲規則，進而影響遊戲玩法，三者之間互相關聯、互相影響、互相建構。概而言之，規則是溝通玩法與體驗的橋樑，是沉浸感實現的具體方式。

2.2. 沉浸感在桌遊課程中的具體表徵

桌遊課程的沉浸感通過創設學習情境與多維互動實現具身認知，具體表現為兩個層面。

第一，借助遊戲規則創設學習情境。已有學者從遊戲學和敘事學整合視角，將遊戲規則分為玩法型（Paidea rules）和勝負型（Ludus rules），進一步細分為符號（Symbolic）、語義（Semantic）、外在（Extrinsic）和內在規則（Intrinsic）。除此之外，還有硬規則與軟規則，抽象規則與敘事規則等分類方式（Caillois, 1962; Ang, 2006）。

在桌面遊戲中，學會玩桌遊不是簡單地記憶與運用遊戲規則，學會規則只是建立了遊戲的能力。玩法既要遵循規則，又以規則為導向。具體到桌遊課程中，規則對於師生而言，既是需要學習的，也是可開發的。教師在設計桌游課程時，可以學習目標開發成勝負型規則，並指導學生進行分析、拆解成一個個可實現的小目標，進而轉化為學習策略。同時，將學習過程開發成玩法型規則，變成一個個有趣的遊戲行動，引導學生思考行動間的聯繫、後果與影響，合理規劃自己的學習進程與具體行動，一步步接近並達成學習目標。

表 1 桌遊規則的類型含義與桌游課程的關聯

類型	玩法型規則		勝負型規則	
含義與目的	不以結果決定勝負的遊戲，為了玩遊戲而制定的規則		以結果決定勝負的遊戲，為了贏得或輸掉遊戲而制定的規則	
例子	每個棋子如何移動；每個配件如何使用		遊戲的結束條件或計分規則	
子類型	符號規則	語義規則	外在規則	內在規則
含義	關於可以和不可以做什麼的規則	行動間的聯繫、後果與影響	遊戲的最終目標	遊戲的策略技巧

來源	說明書規定	說明書規定與玩家體驗總結	說明書規定	玩家體驗總結
屬性	預設的	預設與生成的	預設的	生成的
課程	**學習過程與方案**		**學習目標與評價**	
學習目標與活動	班課規則	活動環節、獎懲方案	學習目標	行動目標或行動策略，由學習者建構設計
學習評價	過程性評價(如何玩→如何學)		終結性評價(如何贏→如何高分)	

第二，通過遊戲敘事實現多維互動。玩家在規則的框架下，探索遊戲構建的世界。規則在一定程度上規定著遊戲情境中世界的運作方式。但是，敘事的改變會對語義規則、內在規則產生實質性的影響，進而產生不同的玩法與體驗。玩家所執行的行動、採取的策略也會影響著遊戲的敘事，因此，每一次遊戲都有可能產生不同的情節與結果。這是遊戲沉浸感的本質，也是吸引玩家重複遊戲的關鍵。

具體到桌遊課程中，教師在課前發佈本節課的主線任務，構築一個基本的敘事空間，並指導學生自主探索合理的實現路徑，引導學生思考為達成目標，需要到哪個位置（面板）、使用什麼工具（配件）、與誰發生什麼（玩家）、可能會產生效果（情節）。這個過程中，師生與遊戲配件、規則等不同實在的多維互動形成了每個參與者的個性化課程敘事。

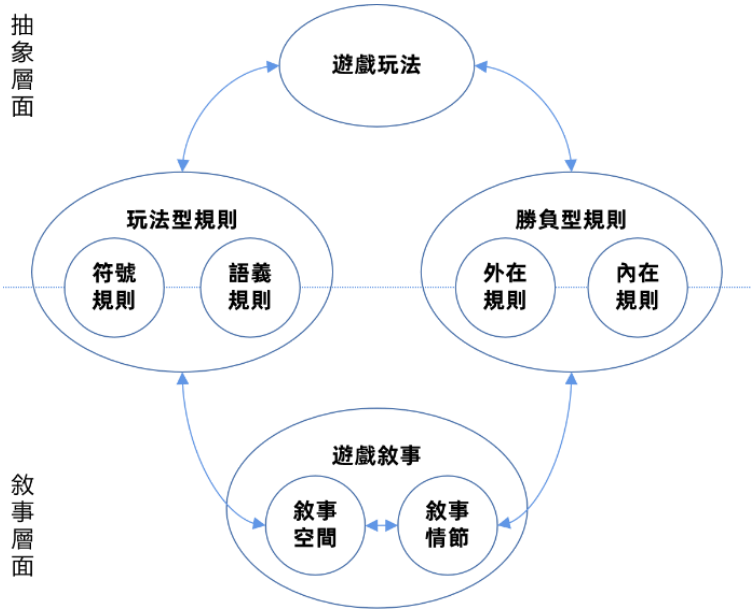


圖 2 遊戲規則、遊戲玩法與遊戲敘事的關係（Ang, 2006）

總的來說，桌遊擁有與生俱來的在“預設-生成”“規則-自由”之間平衡的機制，使得玩家需按既定規則參與遊戲，但又不失去自主支配的自由，為學習情境與多維互動提供了絕佳的條件。此外，桌游還在普通玩具只提供“玩法型規則”的基礎上，融合了“勝負型規則”，既為玩家提供了長期目標，又逼促玩家為實現遊戲目標要合理使用配件與規劃行動，即制定短期目標，在一定程度上為課程、教學與評價提供了框架。

3. 桌遊課程的物質經驗性促成知識建構

身體經驗是建構知識的一種源泉，而建構是通過活動的、鮮活的生理體驗得以實現的（Freiler, 2008；葉浩生，2017）。

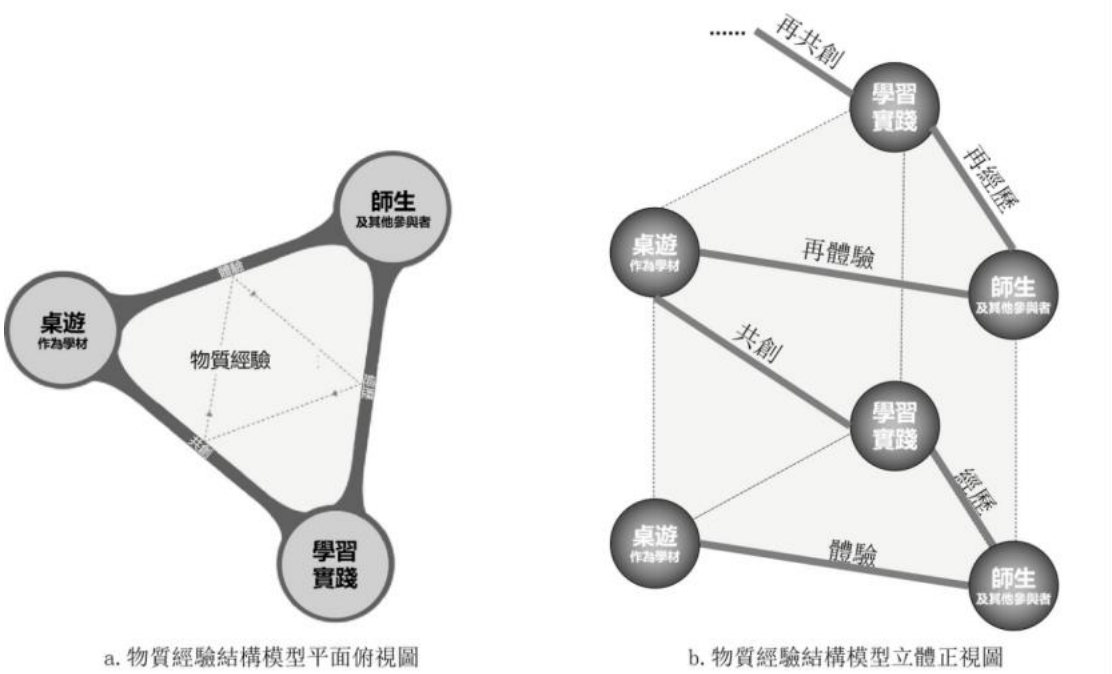
3.1. 桌遊的物質經驗性

桌遊作為一種人工製品（人造物），其物質性不僅體現為“作為組成成分的物理屬性（physicality）”，還內蘊了其可以被體驗和操作的物質屬性、呈現形式與組織方式（Barad，2007）。人們與物質交互或通過物質獲取的經驗稱為“物質經驗（materials experience）”（Karana et al., 2014）。物質在形塑我們與人造物的內部對話，以及在形塑我們的行動與實踐中均發揮積極作用。概言之，物質經驗並不是指人與物之間的相互作用，而是指人與物在相互作用中產生了特定的物質體驗（Giaccardi & Karana, 2015）。具身認知理論強調，身體經驗是人的一種存在方式，是人作為人獨特體驗。人的主體性也是通過物理性的身體與世界的互動而形成的，具身的主體性就是通過這種獨特的身體經驗而實現的（葉浩生，2017）。

3.2. 物質經驗性在桌遊課程中的具體表徵

桌遊要真正“參與”學習活動，是其物質屬性（materiality）而非物理屬性在發揮關鍵作用。其中包含三個關鍵要素與三種關係（Maurer & Fuchsberger, 2019，如圖 3 所示）。首先，一個完整的桌遊經驗課程中，至少需有師生（參與者）、桌遊（物質）與實踐（經驗）組成（如圖 3a）。

其次，三者間形成螺旋互構發展的作用（如圖 3b）。師生與桌遊第一次互動並產生初步判斷時，形成了最初的學習體驗（encounters）。隨著師生與桌遊互動的逐漸深入，師生對桌遊的判斷會發生改變，在情境化經歷中做出適切的行為表現（performance），進而建構起情境化學習實踐（practices）。在每一個情境化學習實踐中，師生會為該情境中使用的學習材料（桌遊）賦予不同的意義內涵、使用規則、操作方法等。這個過程中，師生共同創造（co-create）出學習人造物，即適合具體學習情境的個性化學材與學具。此時的桌遊已不是師生第一次接觸互動時的那個桌遊，而是被賦予了具體物質經驗的桌遊，也因此引發新的體驗、經歷和共創活動，並繼續螺旋互構創造出更加適合具體情境的桌遊與學習實踐，進而促進師生的發展。



a. 物質經驗結構模型平面俯視圖　　b. 物質經驗結構模型立體正視圖

圖 2 桌遊課程中物質經驗性結構模式圖（改編自 Maurer & Fuchsberger, 2019）

近年來，學術界普遍認可教育遊戲的重要價值和發展前景，但相關的實證研究依然匱乏，尤其是對學業成就的促進效果還需要更充分的證明。教育遊戲在國內的發展或應用情況不盡如人意，存在著發展速度緩慢，應用不均衡等問題。具身認知、學習科學等研究成果為遊戲化課程的開發提供了參考，仍需進一步深入研究，架起溝通基礎研究與教學實踐的橋樑。

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Cultural Analysis of Subculture in a Lower Track Classroom

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Abstract: *In this paper, we introduce the concept of subculture as a toolkit to understand occurrences in a classroom where manifestations of subcultures in the form of power play and resistance emerged and reified subcultures. Using event-oriented inquiry to intentionally tease out purposeful data from a case study lower track classroom and re-presenting the data using narratives, we show how subcultures of a science classroom could in fact, be closely aligned to the cultures of the scientific enterprise. We illuminate the tensions when engaging in scientific discourse in the classroom and show how subcultures could be manifested as a result of power play. This paper contributes to the education literature by offering an alternative lens to theorize classroom occurrences, informed practices and suggested the need for critical re-examination of teaching practices that lead to the emergence and reification of subcultures.*

Keywords: Cultural Analysis, Lower Track, Power Play, Subculture

1. Introduction

Students' display of acts of resistance against dominant classroom structures have been widely reported in studies (see e.g., Boren, 2019; McFarland, 2001; Toshalis, 2015). Students are social agents who covertly or overtly respond to external forces that perceivably constrain them. These forces are constitutive of norms, practices, rules, and behaviors that make them feel, more or less, as a participating member of a community. The students accept and associate themselves with cultures that may not necessarily align to the dominant institutional cultures. By culture, we refer to the "set of publicly shared codes or repertoires, building blocks that structure people's ability to think and to share ideas" (Eliasoph & Lichterman, 2008, p. 735). The students' culture are subcultures that they have co-constructed, constituting a new normalcy that circumscribes and enables them to exist in a cultural space. Subcultures do not imply less importance or subordination. Rather, it is a form that emerges from within a more long-standing structure that most people would regard as normalcy. Here, we apply the lens of subculture to understand the common occurrences in a classroom that many educators could resonate with. Using subculture as a toolkit, we want to provide an alternative theorization of these occurrences as manifestations of agency within cultures and the practice of subculturing and shed light on practices that better engage students.

2. Context of the Study

The context of this study was situated within a lower track Grade 8 (aged 14) classroom, where students who belonged to the lower 40th percentile of school-going children in that age group, were learning science. The students were tracked using their academic performance at Grade 6. Depending on their academic scores on four subjects (two languages, mathematics, and science), they were emplaced into one of the three academic tracks that offered different curriculum and years of schooling at the middle school (Grades 7-10) levels. However, the cultural phenomena observed was not unique to this class or track. Rather, it could be observed in most schools and one who has had the experience of teaching in urban city schools, could resonate with the descriptions shown later because the phenomena were as "normal" as they could be. In our case study of such a class, we adopted event-oriented inquiry (Tobin, 2014) and narrative inquiry to re-present (Byrne, 2015) the salient episodes that instantiated subcultures at play in a lower track science classroom. This

was done in hopes that the analyses would shed light on how and why students resisted classroom norms and establish subcultures—foregrounded to differentiate it from cultures and legitimised its existence and significance in the science classroom. To understand subculture, one must first understand culture. Culture, however, did not exist in isolation. It was situated within a context (structure) where individuals exercised agency to mediate culture.

3. Culture as a Toolkit

The term "culture" had inspired debate across countless academic generations. Since the seminal writings of Clifford Geertz (1973), the commonly accepted definition of culture had been described as a way of life by a community of people. This way of life included the items, language, and culturally approved norms one would require to be accepted as a member of a particular culture. Recent research had revealed the limitations of cultural values as explanations, leading to an alternative definition of culture as defined by Ann Swidler who conceptualised culture as a toolkit which individuals utilise to resolve varying forms of problems. This toolkit consisted of symbols, norms and perspectives unique to a culture. In our work, we refer to subculture as a toolkit which people utilised to prioritise end goals. This meant that individuals tend to prioritise end goals which are achievable based on the repertoire of skills available in their toolkit.

4. Subculture

Subcultures are agentic and emergent as students actively co-constructed, owned, and harnessed to mediate their science learning experiences in the classroom, such as how they chose to interact with the teacher and behave in front of their classmates. The term "sub" was often used as a prefix to suggest lower, below, under, division, and inferiority. One can easily think of associated words such as subaltern, subordination, substandard, subway, subject, subconsciousness, and subdivided. Subculture was a form of culture that the students had co-established but had been dismissed or ignored as deserving of attention because students were expected to conform to the dominant cultures decided by those who hold power and knowledge (Foucault, 1980). It is possible to harness subculture as a cultural toolkit to: (a) understand what has happened in a science classroom, (b) use it to inform practice, and (c) build knowledge about the construction and manifestations of subculture particularly in the form of resistance. First, students have co-constructed a subculture of science learning depicted by verbal exchanges that reflected resistance to the acceptance of practices that was contrary, in fact, to the practices of the scientific enterprise. In the case of the class analysed in this paper, subcultures arose as individuals resisted against the dominant school culture through the use of symbolic actions (such as the refusal to answer a question properly or the refusal to repeat an answer) as statements of resistance. Second, subculturing may be defined as the process of catalysing the emergence of new norms in the form of acts, behaviours and artefacts, in response to some internal and external factors or forces. When defined in such a way, subculturing may be undertaken by any or all groups of social agents involved in a context and on either side of the power balance. The initiation of subcultures may be incited by an individual and propagated by a group with vested interest in the process. In most cases, power is always in flux and under negotiation between different parties (Blumer, 1969). Third, through Swidler's definition, it is arguable that these students did respond to the same ideals but were not equipped with the appropriate strategies to reach the culturally dominant end goal. As a result, students utilised available strategies in their toolkits to pursue different end goals as seen in this study. In the study, Williams' (2009) two dimensions of resistance has proved especially relevant to the analysis of forms of resistance undertaken. Analysing the forms of resistance undertaken by the students would also shed some light on the origins of subculture and the manifestations of subculturing.

5. Methodology

Sewell's (2005) event-oriented social theory stated that certain events were considered to have great salience and to be transformative to participants in a study. These events were conceptualised as a spike in the curve which allowed Tobin to acquire new insights about the contextualised episode (Tobin & Ritchie 2012). We focused on events when a teacher

attempted to enforce structure in terms of cultural norms and physical arrangements. Due to the intensive micro-analysis of the events, three lesson videos in a Grade 8 classroom in Singapore were selected and analysed. The total duration of the three lesson videos were 122 minutes. We identified significant events that showcased instances of structure and agency in the classroom on the part of the students as well as the teacher. The coding process was technically supported by HyperResearch™. The process of coding often began with a list of prescriptive set codes which was identified from the research questions, theoretical framework and literature review. Eight prescriptive set codes were identified based on the theories and themes which formed the foundation of this research paper. We also used emergent coding in the analysis. The analysed data were transformed into cultural resources for interpretation and dialogue about the subcultures observed. We included our voices in the interpretive commentary below each narrative.

6. Findings and Discussion

6.1. Narrative 1: Sit down

At the start of the lesson, the teacher told the class "In three seconds, all of us quieten down". However, this doesn't seem to have much of an impact as students were still talking to each other and doing their own things. The classroom was filled with sounds of chair dragging and student laughter. This soon turned into a seven-minute period where there was plenty of student negotiation with the teacher where students such as Martyn responded "Because I want table" when asked why he was standing up. Mr Tan spent this time getting the class to go to their allocated seating arrangements. He then felt that the class was taking far too long and said, "We are wasting way too much time, we have to move on". […] Students, including Siti, Martyn, and Imran, were either talking or refusing to move to their pre-allocated seating arrangements. Mr Tan was obviously getting exasperated and starts targeting students individually, asking Martyn and Siti to sit down. While Mr Tan was dealing with the left portion of the classroom, Imran took advantage of this fact and continued dancing; ignoring the presence of Mr Tan who was standing at the front of the classroom. […] Mr Tan constantly struggled to make himself heard due to the noise level of the class and this was evident when he told Martyn, "You're laughing too loudly". Students continued with their own activities by walking across the classroom. "Cher [colloquial term of 'teacher'], he take[s] my seat, I'm supposed to sit here then he come and take" while another student responded with, "I sit beside you right". Imran also continued cracking jokes and playing a fool by raising up his hand for his own amusement.

6.2. Interpretive commentary of Narrative 1: Scientific enterprise as cultural toolkit

There was a mixed display of active and overt resistance against the structure of the science classroom. Students often exercised their individual agency by changing seats. There were a few reasons for students to do so. First, students did not want to conform without first putting up a struggle. The established classroom structure required them to be in a constant position for science and other lessons. This expectation seemed counter-intuitive to the practice of getting students to speak up and participate actively in science classroom discourse. Second, students who caused trouble when seated together were usually kept apart. As such, students sometimes sought to challenge seating arrangements as they wanted to sit with their friends. Students exercised their agency by "acting blur" and staying in their original seats, hoping that the teacher would allow them to stay in the incorrect seating arrangement. For example, Martyn exercised his agency by requesting for a change in seating arrangement hence, overtly challenging the structure of pre-allocated seating arrangements. Mr Tan first told Martyn, "Martyn don't be the last person to settle down, sit down." to which Martyn responded, "Change my sit ah". By doing so, Martyn overtly and actively resisted against the structural norms of the classroom and intentionally exercised his individual agency in doing so. While other students did not verbalise their wish to change their seats, their body language suggested that they were unhappy with their allocated seating arrangements. This could be seen from students fidgeting in their seats and talking to classmates seated far away. Such acts of resistance

could be characterised as covert resistance as these individuals did not require their actions to be recognised as acts of resistance. Martyn was constantly reminded by Mr Tan to quieten down as he was "laughing too loudly". Mr Tan also reminded him to focus while Imran completely disregarded Mr Tan's presence by continuing to engage privately with two female classmates sitting behind him. It was a sign that the students did not accept their assigned seating arrangements by engaging with students at other corners of the classroom. At the end of this event, it was evident that the teacher had exerted his authority and re-established the structural norms and expectations of the classroom in the way he wanted it. This sent a message to students that while they could attempt to exercise their individual agency, it would be futile to do so as he would make sure the structure of the science classroom would align to the way he wanted it. On hindsight, the perceived resistance reflected the practices of science characterised by active discussions and debates, collaborations across research teams and laboratories, and vested interest to work with like-minded research teams to build visibility and strength in a field of scientific research. In that light, it would seem that while the intentions to establish structures for science learning to take place in the classroom were good, it could be interpreted as contradictory in spirit to the culture of the scientific enterprise (McComas 1998).

6.3. Narrative 2: The problem with talk

At the start of the lesson, the class was in chaos. There were sounds of chairs being dragged around, and plenty of laughter. There was a sense of restlessness in the air as Mr Tan attempted to set up the projector. When Mr Tan was done setting up the equipment, it's interesting to note that he attempted to re-assert the cultural expectations in a classroom setting. He reminded the students that they were supposed to be quiet while he was teaching. Mr Tan said "Today our timing we have already lost seven minutes. This cannot be the case. Who talk, I'll make you stand up." […] Mr Tan told Martyn to "stand up" as the latter had been talking. Martyn, however, protested his innocence by saying that he was "just asking him [another student] for [a] pen". Another student interrupted the conversation by taking Mr Tan's side and asking Martyn "don't talk la". Mr Tan seemed visibly frustrated with Martyn as he commented that, "The mouth keep talking I want a pen, I want a pen, how can it be?" to which Martyn replied, "Ya, I say I want I want". There was a back-and-forth conversation between Mr Tan and Martyn before Martyn finally stood up. […] Later on, there was a commotion due to a misunderstanding between Mr Tan and Siti. Mr Tan originally said, "I can hear Siti's voice ah; Siti you want to stand up?". However, it turned out that Siti had lost her phone and was trying to find it. Several students also chimed in with comments such as, "Wah, so sad uh" "Oh my god, Hafiz taking picture ah". As a result, the flow of the lesson was disrupted yet again. […] When Mr Tan was attempting to teach the class about the term "white precipitate", he emphasised repeatedly that students had to use the specific term "white precipitate" in order to get the marks for their exam. However, students repeatedly made comments like "Wow it's turning to milk already" or "Cher, the water foggy" to which Mr Tan replied, "So, I already said I don't want to see the word milky, chalky or whatever. This is white precipitate".

6.4. Interpretive commentary of Narrative 2: Scientific talk as cultural toolkit

It was interesting to note that Mr Tan continued to reinforce the classroom norms at the start of the lesson. This could be his reaction to students' agency within the structures of a classroom. The exchange between Martyn and Mr Tan was also noteworthy as it was an indication of the dynamism within the classroom. The contestation over whether Martyn had been talking and his refusal to stand up highlights how Martyn actively used his agency to impact the cultural structure of the class. However, the fact that Martyn eventually stood up also indicated that his decision was influenced by the dominant expectation that the student should listen to the teacher. As such, while Martyn had the agency to try and change the dominant cultural norm, ultimately his decision was still influenced by the structures in a classroom, thus strengthening the dominant structure. Tensions between authoritative and dialogic discourse are present in classrooms with unequal power relationships (Scott et al. 2006). In particular, the contestation over the canonical scientific term (Kelly & Crawford 1997) "white precipitate" was also indicative of a larger issue at hand. An active and highly intentional refusal on the part

of the students to accept the dominant narrative was visible. The contrast between the canonical term was in stark contrast to the colloquial language that the students were using. Clearly, the students refused to buy into the dominant expectation that they should listen to their teachers to do well for examinations.

6.5. Narrative 3: Power play as subculturing

The start of the lesson was a chaotic one as students appeared to be especially restless. When Mr Tan said, "Come 204 stand up for greetings", the students started shouting instead of greeting the teachers in unison. The students seemed very irritable and in one instance, a student said, "shut up la" towards another student who continued talking while Mr Tan was trying to teach. The students seemed on edge and a few students on the right of the classrooms were dancing. In fact, the first ten minutes of the lesson were immensely chaotic. One students asked, "Mr Tan "Teacher can I sit down, I cannot write properly" to which another student swiftly responded, "Shut up la we also writing". Students were shouting across the classroom asking each other to shut up. […] Mr Tan noticed Farhan was not seated where he was supposed to be seating and reminded "those of you who were arranged to sit at the back go and sit at the back now". However, Mr Tan encountered resistance by the students while he was attempting to teach them about cells as they laughed at his pronunciation. While he seemed a little flustered at first, he laughed it off. […] Mr Tan looked frustrated and reminded the students of their roles and responsibilities. Mr Tan said "Have I purposefully made life difficult for you all? All I want is ask you all study hard". After Mr Tan's lecture, the class was noticeably quieter.

6.6. Interpretive commentary of Narrative 3: Power play as cultural toolkit

There was a period where the students were constantly shouting at each other and attempting to put each other down. While students often displayed acts of resistance towards the teacher, it was interesting to observe how a large part of the student-student interactions during the first ten minutes of class involved students actively attempting to get the better of one another. The students were displaying resistance not towards the teacher, but rather, towards each other. The student who said "shut up la" was displaying signs of the culturally dominant norm. This students were sending a signal that he adhered to the dominant classroom norm. This action was interesting in a context where majority of the students sought to subvert the dominant culture and not adhere to it. However, after witnessing the chaos in the classroom, Mr Tan swiftly sought to re-establish the physical structure and cultural expectations in the classroom. By reminding some of the students to go back to their seats, Mr Tan was in fact sending a message that the physical structure of the classroom would remain unchanged despite the students' best efforts to feign ignorance and exercised their agency by choosing their own seats. While the students were actively exercising their agency throughout the first fifteen minutes of the lesson, Mr Tan eventually removed their capital by "shutting them down". He individually targeted some students and eventually lectured the whole class on the importance of being well behaved and listening to the teachers. The students eventually settled down, but a particular incident highlighted how students could exercise their agency in an active manner. By publicly mocking Mr Tan for his pronunciation of "cells", an act described by students as "owning the teacher" (Author, 2020), the student was actively using his agency to tease Mr Tan, thus undermining his authority. In doing so, the student exercised his agency in the classroom and earned some respect among his peers for his actions.

7. Conclusion

We discussed how subcultures could emerge from the actions of students, in response to the dominant cultures in a science classroom. We shifted the discourse from cultures to underscore the legitimacy of subcultures in mainstream structures and advocated for its use as a cultural toolkit for theorizing and practicing in classroom teaching. In this paper, we showed how subcultures emerged from the power play and the manifestations of subculturing in the form of resistance, alternative language not used in disciplinary discourse, and power play in the classroom. It was noteworthy that the

subcultures of the science classroom were a closer reflection of the cultures of the scientific enterprise than the normative science classroom structure.

Acknowledgements

This study was funded by Singapore Ministry of Education (MOE) under the Education Research Funding Programme (ERFP) Grant (OE25/17TTW) and administered by National Institute of Education (NIE), Nanyang Technological University, Singapore. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Singapore MOE and NIE. Approval was obtained from the NTU Institutional Review Board and MOE. Informed student assent and parental consent were obtained prior to data collection.

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Teaching Data Science to Secondary Students

Using a Computational Literacy Approach

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Abstract: *With the constant advent of new technologies and software, the use of a computational literacy (CL) approach for teaching and learning is beneficial to students because it allows them to easily understand the conceptual framework of data science and show procedural calculations in a stepwise manner when synthetic and real data are given. The purpose of this study is to use computers and computational technologies to solve real-life problems and scenarios and look at their effects on how student's learning by doing is developed. To address this, we worked with a summer short course (MATH0001: Once Upon a Data – From Data to Artificial Intelligence and Human Decision) in the mathematics curriculum of the department of mathematics. This course focuses on a wide range of mathematical concepts and easy-to-learn algorithms that can be used to solve some of the challenges posed by Artificial Intelligence and Big Data, and turn data into useful information and real-life connections. Using the mathematical thinking processes, we use the general framework of computational literacy based on a four-step process: define the questions, reduce them to computational form, compute answers using computing software, and interpret the results. A CL approach was used to teach fundamental concepts along with software to students in this study and these steps were sequentially assigned to a single topic, where these topics include probability, statistics, linear algebra and data science. Our preliminary observation indicates that the CL approach increases students' engagement in learning about word problems and digital problems. This research will be continued and expanded on in the summer of 2023 to collect more data from additional courses and the methods will be applied to different topics.*

Keywords: Computational Literacy, Data Science, Mathematical Thinking Process, RStudio.

1. Introduction

In today's world, computational literacy is an indispensable tool in the study of the data science that uses computers and computational technologies to solve real-life problems and scenarios (e.g., (Papert, 1980), (Wing, 2006), (DiSessa, 2018), (Lodi & Martini, 2001) and (Braun & Huwer, 2022)). Using the mathematical thinking processes (Pólya, 1957), we use the idea of computational literacy (CL) based on a four-step process in our active learning activities (Wolfram, 2020):

Step 1: Define the questions:

- Think through the scope and details of the problem, defining manageable questions to tackle.
- Identify the information students will need to solve the problem.

Step 2: Reduce them to computational form:

- Transform the question into an abstract precise form, such as code, diagrams or algorithms ready for computation/calculation.
- Choose the concepts and tools to use to derive a solution.

Step 3: Compute answers using computing software:

- Turn the abstract question into an abstract answer using the power of computation, usually with computers.

- Identify and resolve operational issues during the computation.

Step 4: Interpret the results:

- Take the abstract answer and interpret the results, recontextualising them in the scope of our original questions and skeptically verifying them.
- Take another turn to fix or refine.

The rest of the paper is summarized as follows. In Section 2, we describe what kinds of data science topics we planned to cover/teach. In Section 3, we explain how we used mathematical thinking processes in the data science problem design and describe the different types of real-life problems. The applications of a CL approach in online teaching and learning using Zoom and RStudio are also emphasized. Section 4 summarizes some of the useful and interesting student feedback and suggestions collected by the survey. Conclusions and future works are presented in Section 5.

2. Methodology

There are six lectures in MATH0001 short course. Each two and half hour long lecture is divided into two parts. The first part lasts one and half hours, while the second part lasts an hour. The teaching materials are summarized in Table 1. Using a straightforward lecture note presentation and a verbal communication approach for conveying all relevant topics, a teacher and students interact with each other via online teaching using Zoom. To take advantage of how students gather facts and organize their thoughts and ideas from activities such reading, hearing and seeing when solving real-life problems, we use interactive laboratory activities, where students are required to do a set of procedural knowledge exercises in terms of learning by doing. Each laboratory activity is based on the methodologies of the CL approach. During the laboratory activity, students get engaged, motivated and interested when discussing their thoughts via Zoom and visualizing different outputs of graphical representation using RStudio. After the lecture, students are required to do similar problems, summarize their findings and submit their works in a docx file via Gradescope. In the lecture the following day, we give them feedback and pose answers.

Table 1. Schedule of Teaching Materials.

	Topics	Teaching Materials	Laboratory Activities
Lecture 1	Mathematics Beyond the Numbers	Classification of Data Types, and Basic Statistical Operations, e.g., Mean, Medium, Standard Deviation, Variance	Analyzing the relationship between population and murder rates
Lecture 2	Probability – Moving from Chaos to Stability	Binomial Distribution, Normal Distribution, and Law of Large Numbers	Analyzing the long term behavior of flipping fair/unfair coins and rolling dice
Lecture 3	Interpolation and Extrapolation – Difference between Observation and Reality	Least Squares Method and Linear Correlation	Analyzing the linear correlation between mileages of different autos
Lecture 4	Networks and Matrices – Connecting to the Real World	Network Measures, Centrality and Ranking	Analyzing the trust friendship network and the organization network using different types of centrality measures

Lecture 5	Text Analytics – New Era of Networked World	Frequency Table, Histograms, and Density	Analyzing short stories for making word clouds and analyzing the text contents
Lecture 6	Number Patterns – Using Vectors to Explore Pattern, Relationship and Test	Naïve Bayes Classifier and Exclusive-Or (XOR) Problems	Analyzing whether a patient had the flu or not, based on if he/she had chills, a runny nose, headache and fever

3. Design of Laboratory Activities using a Computational Literacy Approach

Features of the CL approach allow students to obtain an entirely procedural framework for solving real-life data driven problems based on computer-based algorithmic learning modes. RStudio is a straightforward tool, where lines of R codes and their graphical and numerical results show in the console, so it is a good tool to use when the focus is on collecting, cleaning, and preparing data for analysis. Mathematical formulae and equations are easily visualized by RStudio and students immediately have first-hand information after running a few lines of R codes. The six laboratory activities are summarized as follows:

Lab 1: Analyzing the relationship between population and murder rates ((Anderson & Semmelroth, 2015), (Bruce & Bruce, 2017) and (Schmuller, 2017))

Step 1: Localize estimates of population and murder rates by referring to different cities

Step 2: Compare different cities using their mean, medium, standard deviation and variance values and write down their mathematical formulae

Step 3: Calculate these values and plot the distribution of the population data by cities using RStudio

Step 4: Obtain different observations and results from the data and discuss whether the findings match a real-life scenario

Lab 2: Analyzing the long term behavior of flipping fair/unfair coins and rolling dice (Wagaman & Dobrow, 2021)

Step 1: Understand the concept of the central limit theorem using repeated experiments

Step 2: Compare standard and non-standard normal distribution cases and write down their mathematical formulae

Step 3: Calculate these values using RStudio, plot the binomial/normal distribution of the sample data for fair/unfair coins using RStudio and display the histograms/frequencies for various case studies

Step 4: Obtain different observations and results from the data by varying the size of the sample data, use numerical simulations to examine the concept of the law of large numbers and discuss their findings to determine whether it has a stable tendency and matches a theoretical concept

Lab 3: Analyzing the linear correlation between the mileage of different automobiles (Makridakis, Wheelwright, & Hyndman, 1997)

Step 1: Investigate the relationship between the price and mileage of 19 automobiles

Step 2: Write down the mathematical formulae for computing a least squares line

Step 3: Calculate these values using RStudio, have RStudio plot a scatter plot of the sample data and plot a least squares line in the same figure

Step 4: Interpret numerical results, e.g., the more expensive the car is, the higher the cost of petroleum is

Lab 4: Analyzing the trust friendship network and the organization networks using different types of centrality measures (Borgatti, Everett & Johnson, 2022)

Step 1: Find the most influential node in the undirected/directed using degree, betweenness, central, and eigenvector centrality measures

Step 2: Find the location of these nodes in the network and write down the mathematical formulae

Step 3: Find these nodes and plot the networks using RStudio

Step 4: Interpret numerical findings using trust friendship and organization networks

Lab 5: Analyzing short stories for making word clouds (Kassambara, 2017) and analyzing the text contents ((Huang, 2016) and (Li, 2019))

Step 1: Investigate the employee's survey data to find which six high technology companies are worth working for

Step 2: Compare the work ethic codes for different companies using the bar chart

Step 3: Calculate/display a frequency table of the text survey data and use the word cloud for displaying all key words using RStudio

Step 4: Discuss the reasons/factors why employees love to work for their companies given in the open source reviews

Lab 6: Analyzing whether a patient had the flu or not, based on if he/she had chills, a runny nose, headache and fever (Russell & Norvig, 2009)

Step 1: Classify a set of patients who have the flu based on a discrete set of symptoms data

Step 2: Compare different metrics for solving the same data set to see whether or not these methods produce the same result and write down their mathematical formulae

Step 3: Calculate these values using RStudio

Step 4: Use/apply a similar scientific investigation approach on the XOR problems and discuss their pros and cons using MATLAB (Haykin, 2008)

4. Discussion

As a real pilot study, there were 17 students who took MATH0001 and they were international and local high school students. A six likert scale is used here from strongly agree to strongly disagree. Fifteen students' feedback are summarized in Table 2.

Table 2. Summary of Students' Feedback.

	Strongly Agree: 6	Agree: 5	Slightly Agree: 4	Slightly Disagree: 3	Disagree: 2	Strongly Disagree: 1
The teacher(s) used relevant examples to assist my learning.	8	7	0	0	0	0
The teacher(s) encouraged active participation in class.	10	4	1	0	0	0
There was effective communication between teacher(s) and students.	8	5	2	0	0	0
The course enhanced my knowledge in this subject.	9	5	1	0	0	0
Learning outcomes of the course were clear.	7	7	1	0	0	0
The course was well organized.	7	8	0	0	0	0
Overall, I am satisfied with the learning experience.	8	7	0	0	0	0

Here are further students' comments: 1. Some topics were interesting and made me want to read more. 2. Learning/using RStudio to do mathematics and solve problems allowed me to gain programming experience. 3. More group discussion activities are needed.

5. Conclusion and Future works

The use of the CL approach with RStudio in online teaching and learning has the benefit of helping to promote data science and its related topics. Further studies are needed: 1. It would be beneficial to study the effects of making use of RStudio in more applications, e.g., writing R codes and implementing/creating the html. 2. We plan to embed more spontaneity, novelty and group discussion activities in the face-to-face lessons in our coming course in the summer. 3. Relevant observations and results of the students' learning outcomes will be published elsewhere.

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