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數位電子式聽診器於醫學大學醫學系學生呼吸音聽診教學之應用

Application of digital electronic stethoscope in the teaching of breath sound auscultation for medical school students

外科臨床實習/Clerkship, Surgery

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一. 本文 Content

1. 研究動機與目的 Research Motive and Purpose





聽診器長久以來就是醫師的代表工具。胸部聽診被視為重要的身體檢查項目,可追溯至希波克拉底時代。直到 19 世紀 Laënnec 發明聽診器,它才成為醫學廣泛採用的診斷方法。20 世紀下半葉,隨著各種影像學技術的進步,如 X 光、電腦斷層掃描、磁振造影等,醫學界對肺部聽診的興趣轉向可直接觀察肺部病變的新檢查工具。



然而,病史詢問和身體檢查仍是醫學診斷的基石。大部分疾病可通過詳細的病史詢問及精確的身體檢查取得診斷。因此所有醫學教育者都強調病史與身體檢查的重要性,醫學生也必須在每日臨床實習中加以實踐。但是,在現今醫療快速發展的環境下,各種高科技影像及檢查新技術層出不窮,容易吸引 away 醫學生對傳統病史詢問與身體檢查的注意力。臨床教師在有限的時間中也不易傳授這些

基本技能。如何在醫學教育中落實病史詢問和身體檢查的訓練,使學生真正學會應用,一直是醫學教育中持續關注的課題。

為培育出全方位的優秀醫療人才,我們期待學生能夠精通各項身體檢查技能。對胸腔科醫師而言,肺部聽診尤其重要,要聆聽及分析呼吸音是基本的臨床技能。在醫療環境快速变遷的今日,我們有必要設計適當的教學方法,讓醫學生學習這 200 年才發展出的聽診術,以及它的重要代表 - 呼吸音聽診技巧。

幸運的是,科技發展也為聽診教學帶來新的契機。電子聽診器不僅可以錄音存檔,進行聲學分析,也可以將聲音訊號轉換為視覺化的圖形,即聲紋圖,使原本主觀的聽診音色變為客觀的圖形資料。運用電子聽診器的優勢,呼吸音聽診教學可以朝向更科學、客觀的方向發展。

中山醫學大學醫學系學生在五年級臨床技能課程中,有接受過呼吸音聽診的基礎教學。但是學生反映課程內容過於緊湊,未能在病患身上實際演練。到了臨床實習階段,也無 senior 可以提供進一步指導,因此呼吸音聽診的技能很難獲得增進。有鑑於此,透過充分利用電子聽診器的優勢,設計一套創新而完整的呼吸音聽診教學課程刻不容緩。

此外,隨著教學評量工具的發展,我們可以利用教學評量軟體,將課程教材如影音檔案轉換為學習評量的題目,以便於出題與評分。透過這種電子化的教學評量,不但可以即時檢視學生的學習狀況,也可以重複進行評量,詳細評估學習成效。運用此種教學評量於呼吸音聽診課程,將可以大幅提升教學成效。

綜合以上,本研究擬開發一套運用電子聽診器與電子化教學評量的呼吸音聽診課程。我們預期這樣的創新課程不但可以增進臨床前醫學生對正常呼吸音的認識,也可以使他們熟練聽診技巧,奠定臨床實習時聆聽呼吸音的基礎,達成醫學教育培育臨床醫師的願景。如果證實本課程確實可促進學習成效,我們將可擴展應用到其他聽診項目的教學,以落實醫學生聽診技能的全面訓練。





2. 研究問題

研究計畫主題

數位電子式聽診器於醫學大學醫學系學生呼吸音聽診教學之應用。

這個研究計畫的重點在於**創新呼吸音聽診教學**， 研究對象局限於醫學大學醫學系實習生，使用之工具為數位電子聽診器以及相關的應用軟體。

創新電子式聽診器呼吸音聽診課程

將電子式聽診器及 Eko 聽診軟體運用於呼吸音聽診教學藉以建構創新呼吸音聽診之課程。藉著高科技的電子聽診器產品及課程設計提升學生對於呼吸音聽診的學習興趣, 改善目前醫學大學醫學系實習課程中的呼吸音聽診不良的教學品質。培養學生能夠成為一個精熟於呼吸音診斷病人疾病的好醫師。

這個課程衍生出來的另外一個效益為建立呼吸音聲的聲音檔題庫，可以使用聲音及聲紋圖來測驗學生的聽診程度。這是之前的聽診教學未曾使用的測驗方法。

研究計畫的主要目的

研究使用**數位電子式聽診器**之創新呼吸音聽診教學課程是否能有效地提升醫學大學醫學系實習醫學生呼吸音聽診**教學品質**以及學生**學習成效**。

這個研究的主體是醫學系實習生的**呼吸音聽診教學**，介入因子為**創新電子式聽診器呼吸音聽診課程**。研究的指標是**教學品質**和**學習成效**，研究籍學生滿意度調查檢驗教學品質，並且以前後測來看學生的學習成效。

3. 文獻探討 Literature Review

聽診器是近百年來醫療專業人員的象徵!

醫學歷史學家 Jacalyn Duffin 認為，聽診器的發明標誌著將疾病從一系列症狀重新定義為將疾病視為解剖系統問題的重要一步. Duffin 認為，這種重新概念化在一定程度上發生了，因為在聽診器出現之前，沒有用於探索身體內部解剖結構的非侵入性醫療器材。

研究表明，醫學生的身體理學檢查技能往往需要提高。尤其美國，加拿大和英國都有大量研究論文來證實這個情況。目前的的教學研究為個別的身體理學檢查教學方法的有效性提供了一定程度的證據。它認可身體理學檢查醫學教育需要進一步發展(Mosshammer, Graf et al. 2017, Yale, Tekiner et al. 2021)。Kim et al. 研究顯示呼吸音聽診確率為醫學生 60.3%，實習生 53.4%，住院醫師 68.8%，研究醫師 80.1%(Kim, Hyon et al. 2021)。也就是說用聽診來診斷病人的疾病的準確度無法被委員所接受，有待努力提升。聽診器問世 200 週年的紀念文章亦指出,在 20 世紀下半葉，開發了新的強大的無創診斷方式，因而對聽診的興趣下降。結果，各級培訓的學生和醫生的聽診技能下降到令人失望的低水平。回顧文獻並考慮到患者就診的環境，包括先進診斷設施的可用性，作者群得出結論:歷史悠久的聽診器儘管有其局限性，但仍具有作為患者友好、有效、和經濟的醫療儀器。然而，需要採取新的舉措來培訓學生、醫生和相關衛生專業人員進行聽診，以避免可能傷害患者，並產生額外高價儀器的費用。(Bank, Vliegen et al. 2016, Legget, Toh et al. 2018)

1816 年, 聽診器由法國巴黎 Necker-Enfants Malades 醫院的 René Laennec 發明(Laennec 1819)。它是單聲道的由一根木管組成。 Laennec 發明了聽診器，因為他不習慣將耳朵直接放在女人的胸部聽她的心臟(Roguin 2006, Permin and Norn 2016)。

1840 年，Golding Bird 是第一個發表他一直在使用帶有軟管的聽診器(Bird 1840)。

1940 年代, Rappaport 和 Sprague 在設計了一種新型聽診器，它成為其他聽診器的測量標準，由兩側組成，其中 Diaphragm side 用於呼吸系統聽診，bell side 用於心音聽診。

直到 1960 年代初，哈佛醫學院教授 David Littmann 發明了一種比以前的型號更輕並改進了聲學性能的新型聽診器[U.S. Patent 3,108,652]。 因此 Littmann 成為 3M 聽診器品牌的名稱。

電子聽診器能夠將聲音轉換為電子信號，該信號可以進一步放大以獲得更佳聆聽效果(Araj and Cox 2019, Silverman and Balk 2019)。電子聽診器的性能通過將低於 50 Hz 的心音、胸音和腸音轉換為 200 Hz 的頻率範圍，而不會損失保真度，從而提高了其性能，該頻率範圍很容易被人耳檢測到(Aumann and Emanetoglu 2019)。也就是說電子聽診器能夠聽到傳統式聽診器聽不到的低頻聲音。 這些電子信號可以進一步處理和數字化，以傳輸到個人或膝上型電腦，手機以及耳機裡面。目前，許多公司提供電子聽診器。Eko Core 可以將聲音無線傳輸到智能手機或個人,膝上型平板電腦。由於聲音以電子方式傳輸，因此電子聽診器可以是無線設備，可以是錄音設備，並且可以提供降噪、信號增強以及視覺和音頻輸出。大約在 2001 年，Stethographics 將心音和呼吸音除了聲音之外，並以聲紋圖形表示。所有這些功能都有助於遠距醫療（遠距診斷）和教學的功能。目前，幾乎所有可用的電子聽診器都允許選擇不同的頻率模式，使聽者能夠更好地聽到來自心臟、肺和身體其他部位的聲音。電子聽診器還可以通過多種機制抑制環境噪聲和摩擦噪聲，讓聽者聽到盡可能原始的聲音。 例如，3M® Littmann Range 提供壓電傳感器，該傳感器使用環境降噪作為噪聲消除器，並可將聲音放大 24 倍。

因為上述電子式聽診器的特性，許多人努力做了許多開創性的研究，將電子式聽診器應用到不同的領域之中，提升了醫療的水準

研究顯示數位化錄音和心音圖 (digitalised sound recordings and phonocardiograms ,dPCG) 技術, 有助於診斷心臟雜音，尤其是對於那些心臟病學經驗較少的人(Voros, Nolte et al. 2011)。

新生兒是很特殊的一個群體。因為他們很脆弱，很難承受侵入性的治療或診斷，並且沒有辦法控制自己去配合一些診斷性的儀器。因此簡單非侵入性的電子式聽診器在新生兒診斷的領域當中被視為一個利器。Zhou 使用電子式聽診器和電腦化呼吸音分析,在新生兒中。 共獲得了 26 名足月和 26 名早產兒的錄音。Zhou 發現電子式聽診器 能夠確定足月兒和早產兒在室內空氣中呼吸的聲學特徵之間的顯著差異(Zhou, Marzbanrad et al. 2020)。Ramanathan 使用數字聽診器 (DS) 來評估生命最初 2 小時內呼吸音特徵的變化及其與分娩方式的關係。呼吸音的頻率分佈從 1 分鐘到 2 小時顯著下降，平均 (標準差) 頻率從 333.74 (35.42) 下降到 302.71 (47.19) Hz，$p < 0.001$，以及功率比例 (標準差)最低頻帶從 0.27 (0.11) 增加到 0.37 (0.15)，$p < 0.001$。在 1 分鐘時，自然產嬰兒的頻率略高於剖腹產，但在 2 小時時沒有差異。關於新生兒的肺通氣過程目前已知 肺液清除和肺通氣是促進呼吸的關鍵過程，而分娩方式會影響這一過程。 電子式聽診器提供增強的聽診功能，並已在兒科人群中用於評估肺和心臟,以預測呼吸音的發展，評估預測新生兒出現症狀前的呼吸窘迫(Ramanathan, Marzbanrad et al. 2020)。 Treston 使用電子式聽診器、手持超音波和心電圖在出生後立即評估新生兒心率(Treston, Semberova et al. 2019)。

聽診器的一個強大的功能就是在探索血液在管腔中流動所產生的聲音。因此許多人將電子式聽診器應用於心臟血管疾病的發現與診斷。顱內動脈瘤會產生在一個特殊的頻率範圍內雜音，這種雜音受壁厚的影響很大。了解產生雜音的機制可能使我們能夠無創地研究動脈瘤。 4 名眼動脈瘤患者在血管內治療前後使用數位電子聽診器進行研究。從雙眼的數字記錄中可以獲得雜音的音譜(Jou and Mawad 2010)。Chowdhury 提出了一種實時數位電子聽診器系統的原型模型，以實時(real time)監測患者的心音並診斷任何異常。用於心臟疾病的早期檢測的便攜式系統存在未滿足的需求(Chowdhury, Khandakar et al. 2019) 。Makaryus 使用數位電子聽診器來對冠狀動脈微雜音進行檢測，即通過標準聽診無法聽到的微弱雜音，可能為診斷冠狀動脈疾病提供另一種檢測方法。其研究的目的是測試新型數位電子聽診器心臟超聲譜分析儀（CSA；SonoMedica 模型 3.0，SonoMedica，Inc.，Vienna，Virginia，美國食品和藥物管理局）的準確性與使用心臟電腦斷層掃描 (CT) 血管造影的金標準診斷相比，診斷冠狀動脈疾病。數位電子聽診器心臟超聲譜分析儀識別任何主要心外膜冠狀動脈狹窄 >50% 的總體敏感性為 89.5% ($p <0.0001$)。基於較小樣本量的性別特定模型在胸毛較重的男性中的結果稍差，特異性較低。總之，數位電子聽診器心臟超聲譜分析儀顯示出在門診環境中檢測顯著早期冠狀動脈疾病 的高靈敏度和特異性，並且代表了一種新的無創設備，用於檢測冠狀動脈疾病中發生的異常冠狀動脈血流。(Makaryus, Makaryus et al. 2013)

在手術室要偵測病人的狀況所能夠使用的醫療儀器十分有限。 因為病人在開胸剖腹的情況之下要移動到別的地方去進行檢測非常的困難。在手術的情況之下病人的生理狀況變動大且即時，常常需要實時的連續性的檢測。因此數位電子聽診器就是一個很好的工具能夠連續的檢測病人的狀況。。許多麻醉醫師就發表了數位電子聽診器用在麻醉病人的研究。Duck 在全身麻醉下對患者進行的基本心音監測程序。由於第一心音(S1)的振幅大小(電子聽診器的圖形表示)可以表達左心室功能，因此研究其與心輸出量的相關性。在各種情況下，S1 的振幅與 CO (心輸出量) 的變化具有顯著相關性(Duck Shin, Hoon Yim et al. 2014)/。Klum 使用多模式貼片聽診器從單個 55 毫米心電圖導程估計埃因托芬心電圖 (ECG)導程 I 和 II。使用聽診器和 ECG 子系統，估計射血前期 (PEP) 和左心室射血時間 (LVET)。得出結論為，使用可穿戴多模態採集設備估計 ECG、PEP、LVET 和呼吸參數是可行的，並鼓勵進一步研究多模態信號融合以估計呼吸信號(Klum, Urban et al. 2020)。亦有麻醉科醫師使用數位電子式聽診器以及數字信號處理軟件（Goldwave）在監測插管患者通氣。這項初步研究表明，此技術可能有助於為檢測氣管插管錯位提供實用的實時警告系統(Doyle and Nair 2009)。 另外有麻醉醫師研究開發的數位電子式經食道聽診器來偵測病人在心臟手術時候的狀況。在保留傳統食道聽診器優點的同時彌補了傳統食道聽診器的不足，不僅可以通過食道導管檢查心音和雜音，還可以顯示心音和雜音的幅度和波形，並測量患者的體溫。 .因此，所開發的數位電子式經食道聽診器有望在手術過程中對心音的連續聽診用，並通過提供心音數據為心音研究做出貢獻(Shin, Lim et al. 2010)。

電子聽診器克服了傳統聽診器的局限性，將聲音數據轉換為電信號，可以放大、存儲、重放，更重要的是，病人可以將聽診的結果發送給專家和醫師，專家和醫師可以根據所得到的圖形和聲音進行診斷， 讓遠距的病人得到及時的醫療指引及照顧， 使其在遠程醫療中非常有用。(Lakhe, Sodhi

et al. 2016)

電子聽診器可以將聲音數位化，並且以聲紋圖呈現，因此可以和人工智慧(AI)並用來發展出傳統聽診器無法達到的運用。心臟科醫師將電子聽診器與電腦及人工智慧(Artificial Intelligent, AI) 聽診程序一起使用，以分析記錄的心音病理性或無害的心臟雜音(Chorba, Shapiro et al. 2021)。小兒科醫師在”Time-domain analysis of heart sound intensity in children with and without pulmonary artery hypertension: a pilot study using a digital stethoscope”論文中 11 名患有肺動脈高壓（中值 mPAp：55 mmHg [範圍：25-97 mmHg]）和 11 名沒有肺動脈高壓（中值 mPAp：15 mmHg [範圍：8-24 mmHg]）。 P2ratioA2 (P = .0001) 和 P2ratioS2 (P = .0001) 強度比在有和沒有肺動脈高壓的受試者之間有顯著差異。 P2ratioS2 和 P2ratioA2 強度比與 mPAp 之間存在線性相關性 (r > 0.7)。我們發現 P2ratioA2 和 P2ratioS2 強度比可以區分有肺動脈高壓的兒童和沒有肺動脈高壓的兒童。這些發現可能有助於開發診斷肺動脈高壓的聲學設備(Elgendi, Bobhate et al. 2014)。在呼吸音的研究方面目前使用 AI 檢測 crackles 或 rales 的總體靈敏度為 80% (95% CI 72-86%)，特異性為 85% (95% CI 78-91%)(Gurung, Scrafford et al. 2011, Ali, Hasan et al. 2021, Kim, Hyon et al. 2021) 。風濕性心臟病 (RHD) 在全球範圍內造成顯著的發病率和死亡率。為了減輕風濕性心臟病的危害，及時啟動二級預防也就是對風濕性心臟病的篩檢很重要。心臟病醫師設計了一個使用來自數位電子聽診器的波形數據訓練深度學習算法以預測亞臨床風濕性心臟病的研究，並確定亞臨床風濕性心臟病的發生的頻率(Ali, Hasan et al. 2021)。

目前使用電子聽診器與臨床的教學並不多主要集中於心音的聽診。Mesquita et al.於論文中指出與使用傳統聽診器的組 (29.5%) 相比，使用電子聽診器的組 (51.9%) 的識別心音的能力改善明顯更大。使用電子聽診器心音的短期聽診教學能夠顯著提高識別心音的能力(Mesquita, Reis et al. 2013)。Dr. Legget 執行了一個電子聽診器於心臟聽診教學的研究。對照組從訓練到驗證期的平均 95% CI 增加為 2.5% [-11.5, 16.5] P = 0.95, 介入組 15.8% [1.7,29.8] P= 0.027。在兩組的驗證和培訓課程之間，分數增加了 9.1% [1.82, 16.4] (p = 0.018)。對照組和介入組評分的平均 [95% CI] 差異為 1.9% [-5.4, 9.2] (p = 0.59)。 Cohen 的效應量估計值為 0.9。這個研究的結論是電子聽診器是心臟聽診教學的有用設備(Legget et al. 2018)。

綜合上述的研究， 電子聽診器可以加強呼吸音聽診的品質 ， 可以將呼吸的聲音放大，將聽不到的頻率轉換成聽得到的頻率，過濾掉雜音，並且將聲音給予數位化的記錄，並且轉換成為聲紋圖形呈現，並可以配合人工智慧做聲音的分析與診斷。 心臟科應用於對於心音聽診品質的提升；小兒科應用於對新生兒的監測；麻醉科應用於對麻醉病人狀況的掌握；並使用於遠距醫療。且成功的應用於心音聽診教學。。因此我們將電子聽診器應用於呼吸音聽診教學、先讓醫學生需用高科技的電子聽診器以及 Eko app 提起學生對於呼吸音聽診的興趣，透過課程及教材讓學生增加對呼吸音聽診的了解，並且藉由作業在病人身上實作並教師的回饋以獲得正確呼吸音聽診的實作經驗。之後繼續出借電子聽診器以及 Eko app 給學生在別科的實習課程中加強他們呼吸音聽診的學習成效，讓他們就算不在本科也可以藉由科技延伸學習。預計可以達到良好的教學效果，改善學生對於呼吸音聽診學習的興趣，並且達到良好的教學品質與評量。 未來亦可將此教學推展到心臟科、麻醉科、小兒科、以及臨床相關科系，為培養下一代優良的醫師及醫療從業人員做出積極的貢獻 。

4. 教學設計與規劃

創新課程方案名稱： **電子式聽診器呼吸音聽診課程**

(1) 教學設計與規劃說明

教學目標

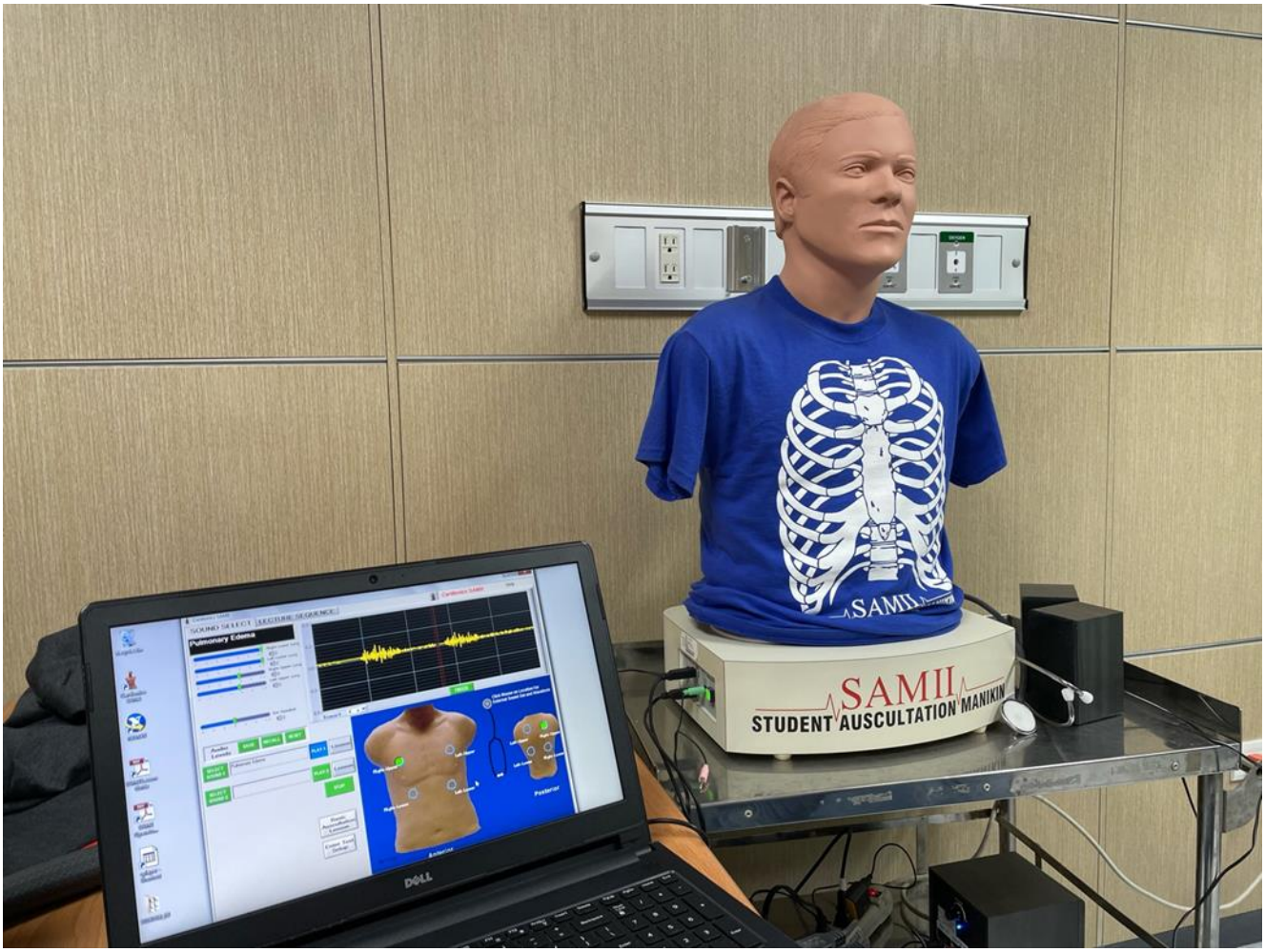
教導醫學大學醫學系五六年級實習醫師呼吸音聽診達到精熟的程度。

教學方法

實習課程本來就是在做中學習。本課程一樣採取實作中學習的方法，讓醫學生能夠落實呼吸音聽診教學。其中落實的方法如下，

1） 臨床技能中心(OSCE center)

至本校臨床技能中心(OSCE center)利用呼吸音模具 SAM II 學習十種呼吸音。 SAM II 可以用聽診器實際在模具上進行聽診教學。並有聲音及聲紋圖可供學習。



2) 呼吸音教學影片

接著發給學生學習教材，其中包括紙本教材及 YouTube 教材，連結如下。因為在醫學系四年級時，這些教材都有提過。故不再做講解。請學生自行複習。

https://www.youtube.com/watch?v=eWGxuwVk3gs

https://www.youtube.com/watch?v=TlgP8MzlMaw

https://www.youtube.com/watch?v=TlgP8MzlMaw

https://www.youtube.com/watch?v=LHqqvrm2j6g Fine Crackles (Rales)

A. Tracheal Sound 正常的氣管聲音為在呼吸週期的兩個階段都可以清楚地聽到。

B. Normal (Vesicular) Lung Sound 肺音的正常頻率為 100 至 1000 Hz 正常的肺音只能在吸氣和呼氣的早期階段聽到。

C. Bronchial Breathing

D. Stridor 高音調。

E. Wheeze 100 至 5000 Hz 吸氣、呼氣或兩者都可以聽到，並且本質上是音樂性(musical)的，具有高音調。

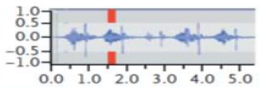
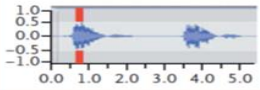
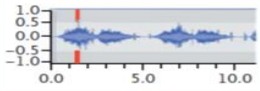
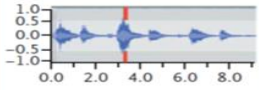
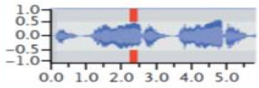
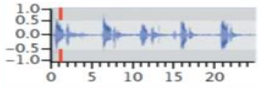
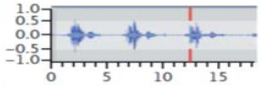
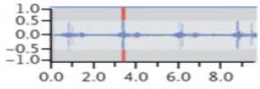
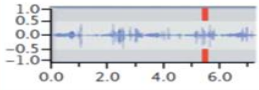
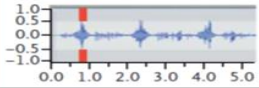
F. Rhonchus 150 Hz 可能吸氣、呼氣或兩者皆可聽到，本質上類似於打鼾的低音調。

G. Fine Crackle 650 Hz 吸氣中後期可聽到細微的劈啪聲，呼氣時可聽到，通常不會轉移到嘴裡，不受咳嗽影響。

H .Coarse Crackles 350 Hz 在吸氣早期和整個呼氣過程中聽到，受咳嗽的影響，轉移到口腔。

I. Pleural Friction Rub 爆炸性。

J.Squawk (short wheezes) 10 to 100 ms ，200 and 800 Hz。

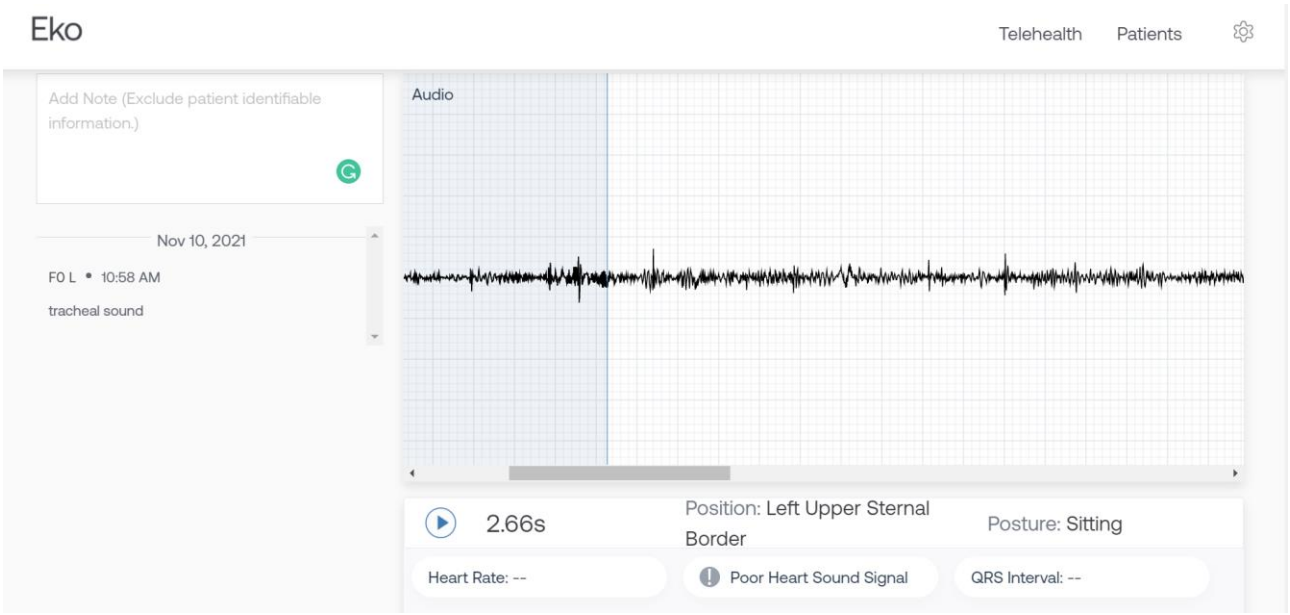
Respiratory Sound	Amplitude–Time Plot	
Acoustics	Unexpanded time	Expanded time
A Tracheal Sound White noise Typical frequency, 100–5000 Hz Drop of energy at 800 Hz		
B Normal (Vesicular) Lung Sound Low-pass-filtered noise Typical frequency, 100–1000 Hz Drop of energy at 200 Hz		
C Bronchial Breathing Strong expiratory component An intermediate sound between tracheal and normal breathing		
D Stridor Sinusoid Fundamental frequency, >500 Hz		
E Wheeze Sinusoid Typical frequency, >100–5000 Hz Typical duration, >80 msec		
F Rhonchus Sinusoid Typical frequency, about 150 Hz Typical duration, >80 msec		
G Fine Crackle Rapidly dampened wave deflection Typical frequency, about 650 Hz Typical duration, about 5 msec		
H Coarse Crackles Rapidly dampened wave deflection Typical frequency, about 350 Hz Typical duration, about 15 msec		
I Pleural Friction Rub Rhythmic succession of short sounds Typical frequency, <350hz Typical duration, >15 msec		
J Squawk Sinusoid Typical frequency, 200–300 Hz Typical duration, about 200 msec Followed or preceded by crackles		

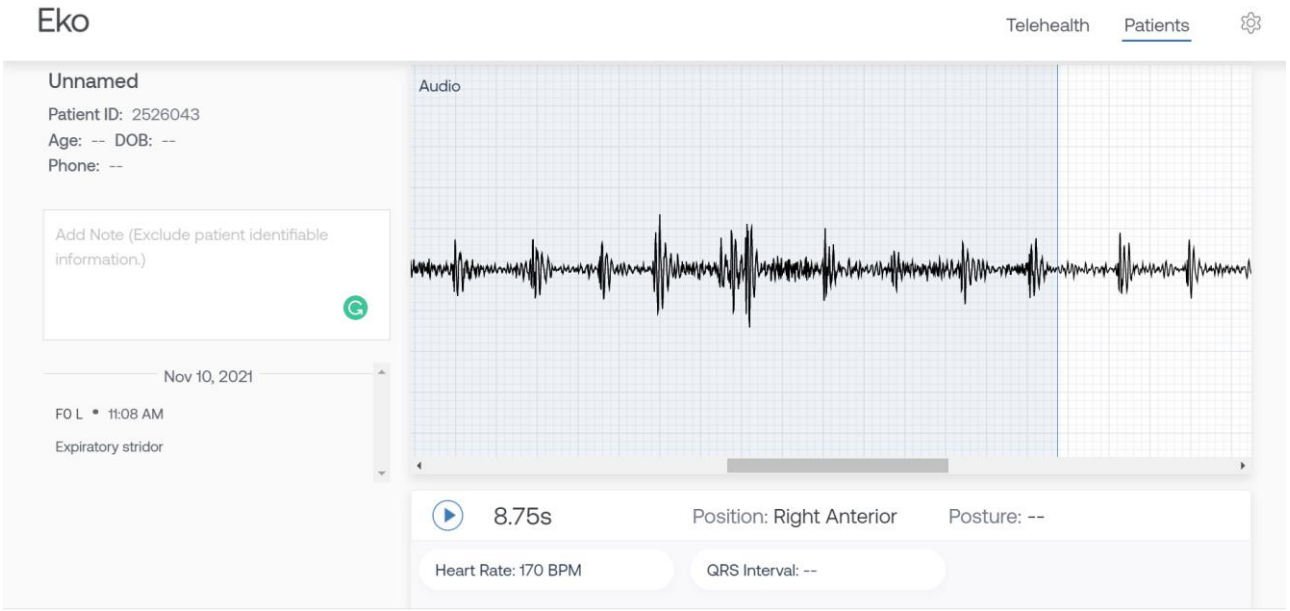
(Bohadana, Izbicki et al. 2014)

3）呼吸音聽診作業

學生在本科實習結束之前必須交出五個呼吸音的電子紀錄，並且與檔案中敘述呼吸音聽到的位置及此呼吸音的名稱。

範例如下:


Eko
Telehealth
Patients
Add Note (Exclude patient identifiable information.)
Nov 10, 2021
F0 L • 10:58 AM
tracheal sound
Audio
2.66s
Position: Left Upper Sternal Border
Posture: Sitting
Heart Rate: --
Poor Heart Sound Signal
QRS Interval: --


Eko
Telehealth
Patients
Unnamed
Patient ID: 2526043
Age: -- DOB: --
Phone: --
Add Note (Exclude patient identifiable information.)
Nov 10, 2021
F0 L • 11:08 AM
Expiratory stridor
Audio
8.75s
Position: Right Anterior
Posture: --
Heart Rate: 170 BPM
QRS Interval: --

Eko

Telehealth Patients

Unnamed

Patient ID: 2526043

Age: -- DOB: --

Phone: --

Add Note (Exclude patient identifiable information.)

Nov 10, 2021

F0 L • 11:11 AM

inspiratory fine crackles

Audio



10.52s

Position: Right Upper Sternal Border

Posture: Sitting

Heart Rate: --

Poor Heart Sound Signal

QRS Interval: --

Eko

Telehealth Patients

Unnamed

Patient ID: 8469020

Age: -- DOB: --

Phone: --

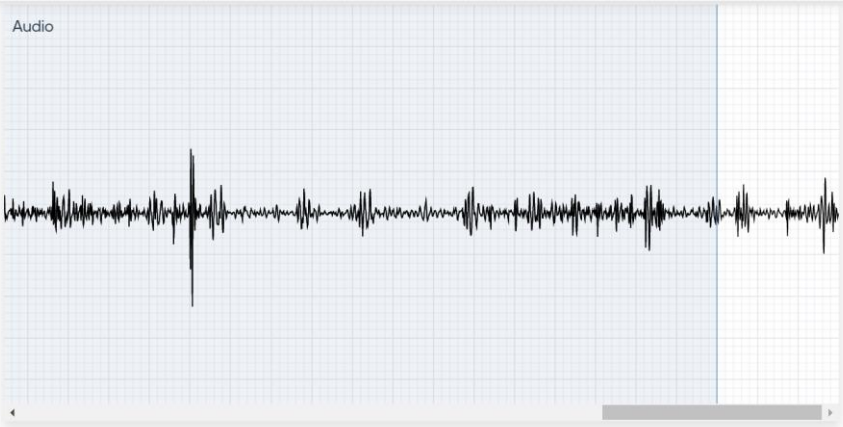
Add Note (Exclude patient identifiable information.)

Nov 10, 2021

F0 L • 10:40 AM

normal hear sound mixed with course crackles

Audio



14.40s

Position: Left Lower Posterior

Posture: --

Heart Rate: --

QRS Interval: --

Eko

Telehealth Patients

Unnamed

Patient ID: 26482371

Age: -- DOB: --

Phone: --

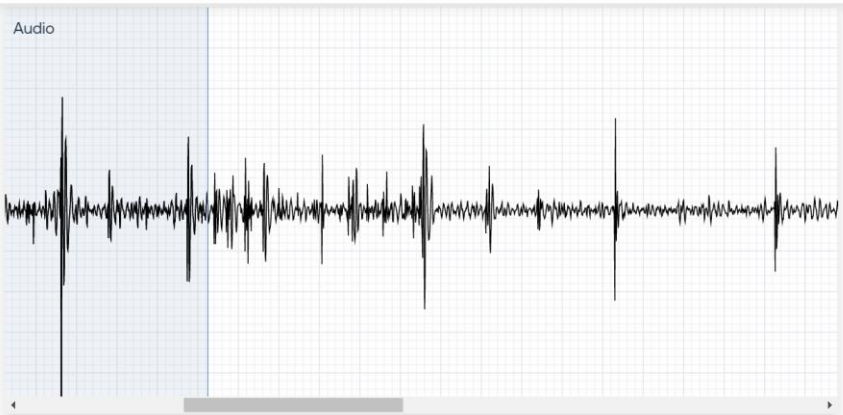
Add Note (Exclude patient identifiable information.)

Oct 29, 2021

F0 L • 09:44 AM

Sputum sound

Audio



4.05s

Position: Left Mid Posterior

Posture: --

Heart Rate: --

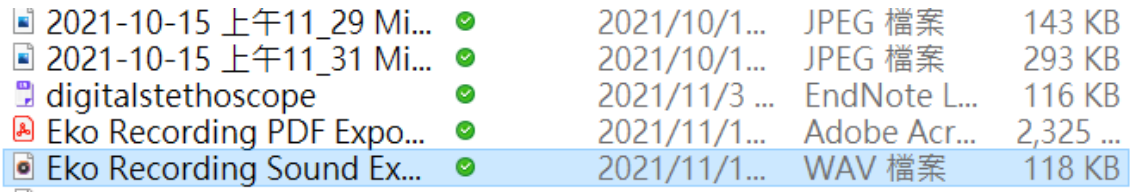
QRS Interval: --

如果學生有結果，我們可以與他們在線反饋。

也可以將圖形轉成 pdf 檔，



聲音轉成 wav 檔



3）成績考核方式

由任課老師針對學生呼吸音聽診作業給予即時的回饋，並加以評分。每一個呼吸音作業佔比 20 分。

4)各週課程進度

中山醫學大學醫學院醫學系胸腔外科實習課程是一個為期 2 週輪訓課程。 呼吸音聽診課程於此兩周之間的安排如下

1、 第一週的星期一發給呼吸聽診之教材。

2、 發放電子聽診器。

3、 給予呼吸音聽診作業。作業為數位化繳交方式。

4、 指導老師針對線上數位化作業給予及時反饋及評分。

5) 預計採用之學習成效評量工具l

Zuvio IRS

6) 教學場域

胸腔外科教學病房及門診。

5. 研究設計與執行方法 Research Methodology

A. 研究架構

本研究採取實驗研究法. 介入、縱向、對照、單中心和隨機實驗研究。

將中山醫學大學附設醫院胸腔外科的實習學生分為兩組

介入組給予電子聽診器並指定聽診作業。

對照組照原先學習場域學習呼吸音聽診。

以前後測比較兩組之學習成效。

比較兩組之教學滿意度。

B. 研究問題/意識

使用**電子式聽診器呼吸音聽診課程**是否能有效提升醫學生的聽診能力？

理學檢查（physical examination）中之呼吸音聽診教學之落實及測驗。

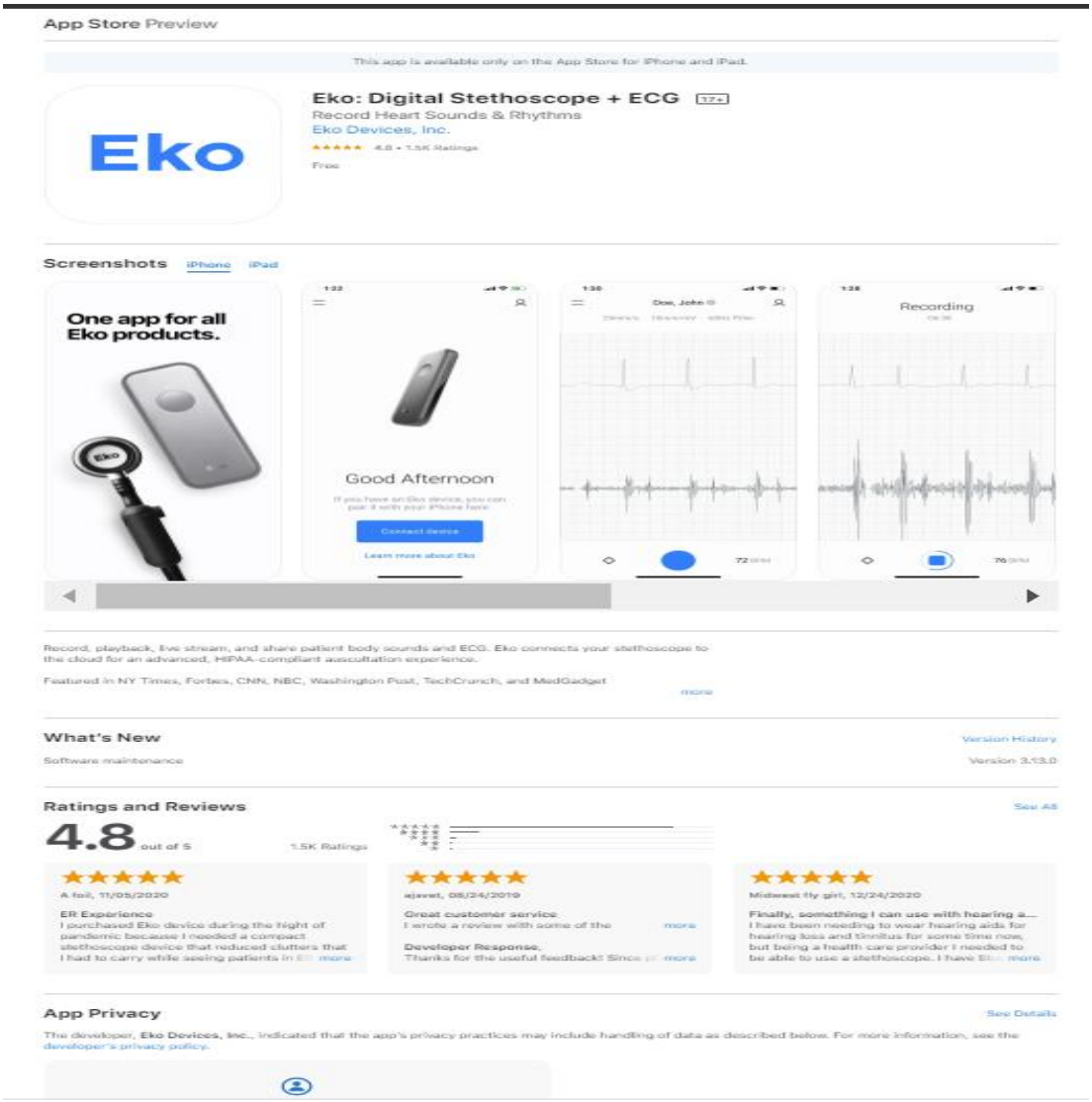
C. 研究範圍

【說明】 針對本研究擬關注的範圍，如課程範疇、教材選用、教學資源應用、評量工具、社群教師與協作方式等規劃範圍進行說明。

本研究的**課程範疇**為外科學實習胸腔外科實習中呼吸學之聽診教學。

教材選用: 引進電子聽診器以量化聽診教學。

引進 Eko digital stethoscope platform https://www.ekohealth.com/. and App



教學資源應用、評量工具： Zuvio Interactive response system (IRS)。 中山醫學大學有訂閱 Zuvio IRS 互動式教學即時反饋系統。除了上課隨機抽點學生之外，在測驗的功能更為強大，可以隨機改變順序 ，評分並統計學生分數表現。更重要的是他是一個可以使用影音檔的測驗平台。 對於需要測驗聲音檔的我們是一個很適合的平台 。

社群教師與協作方式：可舉辦成果交流會 組織電子聽診教師社群， 推廣至各醫學相關院校及醫護相關科系。

D. 研究對象與場域

【說明】　　針對擬教學之對象與進行資料收集之場域(如實習場域、大學課室等)，進行描述與說明。

擬教學之對象 中山醫學大學醫學系至中山醫學大學附設醫院胸腔外科臨床實習的大五大六醫學生`。

進行資料收集之場域為實習場域: 中山醫學大學附設醫院胸腔外科病房及門診。

醫學生每天都會接觸到病人，在老師的指導下實行非侵入性的檢查及治療。經由學習學生能夠學習胸腔外科病人的診斷與治療。其中，呼吸音聽診為實習課程中重要的一環。是一種非侵入性的診斷方法。我們會指導學生在實習場域之中進行呼吸聽診，並且收集學生呼吸聽診狀況的資料。

E. 研究方法與工具

【說明】　　針對研究目的與問題，陳述將採用何種研究方法及工具進行資料蒐集，以有效檢視教學研究之成效，並回應提出之研究問題。

本研究採取實驗研究法. 介入、縱向、對照、單中心和隨機實驗研究。

將中山醫學大學附設醫院胸腔外科的實習學生分為兩組

介入組給予電子聽診器並指定聽診作業。

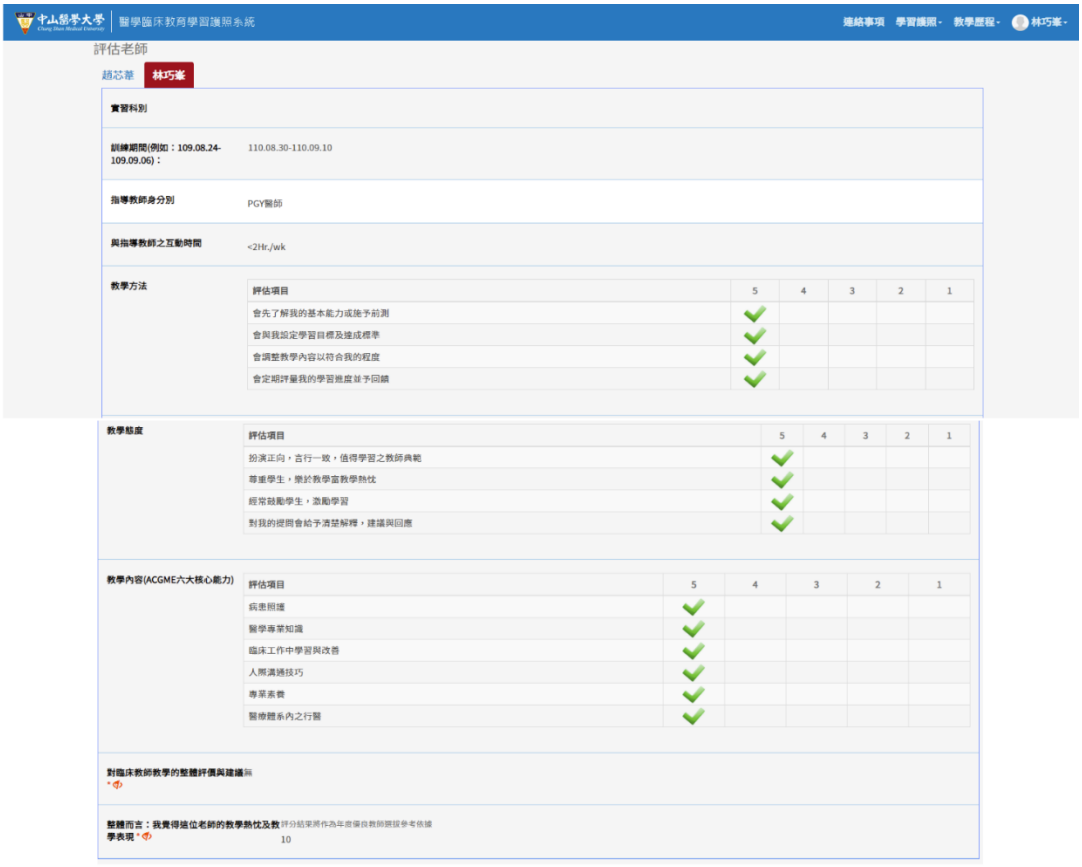
對照組照原先學習場域學習呼吸音聽診。

以前後測比較兩組之學習成效。

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(1)　本實驗使用 Zuvio IRS 對學生進行前後測，比較 介入組及對照組成績學生的變化。

(2) 使用本校醫學臨床教育學習護照中的臨床教學滿意度調查對於介入組及對照組同學的滿意度進行分析比較， 已驗證是否有效提升教學品質。



F. 資料處理與分析

預計使用 IBM SPSS

Kolmogorov-Smirnov test 看學生成績及教學滿意度是否為常態分佈。

Student t test or Mann-Whitney test 比較介入組及對照組的分數及教學滿意度。

Paired Students t- test/ Wilcoxon signed-rank test 比較課程前和課程後的分數。

Correlation tests 比較作業分數和測驗分數及教學滿意度。

Chi-square test 統計介入組及對照組課後租借電子聽診器之比例來看他們對於聽診課程的興趣及電子聽診器的接受度 ，間接看出教學成效。

G.實施程序

一、電子式聽診器呼吸音聽診課程

實習課程本來就是在做中學習。本課程一樣採取有實作中學習的方法，讓醫學生能夠落實聽見

教學。其中落實的方法如下，

1. 發給學生學習教材，其中包括紙本教材及 YouTube 教材，連結如下。因為在醫學系四年級時，這些教材都有提過。故不再做講解。請學生自行複習。

2. 呼吸音聽診作業

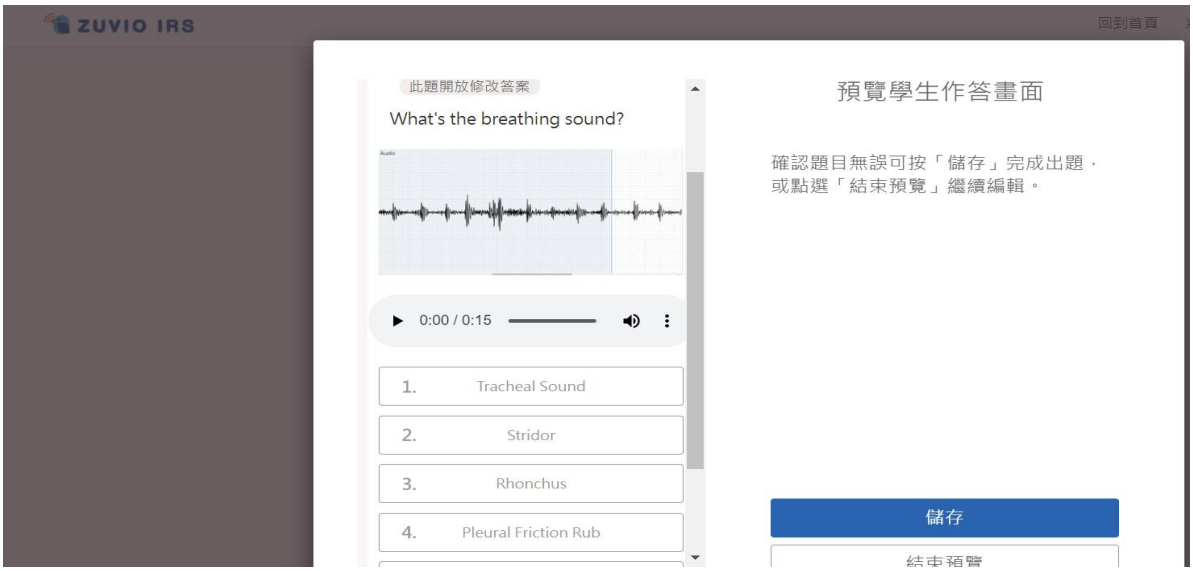
同學在本科實習結束之前必須交出五個呼吸音的紀錄，並且與檔案中敘述呼吸音聽到的位置以及此呼吸音的名稱。

二、前後測

使用 Zuvio IRS 出題

1、 建立呼吸音之聲音檔題庫 50 題

2、 以 Zuvio IRS 隨機出題



三、實施步驟

本教學試驗是一個以兩周為週期輪訓課程的試驗

1. 中山醫學大學附設醫院胸腔外科實習的第一天簽署教學試驗同意書。

2. 給予前測。利用 zuvio 可抽題之功能由呼吸音庫中抽 10 題來測驗。測驗時間點為第一週週一及第二週週五。

3. 前測完發給實驗組呼吸聽診之教材電子聽診器,Eko App,並給予呼吸音聽診作業。

4. 指導老師於這兩週之中給與臨床即時反饋教學 。

5. 實驗組及對照組於本科實習最後兩日實施後測。

6. 實驗組及對照組學員離開本科之前可以跟本科借電子聽診器繼續使用。

3. 教學暨研究成果 Teaching and Research Outcomes

i. 教學過程與成果

樣本總共有 87 位參與者。 在性別方面,有 47 位男性(56%)和 37 位女性(44%)。 班級方面,58 位學員屬於五年級(69%),26 位屬於六年級(31%)。 樣本中有 43 位學員(51%)屬於實驗組,41 位(49%)屬於對照組。 大多數學員(n=74, 88%)有參加 OSCE 課程,而 10 位(12%)沒有參加。

Kolmogorov-Smirnov 測試的年齡和分數的 P 值都小於 0.001。這表示數據庫並非正態分佈。

年齡的中位數為 24 歲,範圍是 22 到 33 歲。在樣本中,有 65 位(90.3%)觀看了 YouTube 視頻,62 位(87.3%)檢查了答案。 在詢問課程幫助程度的 5 分量表上,中位數是 5 分(「非常有幫助」),範圍是 2 到 5 分。

總結來說,樣本總數為 84。 男性略多於女性,主要是五年級學生,實驗組和對照組的人數相似。 大多數參加了 OSCE 並使用了 YouTube 和答案檢查。 中位數年齡為 24 歲。 大多數認為課程非常有幫助。

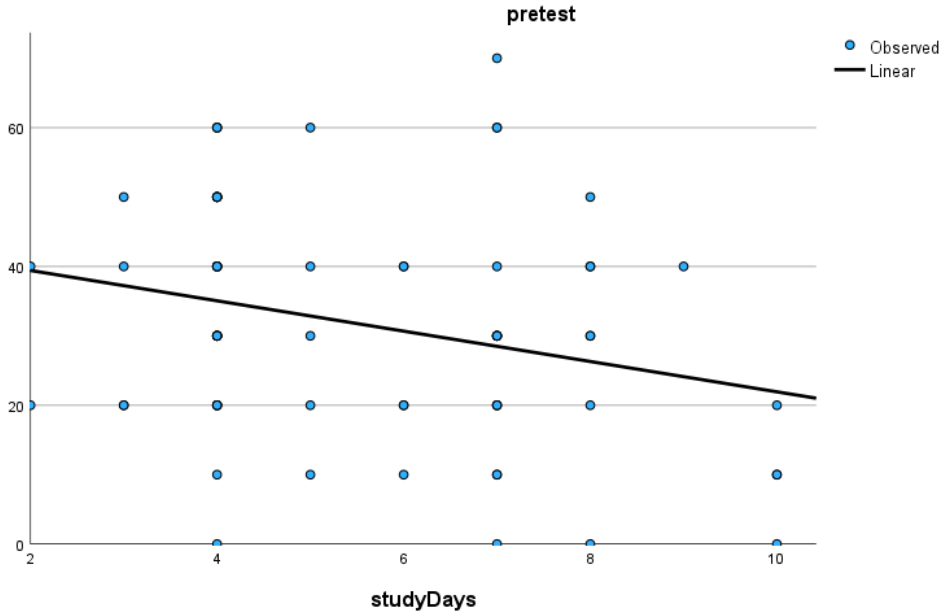
Table 1. Demography of the Students attend the breathing sound course

		N/ Median	% / min,max
		84	100
Gender	Male	47	56
	Female	37	44
Class	5	58	69
	6	26	31
Team	Intervention	43	51
	Control	41	49
OSCE	attend	74	88
	skip	10	12
Age		24	22,33
Teaching Video		65	90.3
Check Answer		62	87.3
Helpful	1,5	5	2,5
		6	2,10

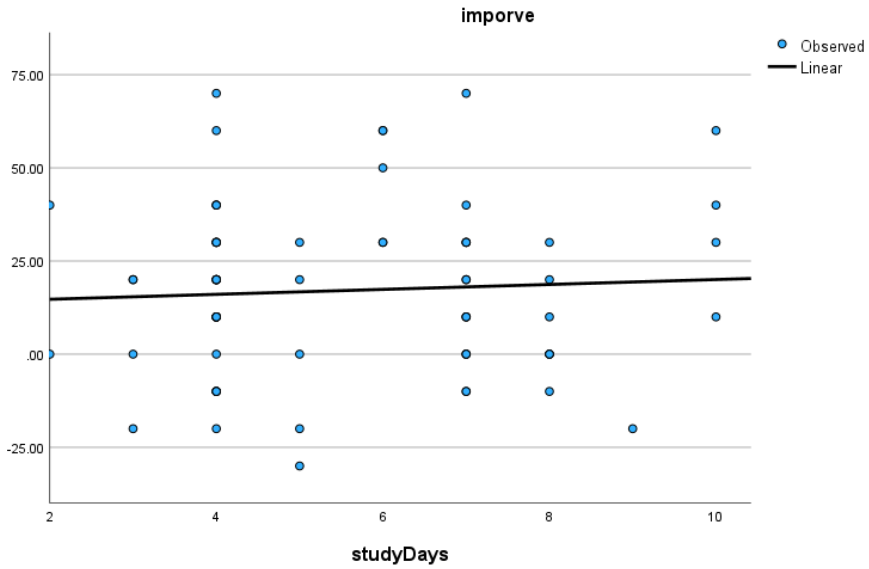
Time pre-,post-tests (days)	Intervention	5	4,10
	Control	7	3, 10

一個有趣的發現是,前測日期是由教師安排,但是後測日期是由學生自行安排,我們發現預測測驗分數越低的學生,需要的時間才會進行事後測驗也越長。

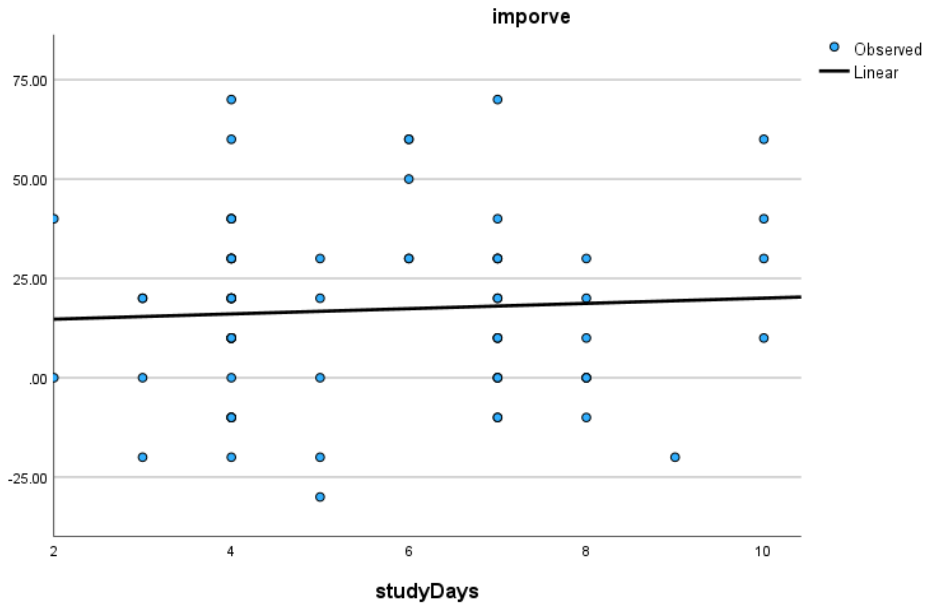
Pre-test Score=-2.186days +43.8 ,p=0.029



Post test score= -1.524 days+ 51.79, p=0.170



Score improvement =0.662days +13.4, p=0.631


imporve
Observed
Linear
75.00
50.00
25.00
.00
-25.00
2
4
6
8
10
studyDays

測驗分數結果

整體而言,前測的中位數分數是 30 分,在後測中提升到 50 分。中位數的進步是 20 分。

分別看實驗組和對照組,實驗組的前測中位數分數是 30 分,後測中位數分數是 40 分,中位數進步了 10 分。對照組的進步更多,前測中位數是 30 分,後測中位數是 55 分,中位數進步了 20 分。兩組在前測和後測之間都顯示了統計上顯著的進步。

參加過 OSCE 課程的學員,其前測和後測的中位數分數都比沒有參加的學員高。參加的學員中位數進步了 20 分,而沒有參加的學員中位數進步了 35 分。

對於觀看過呼吸音教學影片的學員,前測中位數是 30 分,後測中位數是 50 分,中位數進步了 20 分。沒有觀看影片的學員沒有進步。

五年級學員的中位數進步是 20 分,六年級學員是 10 分。前測和後測的分數在兩個年級之間沒有差異。

是否檢討前測答案與後測分數的進步也沒有關係,兩組的中位數進步都是 20 分。

總結來說,課程整體上有效提升了測驗分數,實驗組和對照組也都有顯著進步。觀看教學影片與更大的進步相關。

Table 2. The scores of the breathing sound course.					
			Median	min,max	p
	pretest		30	0,70	<0.001*
	posttest		50	20,90	
	improvement		20	-30, 70	
Intervention	pre-test	I	30	0, 60	0.269
		C	30	10, 70	
	post-test	I	40	10, 90	0.073
		C	55	20, 80	
	pre-post	I			<0.001*
		C			<0.001*
	improvement	I	10	-20, 70	0.539
		C	20	-30, 60	
OSCE	pre-test	1	30	20, 70	0.209
		0	20	10, 30	
	post-test	1	50	20,90	0.339
		0	55	50, 60	
	improvement	1	20	-30, 70	0.871
		0	35	30, 40	
Teaching Video	pre-test	1	30	0, 70	0.565
		0	30	20, 60	
	post-test	1	50	20, 90	0.180
		0	30	20, 70	
	improvement	1	20	-30, 70	0.084
		0	0	-10, 30	
Check Answer	pre-test	1	30	0, 70	0.146
		0	20	20, 80	
	post-test	1	50	20, 90	0.773
		0	50	20, 80	
	improvement	1	20	-30, 70	0.393
		0	20	0, 60	
Class	pre-test	5	30	0, 70	0.775
		6	30	0, 60	
	post-test	5	50	20, 70	0.772
		6	50	20, 70	
	improvement	5	20	-30, 70	0.613
		6	10	-10, 60	
Backward stepwise linear regression					
Teaching Video	β,95%CI		0.19	-2.94, 34.87	0.097
*Paired-Samples Wilcoxon Signed Rank Test					
I intervention, C control.					

ii 教師教學反思

以下是結果討論部份的中文修訂建議:

由於課程只有短短 2 周的時間,時間是個主要的限制和潛在的偏差來源。預測測驗的日期通常安排在實習的第 1 或 2 天,但是事後測驗的日期是由每個學生自行決定,並受到與 OSCE 中心日期衝突的影響。實習課程緊湊以及 OSCE 中心可使用時段有限,導致預測測驗和事後測驗之間的實際間隔僅有 2-10 天。預測測驗分數較低的學生似乎會預留更多時間學習才進行事後測驗。高峰期是第 5 天和第 8 天(星期五和下一個星期一)。這使得許多學生的 14 天課程被壓縮到 7 天,因為有些學生會在其他醫院開始新的實習課程,而 OSCE 中心的可用時段有限。

第二個未預期的限制來自於數位電子聽診器的介入。呼吸音課程教授有 200 多年歷史的古老體檢技巧。引入數位聽診器旨在透過科技提升這個領域,但是也存在一些缺點:1) 數位聽診器比傳統聽診器更沉重,與 Littmann 聽診器等追求輕便易攜的歷史設計理念反向而行,導致學生不願經常攜帶。2) 昂貴的價格使學生使用時小心翼翼。3) 使用需要連結手機,花費更多時間比傳統聽診器。 4) 在我們的臺灣實習環境中,數位聽診器系統不獲准顯示聲學自動分析結果。早期研究顯示此回饋有助學習,但我們的學生沒有此利益,因為相關軟體仍待台灣 FDA 審查通過。因此,很少學生完成 5 次聆聽記錄的任務,且此任務不影響正式成績。數位聽診器創新但實施失敗,導致實驗組和對照組沒有差異-兩組獲得相同教學,進步也相似。

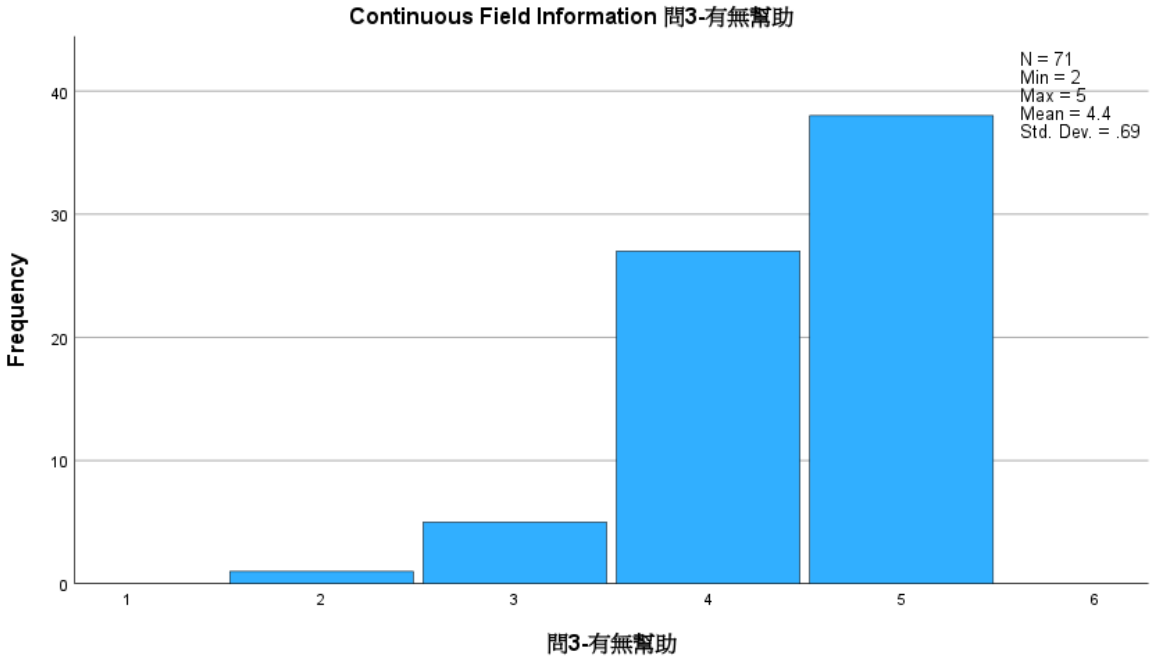
第一天發放的自學呼吸音影片大多數學生都認真學習,這成為影響測驗分數的主要因素。

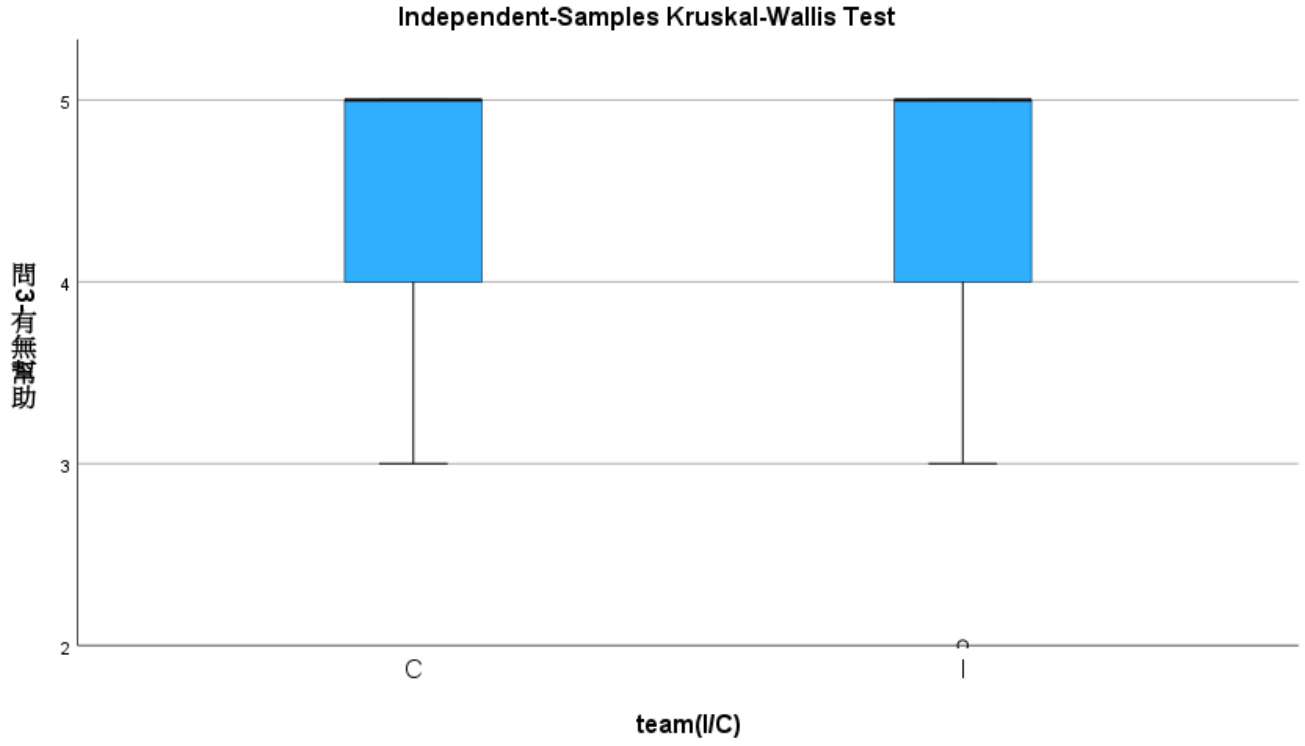
OSCE 中心學習也是由學生自行安排,最後實際上就擇定在事後測驗當天,所以沒有影響分數,但獲正面回饋。

由於數位聽診器作業完成度極低,其對測驗表現沒有影響。需要改良的軟體版本。實驗組和對照組之間無顯著差異的原因在於此項介入失敗。

iii.學生學習回饋

在呼吸音聽診課程中，45.2%的學生認為課程非常有助於他們提升身體檢查技能，32.1%的學生認為有一定幫助。 然而，數位聽診器由於笨重、昂貴、耗時，且缺乏自動分析功能，並未受到廣泛歡迎。組和對照組之間的評估保持一致。





6. 建議與省思 Recommendations and Reflections

正面回饋：超過 77% 的學生 (45.2% "非常有用" 和 32.1% "有用") 認為呼吸音聽診課程對提高他們的體檢技能很有價值，凸顯了其教育潛力。

改善建議

- 數位聽診器：透過探索輕量化版本或縮短操作流程來解決重量、價格和時間問題。 僅在自動分析功能獲得 TFDA 批准並證明有價值後才考慮引入該技術，因為目前台灣並不適合。
- 測試成績和學習：意料之外的低測試成績和自我學習影片後的顯著進步表明需要一個紮實的學習方案。

教學方法

保留：自主學習教材有效，應繼續使用。

改進：考慮使用測試而不是數位聽診器作為更強的激勵因素。

最佳化： ZUVIO 測試模型成功，應進一步利用。

整合：在課程早期實施 OSCE 中心 SAM II。

強調：鼓勵臨床老師優先並整合呼吸音教學融入實習課程。

課程設計

增加實務：增加實務練習以縮小理論與實務之間的差距。

模擬應用： 利用團體模擬練習讓學生在臨床環境中應用聽診技能。

擴大範圍：考慮在各次次專科開設多學科呼吸音課程。

綜合評估實施涵蓋所有相關次專科的測試，以評估學生整體診斷能力。

反思

- 可推廣性： 這項研究代表了中山醫學大學胸腔外科實習生，需要進一步研究評估其在其他醫學教育環境中的適用性。
- 整體評估：需要額外研究評估心音、血管音和腸鳴音教學的有效性。
- 多方面影響：教學效果不僅受方法和工具的影響，也受教師能力和學生學習動機等因素的影響。 因此，應探索教師培訓和學生學習動機策略。

結論：本研究為改善呼吸音聽診教學提供了寶貴的見解。 持續改進方法、工具和評估方法，以及在不同教學環境的探索，對於優化教學成果至關重要。

教育部教學實踐研究計畫成果報告

Project Report for MOE Teaching Practice Research Program

計畫編號/Project Number：PMN1110052

學門專案分類/Division：醫護/Medicine

計畫年度：■111 年度一年期　□110 年度多年期

執行期間/Funding Period：2023.08 .01 – 2024.01.31

數位電子式聽診器於醫學大學醫學系學生呼吸音聽診教學之應用

Application of digital electronic stethoscope in the teaching of breath sound auscultation for medical school students

外科臨床實習/Clerkship, Surgery

計畫主持人(Principal Investigator)：林巧峯 Frank Cheau-Feng Lin

協同主持人(Co-Principal Investigator)：黃旭志 Hsu-Chih Huang

執行機構及系所(Institution/Department/Program)：（學校名／系所名）中山醫學大學

醫學系 School of Medicine, Chung Shan Medical University

成果報告公開日期：□立即公開 ■延後公開(統一於 2026 年 1 月 31 日公開)

繳交報告日期(Report Submission Date)：2024 年 3 月 1 日

二. 本文 Content

3. 研究動機與目的 Research Motive and Purpose





聽診器長久以來就是醫師的代表工具。胸部聽診被視為重要的身體檢查項目,可追溯至希波克拉底時代。直到 19 世紀 Laënnec 發明聽診器,它才成為醫學廣泛採用的診斷方法。20 世紀下半葉,隨著各種影像學技術的進步,如 X 光、電腦斷層掃描、磁振造影等,醫學界對肺部聽診的興趣轉向可直接觀察肺部病變的新檢查工具。



然而,病史詢問和身體檢查仍是醫學診斷的基石。大部分疾病可通過詳細的病史詢問及精確的身體檢查取得診斷。因此所有醫學教育者都強調病史與身體檢查的重要性,醫學生也必須在每日臨床實習中加以實踐。但是,在現今醫療快速發展的環境下,各種高科技影像及檢查新技術層出不窮,容易吸引 away 醫學生對傳統病史詢問與身體檢查的注意力。臨床教師在有限的時間中也不易傳授這些

基本技能。如何在醫學教育中落實病史詢問和身體檢查的訓練,使學生真正學會應用,一直是醫學教育中持續關注的課題。

為培育出全方位的優秀醫療人才,我們期待學生能夠精通各項身體檢查技能。對胸腔科醫師而言,肺部聽診尤其重要,要聆聽及分析呼吸音是基本的臨床技能。在醫療環境快速变遷的今日,我們有必要設計適當的教學方法,讓醫學生學習這 200 年才發展出的聽診術,以及它的重要代表 - 呼吸音聽診技巧。

幸運的是,科技發展也為聽診教學帶來新的契機。電子聽診器不僅可以錄音存檔,進行聲學分析,也可以將聲音訊號轉換為視覺化的圖形,即聲紋圖,使原本主觀的聽診音色變為客觀的圖形資料。運用電子聽診器的優勢,呼吸音聽診教學可以朝向更科學、客觀的方向發展。

中山醫學大學醫學系學生在五年級臨床技能課程中,有接受過呼吸音聽診的基礎教學。但是學生反映課程內容過於緊湊,未能在病患身上實際演練。到了臨床實習階段,也無 senior 可以提供進一步指導,因此呼吸音聽診的技能很難獲得增進。有鑑於此,透過充分利用電子聽診器的優勢,設計一套創新而完整的呼吸音聽診教學課程刻不容緩。

此外,隨著教學評量工具的發展,我們可以利用教學評量軟體,將課程教材如影音檔案轉換為學習評量的題目,以便於出題與評分。透過這種電子化的教學評量,不但可以即時檢視學生的學習狀況,也可以重複進行評量,詳細評估學習成效。運用此種教學評量於呼吸音聽診課程,將可以大幅提升教學成效。

綜合以上,本研究擬開發一套運用電子聽診器與電子化教學評量的呼吸音聽診課程。我們預期這樣的創新課程不但可以增進臨床前醫學生對正常呼吸音的認識,也可以使他們熟練聽診技巧,奠定臨床實習時聆聽呼吸音的基礎,達成醫學教育培育臨床醫師的願景。如果證實本課程確實可促進學習成效,我們將可擴展應用到其他聽診項目的教學,以落實醫學生聽診技能的全面訓練。





4. 研究問題

研究計畫主題

數位電子式聽診器於醫學大學醫學系學生呼吸音聽診教學之應用。

這個研究計畫的重點在於**創新呼吸音聽診教學**， 研究對象局限於醫學大學醫學系實習生，使用之工具為數位電子聽診器以及相關的應用軟體。

創新電子式聽診器呼吸音聽診課程

將電子式聽診器及 Eko 聽診軟體運用於呼吸音聽診教學藉以建構創新呼吸音聽診之課程。藉著高科技的電子聽診器產品及課程設計提升學生對於呼吸音聽診的學習興趣, 改善目前醫學大學醫學系實習課程中的呼吸音聽診不良的教學品質。培養學生能夠成為一個精熟於呼吸音診斷病人疾病的好醫師。

這個課程衍生出來的另外一個效益為建立呼吸音聲的聲音檔題庫，可以使用聲音及聲紋圖來測驗學生的聽診程度。這是之前的聽診教學未曾使用的測驗方法。

研究計畫的主要目的

研究使用**數位電子式聽診器**之創新呼吸音聽診教學課程是否能有效地提升醫學大學醫學系實習醫學生呼吸音聽診**教學品質**以及學生**學習成效**。

這個研究的主體是醫學系實習生的**呼吸音聽診教學**，介入因子為**創新電子式聽診器呼吸音聽診課程**。研究的指標是**教學品質**和**學習成效**，研究籍學生滿意度調查檢驗教學品質，並且以前後測來看學生的學習成效。

7. 文獻探討 Literature Review

聽診器是近百年來醫療專業人員的象徵!

醫學歷史學家 Jacalyn Duffin 認為，聽診器的發明標誌著將疾病從一系列症狀重新定義為將疾病視為解剖系統問題的重要一步. Duffin 認為，這種重新概念化在一定程度上發生了，因為在聽診器出現之前，沒有用於探索身體內部解剖結構的非侵入性醫療器材。

研究表明，醫學生的身體理學檢查技能往往需要提高。尤其美國，加拿大和英國都有大量研究論文來證實這個情況。目前的的教學研究為個別的身體理學檢查教學方法的有效性提供了一定程度的證據。它認可身體理學檢查醫學教育需要進一步發展(Mosshammer, Graf et al. 2017, Yale, Tekiner et al. 2021)。Kim et al. 研究顯示呼吸音聽診確率為醫學生 60.3%，實習生 53.4%，住院醫師 68.8%，研究醫師 80.1%(Kim, Hyon et al. 2021)。也就是說用聽診來診斷病人的疾病的準確度無法被委員所接受，有待努力提升。聽診器問世 200 週年的紀念文章亦指出,在 20 世紀下半葉，開發了新的強大的無創診斷方式，因而對聽診的興趣下降。結果，各級培訓的學生和醫生的聽診技能下降到令人失望的低水平。回顧文獻並考慮到患者就診的環境，包括先進診斷設施的可用性，作者群得出結論:歷史悠久的聽診器儘管有其局限性，但仍具有作為患者友好、有效、和經濟的醫療儀器。然而，需要採取新的舉措來培訓學生、醫生和相關衛生專業人員進行聽診，以避免可能傷害患者，並產生額外高價儀器的費用。(Bank, Vliegen et al. 2016, Legget, Toh et al. 2018)

1816 年, 聽診器由法國巴黎 Necker-Enfants Malades 醫院的 René Laennec 發明(Laennec 1819)。它是單聲道的由一根木管組成。 Laennec 發明了聽診器，因為他不習慣將耳朵直接放在女人的胸部聽她的心臟(Roguin 2006, Permin and Norn 2016)。

1840 年，Golding Bird 是第一個發表他一直在使用帶有軟管的聽診器(Bird 1840)。

1940 年代, Rappaport 和 Sprague 在設計了一種新型聽診器，它成為其他聽診器的測量標準，由兩側組成，其中 Diaphragm side 用於呼吸系統聽診，bell side 用於心音聽診。

直到 1960 年代初，哈佛醫學院教授 David Littmann 發明了一種比以前的型號更輕並改進了聲學性能的新型聽診器[U.S. Patent 3,108,652]。 因此 Littmann 成為 3M 聽診器品牌的名稱。

電子聽診器能夠將聲音轉換為電子信號，該信號可以進一步放大以獲得更佳聆聽效果(Araj and Cox 2019, Silverman and Balk 2019)。電子聽診器的性能通過將低於 50 Hz 的心音、胸音和腸音轉換為 200 Hz 的頻率範圍，而不會損失保真度，從而提高了其性能，該頻率範圍很容易被人耳檢測到(Aumann and Emanetoglu 2019)。也就是說電子聽診器能夠聽到傳統式聽診器聽不到的低頻聲音。 這些電子信號可以進一步處理和數字化，以傳輸到個人或膝上型電腦，手機以及耳機裡面。目前，許多公司提供電子聽診器。Eko Core 可以將聲音無線傳輸到智能手機或個人,膝上型平板電腦。由於聲音以電子方式傳輸，因此電子聽診器可以是無線設備，可以是錄音設備，並且可以提供降噪、信號增強以及視覺和音頻輸出。大約在 2001 年，Stethographics 將心音和呼吸音除了聲音之外，並以聲紋圖形表示。所有這些功能都有助於遠距醫療（遠距診斷）和教學的功能。目前，幾乎所有可用的電子聽診器都允許選擇不同的頻率模式，使聽者能夠更好地聽到來自心臟、肺和身體其他部位的聲音。電子聽診器還可以通過多種機制抑制環境噪聲和摩擦噪聲，讓聽者聽到盡可能原始的聲音。 例如，3M® Littmann Range 提供壓電傳感器，該傳感器使用環境降噪作為噪聲消除器，並可將聲音放大 24 倍。

因為上述電子式聽診器的特性，許多人努力做了許多開創性的研究，將電子式聽診器應用到不同的領域之中，提升了醫療的水準

研究顯示數位化錄音和心音圖 (digitalised sound recordings and phonocardiograms ,dPCG) 技術, 有助於診斷心臟雜音，尤其是對於那些心臟病學經驗較少的人(Voros, Nolte et al. 2011)。

新生兒是很特殊的一個群體。因為他們很脆弱，很難承受侵入性的治療或診斷，並且沒有辦法控制自己去配合一些診斷性的儀器。因此簡單非侵入性的電子式聽診器在新生兒診斷的領域當中被視為一個利器。Zhou 使用電子式聽診器和電腦化呼吸音分析,在新生兒中。 共獲得了 26 名足月和 26 名早產兒的錄音。Zhou 發現電子式聽診器 能夠確定足月兒和早產兒在室內空氣中呼吸的聲學特徵之間的顯著差異(Zhou, Marzbanrad et al. 2020)。Ramanathan 使用數字聽診器 (DS) 來評估生命最初 2 小時內呼吸音特徵的變化及其與分娩方式的關係。呼吸音的頻率分佈從 1 分鐘到 2 小時顯著下降，平均 (標準差) 頻率從 333.74 (35.42) 下降到 302.71 (47.19) Hz，$p < 0.001$，以及功率比例 (標準差)最低頻帶從 0.27 (0.11) 增加到 0.37 (0.15)，$p < 0.001$。在 1 分鐘時，自然產嬰兒的頻率略高於剖腹產，但在 2 小時時沒有差異。關於新生兒的肺通氣過程目前已知 肺液清除和肺通氣是促進呼吸的關鍵過程，而分娩方式會影響這一過程。 電子式聽診器提供增強的聽診功能，並已在兒科人群中用於評估肺和心臟,以預測呼吸音的發展，評估預測新生兒出現症狀前的呼吸窘迫(Ramanathan, Marzbanrad et al. 2020)。 Treston 使用電子式聽診器、手持超音波和心電圖在出生後立即評估新生兒心率(Treston, Semberova et al. 2019)。

聽診器的一個強大的功能就是在探索血液在管腔中流動所產生的聲音。因此許多人將電子式聽診器應用於心臟血管疾病的發現與診斷。顱內動脈瘤會產生在一個特殊的頻率範圍內雜音，這種雜音受壁厚的影響很大。了解產生雜音的機制可能使我們能夠無創地研究動脈瘤。 4 名眼動脈瘤患者在血管內治療前後使用數位電子聽診器進行研究。從雙眼的數字記錄中可以獲得雜音的音譜(Jou and Mawad 2010)。Chowdhury 提出了一種實時數位電子聽診器系統的原型模型，以實時(real time)監測患者的心音並診斷任何異常。用於心臟疾病的早期檢測的便攜式系統存在未滿足的需求(Chowdhury, Khandakar et al. 2019) 。Makaryus 使用數位電子聽診器來對冠狀動脈微雜音進行檢測，即通過標準聽診無法聽到的微弱雜音，可能為診斷冠狀動脈疾病提供另一種檢測方法。其研究的目的是測試新型數位電子聽診器心臟超聲譜分析儀（CSA；SonoMedica 模型 3.0，SonoMedica，Inc.，Vienna，Virginia，美國食品和藥物管理局）的準確性與使用心臟電腦斷層掃描 (CT) 血管造影的金標準診斷相比，診斷冠狀動脈疾病。數位電子聽診器心臟超聲譜分析儀識別任何主要心外膜冠狀動脈狹窄 >50% 的總體敏感性為 89.5% ($p <0.0001$)。基於較小樣本量的性別特定模型在胸毛較重的男性中的結果稍差，特異性較低。總之，數位電子聽診器心臟超聲譜分析儀顯示出在門診環境中檢測顯著早期冠狀動脈疾病 的高靈敏度和特異性，並且代表了一種新的無創設備，用於檢測冠狀動脈疾病中發生的異常冠狀動脈血流。(Makaryus, Makaryus et al. 2013)

在手術室要偵測病人的狀況所能夠使用的醫療儀器十分有限。 因為病人在開胸剖腹的情況之下要移動到別的地方去進行檢測非常的困難。在手術的情況之下病人的生理狀況變動大且即時，常常需要實時的連續性的檢測。因此數位電子聽診器就是一個很好的工具能夠連續的檢測病人的狀況。。許多麻醉醫師就發表了數位電子聽診器用在麻醉病人的研究。Duck 在全身麻醉下對患者進行的基本心音監測程序。由於第一心音(S1)的振幅大小(電子聽診器的圖形表示)可以表達左心室功能，因此研究其與心輸出量的相關性。在各種情況下，S1 的振幅與 CO (心輸出量) 的變化具有顯著相關性(Duck Shin, Hoon Yim et al. 2014)/。Klum 使用多模式貼片聽診器從單個 55 毫米心電圖導程估計埃因托芬心電圖 (ECG)導程 I 和 II。使用聽診器和 ECG 子系統，估計射血前期 (PEP) 和左心室射血時間 (LVET)。得出結論為，使用可穿戴多模態採集設備估計 ECG、PEP、LVET 和呼吸參數是可行的，並鼓勵進一步研究多模態信號融合以估計呼吸信號(Klum, Urban et al. 2020)。亦有麻醉科醫師使用數位電子式聽診器以及數字信號處理軟件（Goldwave）在監測插管患者通氣。這項初步研究表明，此技術可能有助於為檢測氣管插管錯位提供實用的實時警告系統(Doyle and Nair 2009)。 另外有麻醉醫師研究開發的數位電子式經食道聽診器來偵測病人在心臟手術時候的狀況。在保留傳統食道聽診器優點的同時彌補了傳統食道聽診器的不足，不僅可以通過食道導管檢查心音和雜音，還可以顯示心音和雜音的幅度和波形，並測量患者的體溫。 .因此，所開發的數位電子式經食道聽診器有望在手術過程中對心音的連續聽診用，並通過提供心音數據為心音研究做出貢獻(Shin, Lim et al. 2010)。

電子聽診器克服了傳統聽診器的局限性，將聲音數據轉換為電信號，可以放大、存儲、重放，更重要的是，病人可以將聽診的結果發送給專家和醫師，專家和醫師可以根據所得到的圖形和聲音進行診斷， 讓遠距的病人得到及時的醫療指引及照顧， 使其在遠程醫療中非常有用。(Lakhe, Sodhi

et al. 2016)

電子聽診器可以將聲音數位化，並且以聲紋圖呈現，因此可以和人工智慧(AI)並用來發展出傳統聽診器無法達到的運用。心臟科醫師將電子聽診器與電腦及人工智慧(Artificial Intelligent, AI) 聽診程序一起使用，以分析記錄的心音病理性或無害的心臟雜音(Chorba, Shapiro et al. 2021)。小兒科醫師在”Time-domain analysis of heart sound intensity in children with and without pulmonary artery hypertension: a pilot study using a digital stethoscope”論文中 11 名患有肺動脈高壓（中值 mPAp：55 mmHg [範圍：25-97 mmHg]）和 11 名沒有肺動脈高壓（中值 mPAp：15 mmHg [範圍：8-24 mmHg]）。 P2ratioA2 (P = .0001) 和 P2ratioS2 (P = .0001) 強度比在有和沒有肺動脈高壓的受試者之間有顯著差異。 P2ratioS2 和 P2ratioA2 強度比與 mPAp 之間存在線性相關性 (r > 0.7)。我們發現 P2ratioA2 和 P2ratioS2 強度比可以區分有肺動脈高壓的兒童和沒有肺動脈高壓的兒童。這些發現可能有助於開發診斷肺動脈高壓的聲學設備(Elgendi, Bobhate et al. 2014)。在呼吸音的研究方面目前使用 AI 檢測 crackles 或 rales 的總體靈敏度為 80% (95% CI 72-86%)，特異性為 85% (95% CI 78-91%)(Gurung, Scrafford et al. 2011, Ali, Hasan et al. 2021, Kim, Hyon et al. 2021) 。風濕性心臟病 (RHD) 在全球範圍內造成顯著的發病率和死亡率。為了減輕風濕性心臟病的危害，及時啟動二級預防也就是對風濕性心臟病的篩檢很重要。心臟病醫師設計了一個使用來自數位電子聽診器的波形數據訓練深度學習算法以預測亞臨床風濕性心臟病的研究，並確定亞臨床風濕性心臟病的發生的頻率(Ali, Hasan et al. 2021)。

目前使用電子聽診器與臨床的教學並不多主要集中於心音的聽診。Mesquita et al.於論文中指出與使用傳統聽診器的組 (29.5%) 相比，使用電子聽診器的組 (51.9%) 的識別心音的能力改善明顯更大。使用電子聽診器心音的短期聽診教學能夠顯著提高識別心音的能力(Mesquita, Reis et al. 2013)。Dr. Legget 執行了一個電子聽診器於心臟聽診教學的研究。對照組從訓練到驗證期的平均 95% CI 增加為 2.5% [-11.5, 16.5] P = 0.95, 介入組 15.8% [1.7,29.8] P= 0.027。在兩組的驗證和培訓課程之間，分數增加了 9.1% [1.82, 16.4] (p = 0.018)。對照組和介入組評分的平均 [95% CI] 差異為 1.9% [-5.4, 9.2] (p = 0.59)。 Cohen 的效應量估計值為 0.9。這個研究的結論是電子聽診器是心臟聽診教學的有用設備(Legget et al. 2018)。

綜合上述的研究， 電子聽診器可以加強呼吸音聽診的品質 ， 可以將呼吸的聲音放大，將聽不到的頻率轉換成聽得到的頻率，過濾掉雜音，並且將聲音給予數位化的記錄，並且轉換成為聲紋圖形呈現，並可以配合人工智慧做聲音的分析與診斷。 心臟科應用於對於心音聽診品質的提升；小兒科應用於對新生兒的監測；麻醉科應用於對麻醉病人狀況的掌握；並使用於遠距醫療。且成功的應用於心音聽診教學。。因此我們將電子聽診器應用於呼吸音聽診教學、先讓醫學生需用高科技的電子聽診器以及 Eko app 提起學生對於呼吸音聽診的興趣，透過課程及教材讓學生增加對呼吸音聽診的了解，並且藉由作業在病人身上實作並教師的回饋以獲得正確呼吸音聽診的實作經驗。之後繼續出借電子聽診器以及 Eko app 給學生在別科的實習課程中加強他們呼吸音聽診的學習成效，讓他們就算不在本科也可以藉由科技延伸學習。預計可以達到良好的教學效果，改善學生對於呼吸音聽診學習的興趣，並且達到良好的教學品質與評量。 未來亦可將此教學推展到心臟科、麻醉科、小兒科、以及臨床相關科系，為培養下一代優良的醫師及醫療從業人員做出積極的貢獻 。

8. 教學設計與規劃

創新課程方案名稱： **電子式聽診器呼吸音聽診課程**

(2) 教學設計與規劃說明

教學目標

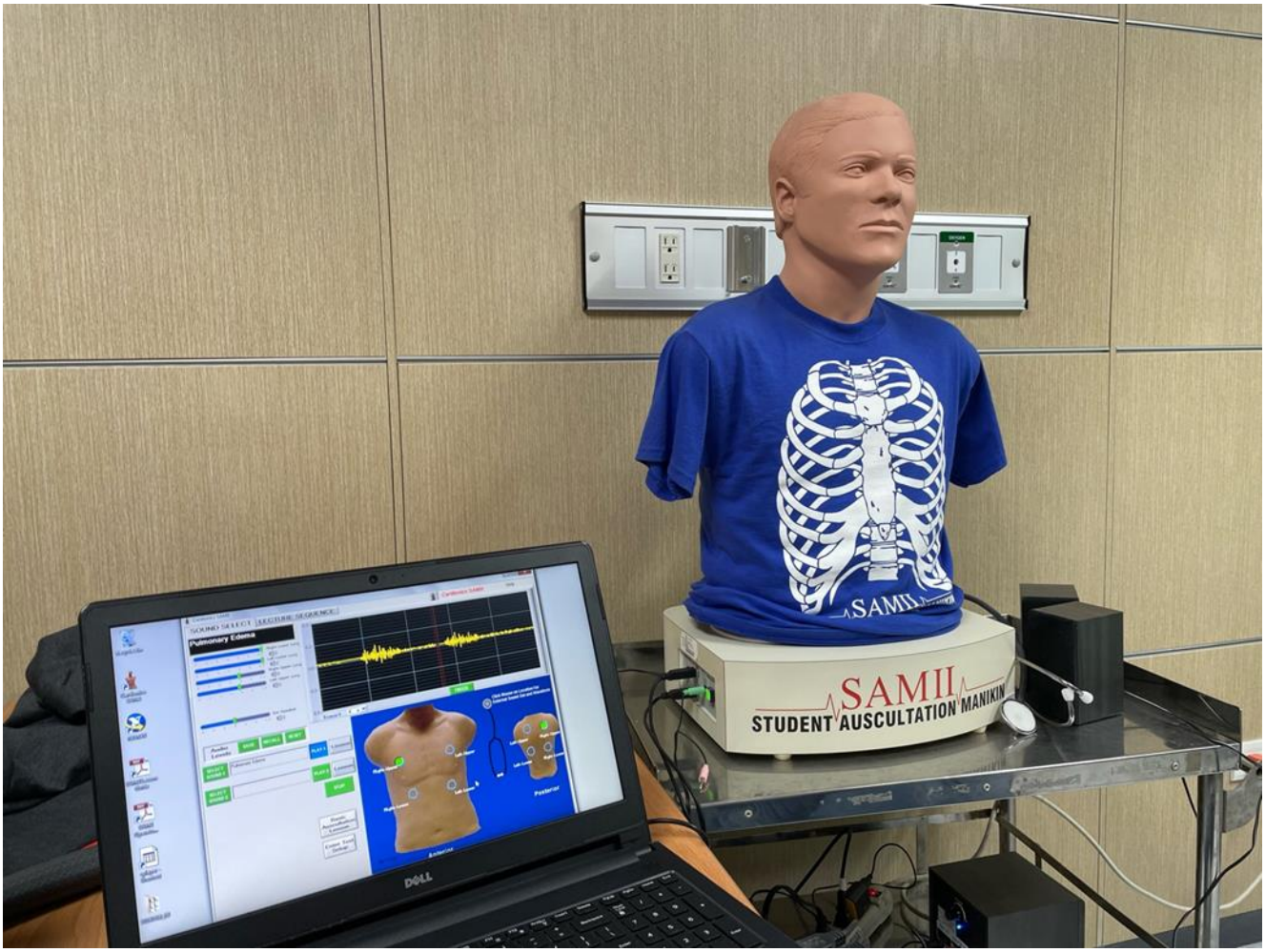
教導醫學大學醫學系五六年級實習醫師呼吸音聽診達到精熟的程度。

教學方法

實習課程本來就是在做中學習。本課程一樣採取實作中學習的方法，讓醫學生能夠落實呼吸音聽診教學。其中落實的方法如下，

3） 臨床技能中心(OSCE center)

至本校臨床技能中心(OSCE center)利用呼吸音模具 SAM II 學習十種呼吸音。 SAM II 可以用聽診器實際在模具上進行聽診教學。並有聲音及聲紋圖可供學習。



4) 呼吸音教學影片

接著發給學生學習教材，其中包括紙本教材及 YouTube 教材，連結如下。因為在醫學系四年級時，這些教材都有提過。故不再做講解。請學生自行複習。

https://www.youtube.com/watch?v=eWGxuwVk3gs

https://www.youtube.com/watch?v=TlgP8MzlMaw

https://www.youtube.com/watch?v=TlgP8MzlMaw

https://www.youtube.com/watch?v=LHqqvrm2j6g Fine Crackles (Rales)

A. Tracheal Sound 正常的氣管聲音為在呼吸週期的兩個階段都可以清楚地聽到。

B. Normal (Vesicular) Lung Sound 肺音的正常頻率為 100 至 1000 Hz 正常的肺音只能在吸氣和呼氣的早期階段聽到。

C. Bronchial Breathing

D. Stridor 高音調。

E. Wheeze 100 至 5000 Hz 吸氣、呼氣或兩者都可以聽到，並且本質上是音樂性(musical)的，具有高音調。

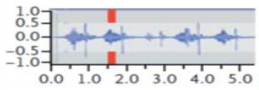
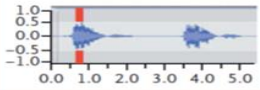
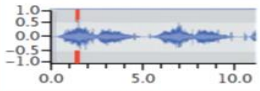
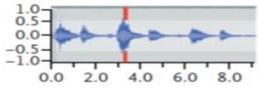
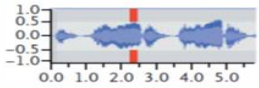
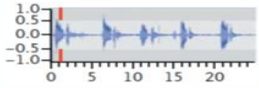
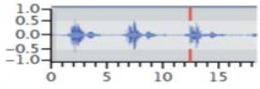
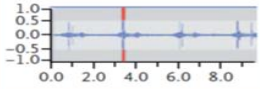
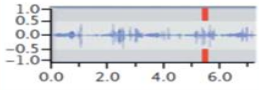
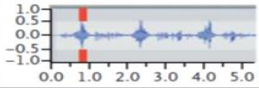
F. Rhonchus 150 Hz 可能吸氣、呼氣或兩者皆可聽到，本質上類似於打鼾的低音調。

G. Fine Crackle 650 Hz 吸氣中後期可聽到細微的劈啪聲，呼氣時可聽到，通常不會轉移到嘴裡，不受咳嗽影響。

H .Coarse Crackles 350 Hz 在吸氣早期和整個呼氣過程中聽到，受咳嗽的影響，轉移到口腔。

I. Pleural Friction Rub 爆炸性。

J.Squawk (short wheezes) 10 to 100 ms ，200 and 800 Hz。

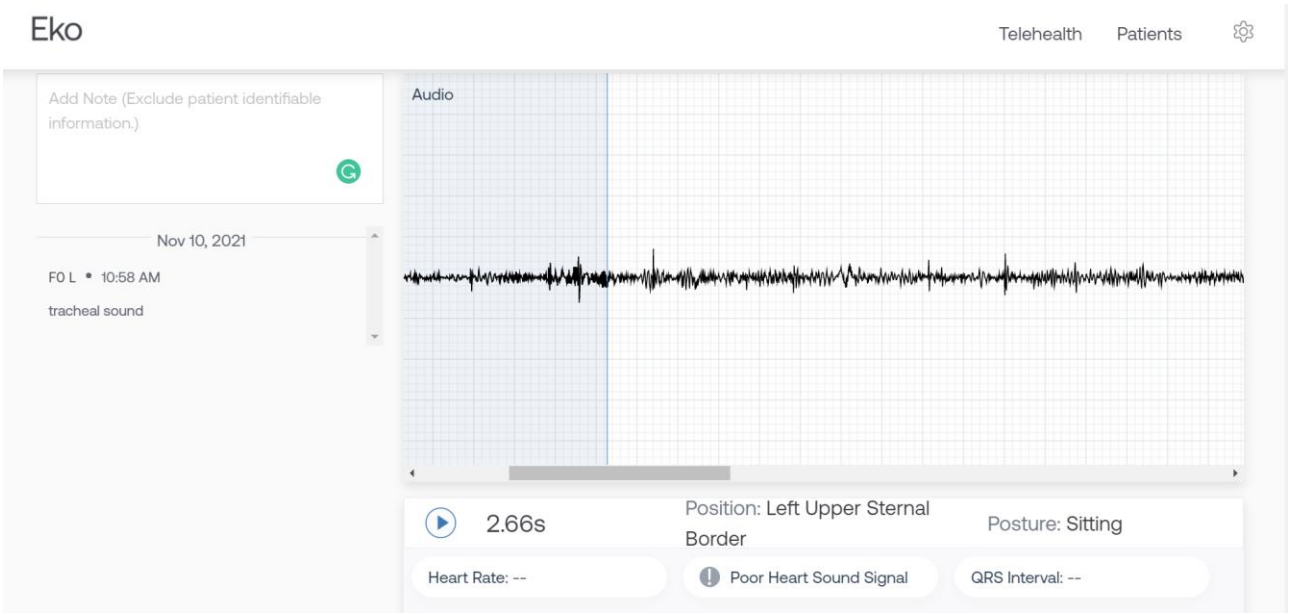
Respiratory Sound	Amplitude–Time Plot	
Acoustics	Unexpanded time	Expanded time
A Tracheal Sound White noise Typical frequency, 100–5000 Hz Drop of energy at 800 Hz		
B Normal (Vesicular) Lung Sound Low-pass-filtered noise Typical frequency, 100–1000 Hz Drop of energy at 200 Hz		
C Bronchial Breathing Strong expiratory component An intermediate sound between tracheal and normal breathing		
D Stridor Sinusoid Fundamental frequency, >500 Hz		
E Wheeze Sinusoid Typical frequency, >100–5000 Hz Typical duration, >80 msec		
F Rhonchus Sinusoid Typical frequency, about 150 Hz Typical duration, >80 msec		
G Fine Crackle Rapidly dampened wave deflection Typical frequency, about 650 Hz Typical duration, about 5 msec		
H Coarse Crackles Rapidly dampened wave deflection Typical frequency, about 350 Hz Typical duration, about 15 msec		
I Pleural Friction Rub Rhythmic succession of short sounds Typical frequency, <350hz Typical duration, >15 msec		
J Squawk Sinusoid Typical frequency, 200–300 Hz Typical duration, about 200 msec Followed or preceded by crackles		

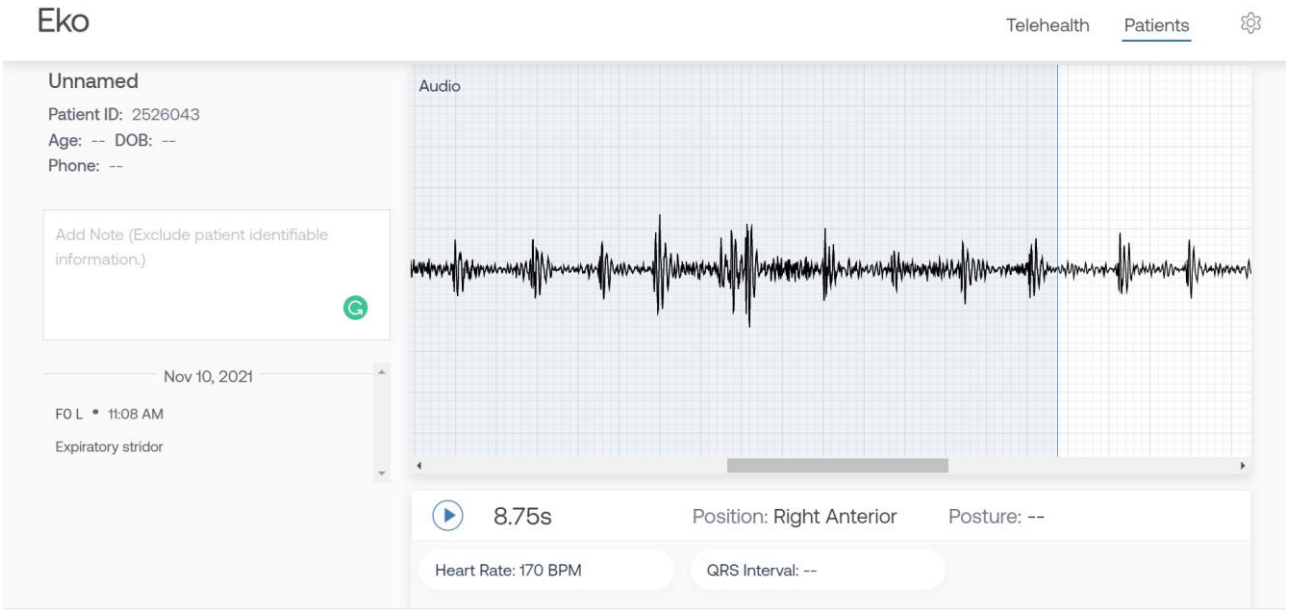
(Bohadana, Izbicki et al. 2014)

3）呼吸音聽診作業

學生在本科實習結束之前必須交出五個呼吸音的電子紀錄，並且與檔案中敘述呼吸音聽到的位置及此呼吸音的名稱。

範例如下:


Eko
Telehealth
Patients
Add Note (Exclude patient identifiable information.)
Nov 10, 2021
F0 L • 10:58 AM
tracheal sound
Audio
2.66s
Position: Left Upper Sternal Border
Posture: Sitting
Heart Rate: --
Poor Heart Sound Signal
QRS Interval: --


Eko
Telehealth
Patients
Unnamed
Patient ID: 2526043
Age: -- DOB: --
Phone: --
Add Note (Exclude patient identifiable information.)
Nov 10, 2021
F0 L • 11:08 AM
Expiratory stridor
Audio
8.75s
Position: Right Anterior
Posture: --
Heart Rate: 170 BPM
QRS Interval: --

Eko

Telehealth Patients

Unnamed

Patient ID: 2526043

Age: -- DOB: --

Phone: --

Add Note (Exclude patient identifiable information.)

Nov 10, 2021

F0 L • 11:11 AM

inspiratory fine crackles

Audio



10.52s

Position: Right Upper Sternal Border

Posture: Sitting

Heart Rate: --

Poor Heart Sound Signal

QRS Interval: --

Eko

Telehealth Patients

Unnamed

Patient ID: 8469020

Age: -- DOB: --

Phone: --

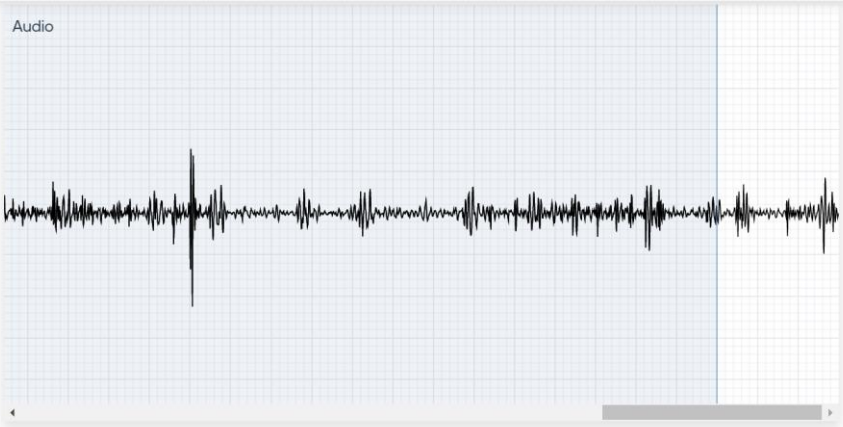
Add Note (Exclude patient identifiable information.)

Nov 10, 2021

F0 L • 10:40 AM

normal hear sound mixed with course crackles

Audio



14.40s

Position: Left Lower Posterior

Posture: --

Heart Rate: --

QRS Interval: --

Eko

Telehealth Patients

Unnamed

Patient ID: 26482371

Age: -- DOB: --

Phone: --

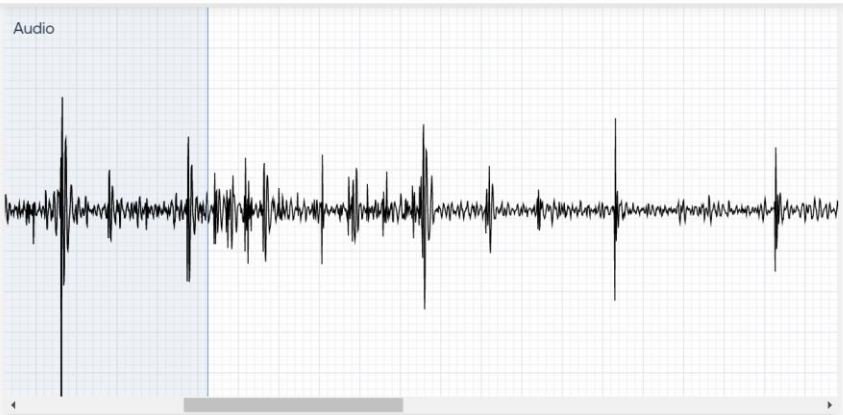
Add Note (Exclude patient identifiable information.)

Oct 29, 2021

F0 L • 09:44 AM

Sputum sound

Audio



4.05s

Position: Left Mid Posterior

Posture: --

Heart Rate: --

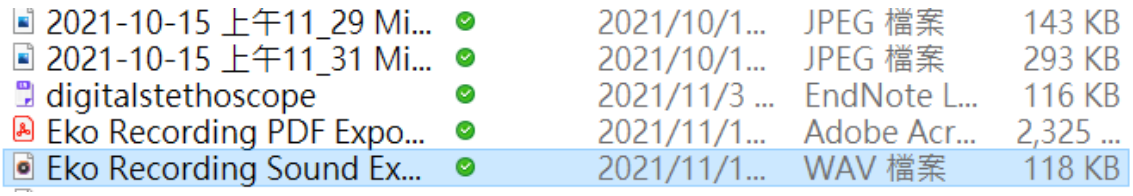
QRS Interval: --

如果學生有結果，我們可以與他們在線反饋。

也可以將圖形轉成 pdf 檔，



聲音轉成 wav 檔



3）成績考核方式

由任課老師針對學生呼吸音聽診作業給予即時的回饋，並加以評分。每一個呼吸音作業佔比 20 分。

4)各週課程進度

中山醫學大學醫學院醫學系胸腔外科實習課程是一個為期 2 週輪訓課程。 呼吸音聽診課程於此兩周之間的安排如下

5、 第一週的星期一發給呼吸聽診之教材。

6、 發放電子聽診器。

7、 給予呼吸音聽診作業。作業為數位化繳交方式。

8、 指導老師針對線上數位化作業給予及時反饋及評分。

5) 預計採用之學習成效評量工具l

Zuvio IRS

6) 教學場域

胸腔外科教學病房及門診。

9. 研究設計與執行方法 Research Methodology

C.　　研究架構

本研究採取實驗研究法. 介入、縱向、對照、單中心和隨機實驗研究。

將中山醫學大學附設醫院胸腔外科的實習學生分為兩組

介入組給予電子聽診器並指定聽診作業。

對照組照原先學習場域學習呼吸音聽診。

以前後測比較兩組之學習成效。

比較兩組之教學滿意度。

D.　研究問題/意識

使用**電子式聽診器呼吸音聽診課程**是否能有效提升醫學生的聽診能力？

理學檢查（physical examination）中之呼吸音聽診教學之落實及測驗。

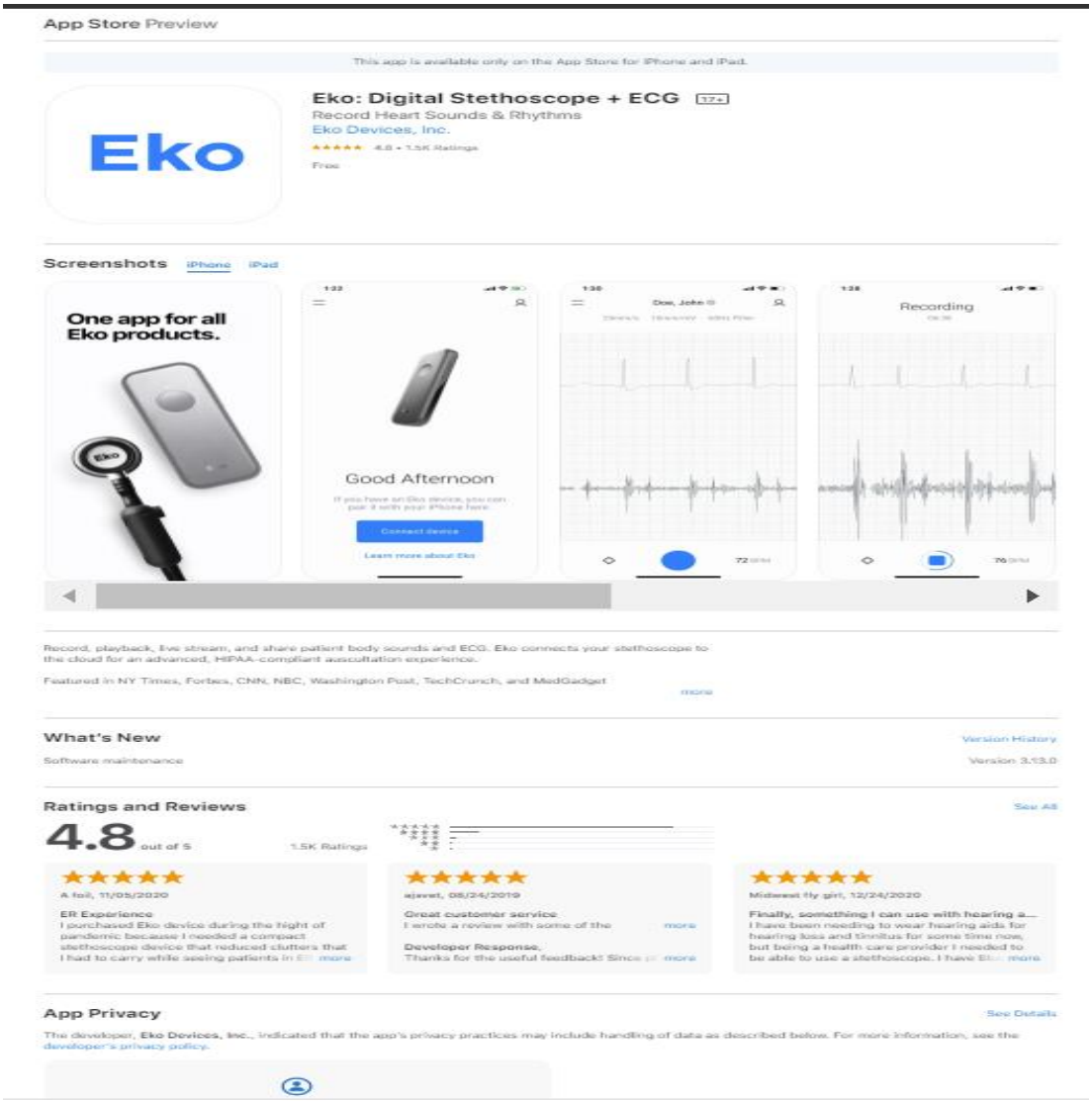
C. 研究範圍

【說明】　　針對本研究擬關注的範圍，如課程範疇、教材選用、教學資源應用、評量工具、社群教師與協作方式等規劃範圍進行說明。

本研究的**課程範疇**為外科學實習胸腔外科實習中呼吸學之聽診教學。

教材選用: 引進電子聽診器以量化聽診教學。

引進 Eko digital stethoscope platform https://www.ekohealth.com/. and App



教學資源應用、評量工具： Zuvio Interactive response system (IRS)。 中山醫學大學有訂閱 Zuvio IRS 互動式教學即時反饋系統。除了上課隨機抽點學生之外，在測驗的功能更為強大，可以隨機改變順序 ，評分並統計學生分數表現。更重要的是他是一個可以使用影音檔的測驗平台。 對於需要測驗聲音檔的我們是一個很適合的平台 。

社群教師與協作方式：可舉辦成果交流會 組織電子聽診教師社群， 推廣至各醫學相關院校及醫護相關科系。

D. 研究對象與場域

【說明】　　針對擬教學之對象與進行資料收集之場域(如實習場域、大學課室等)，進行描述與說明。

擬教學之對象 中山醫學大學醫學系至中山醫學大學附設醫院胸腔外科臨床實習的大五大六醫學生`。

進行資料收集之場域為實習場域: 中山醫學大學附設醫院胸腔外科病房及門診。

醫學生每天都會接觸到病人，在老師的指導下實行非侵入性的檢查及治療。經由學習學生能夠學習胸腔外科病人的診斷與治療。其中，呼吸音聽診為實習課程中重要的一環。是一種非侵入性的診斷方法。我們會指導學生在實習場域之中進行呼吸聽診，並且收集學生呼吸聽診狀況的資料。

E. 研究方法與工具

【說明】　　針對研究目的與問題，陳述將採用何種研究方法及工具進行資料蒐集，以有效檢視教學研究之成效，並回應提出之研究問題。

本研究採取實驗研究法. 介入、縱向、對照、單中心和隨機實驗研究。

將中山醫學大學附設醫院胸腔外科的實習學生分為兩組

介入組給予電子聽診器並指定聽診作業。

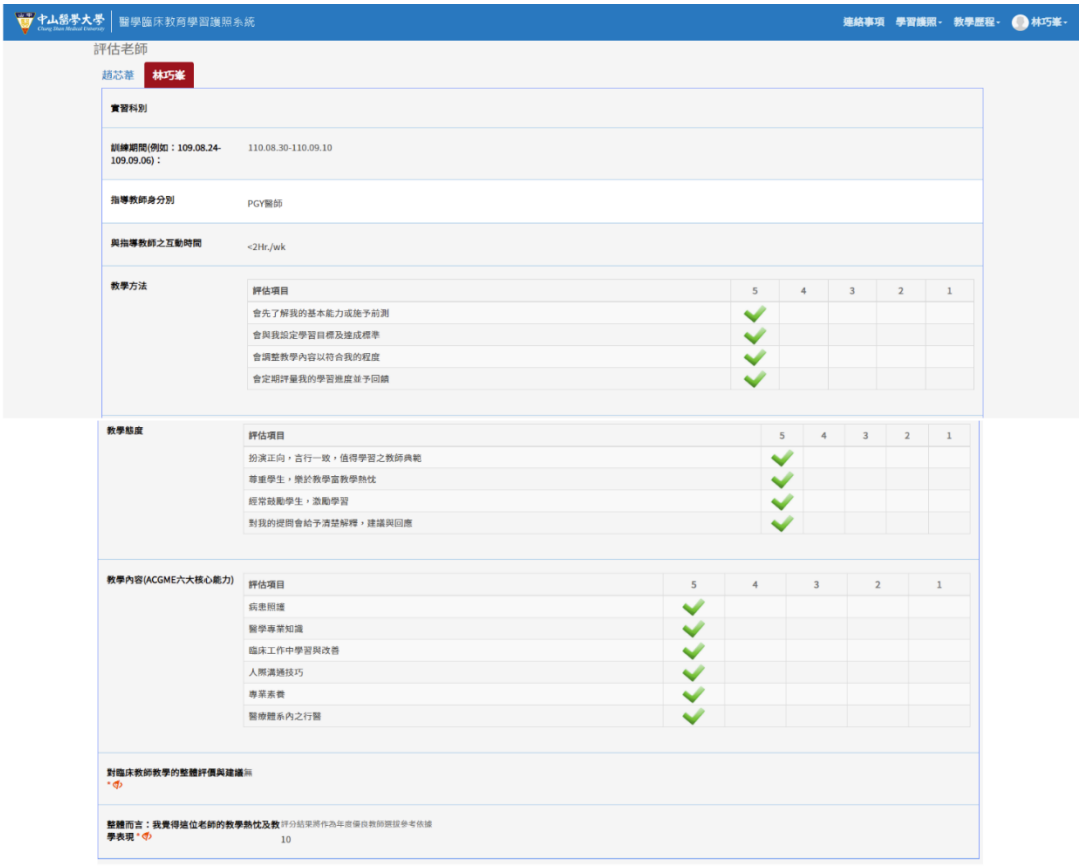
對照組照原先學習場域學習呼吸音聽診。

以前後測比較兩組之學習成效。

.

(1)　本實驗使用 Zuvio IRS 對學生進行前後測，比較 介入組及對照組成績學生的變化。

(2) 使用本校醫學臨床教育學習護照中的臨床教學滿意度調查對於介入組及對照組同學的滿意度進行分析比較， 已驗證是否有效提升教學品質。



F. 資料處理與分析

預計使用 IBM SPSS

Kolmogorov-Smirnov test 看學生成績及教學滿意度是否為常態分佈。

Student t test or Mann-Whitney test 比較介入組及對照組的分數及教學滿意度。

Paired Students t- test/ Wilcoxon signed-rank test 比較課程前和課程後的分數。

Correlation tests 比較作業分數和測驗分數及教學滿意度。

Chi-square test 統計介入組及對照組課後租借電子聽診器之比例來看他們對於聽診課程的興趣及電子聽診器的接受度 ，間接看出教學成效。

G.實施程序

一、電子式聽診器呼吸音聽診課程

實習課程本來就是在做中學習。本課程一樣採取有實作中學習的方法，讓醫學生能夠落實聽見

教學。其中落實的方法如下，

3. 發給學生學習教材，其中包括紙本教材及 YouTube 教材，連結如下。因為在醫學系四年級時，這些教材都有提過。故不再做講解。請學生自行複習。

4. 呼吸音聽診作業

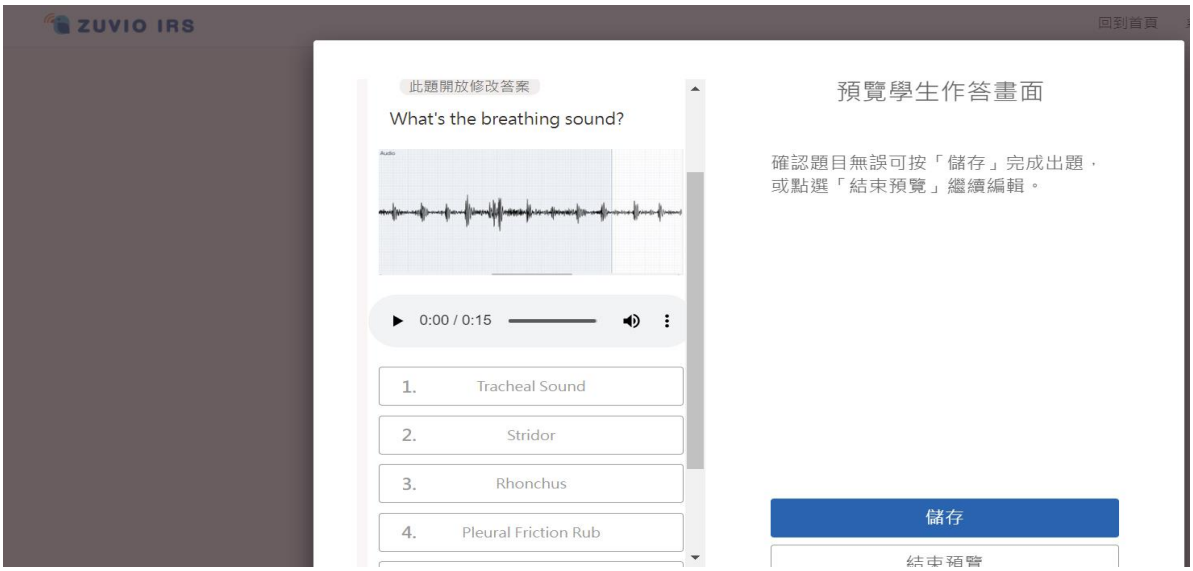
同學在本科實習結束之前必須交出五個呼吸音的紀錄，並且與檔案中敘述呼吸音聽到的位置以及此呼吸音的名稱。

二、前後測

使用 Zuvio IRS 出題

3、 建立呼吸音之聲音檔題庫 50 題

4、 以 Zuvio IRS 隨機出題



三、實施步驟

本教學試驗是一個以兩周為週期輪訓課程的試驗

7. 中山醫學大學附設醫院胸腔外科實習的第一天簽署教學試驗同意書。

8. 給予前測。利用 zuvio 可抽題之功能由呼吸音庫中抽 10 題來測驗。測驗時間點為第一週週一及第二週週五。

9. 前測完發給實驗組呼吸聽診之教材電子聽診器,Eko App,並給予呼吸音聽診作業。

10. 指導老師於這兩週之中給與臨床即時反饋教學 。

11. 實驗組及對照組於本科實習最後兩日實施後測。

12. 實驗組及對照組學員離開本科之前可以跟本科借電子聽診器繼續使用。

3. 教學暨研究成果 Teaching and Research Outcomes

i. 教學過程與成果

樣本總共有 87 位參與者。 在性別方面,有 47 位男性(56%)和 37 位女性(44%)。 班級方面,58 位學員屬於五年級(69%),26 位屬於六年級(31%)。 樣本中有 43 位學員(51%)屬於實驗組,41 位(49%)屬於對照組。 大多數學員(n=74, 88%)有參加 OSCE 課程,而 10 位(12%)沒有參加。

Kolmogorov-Smirnov 測試的年齡和分數的 P 值都小於 0.001。這表示數據庫並非正態分佈。

年齡的中位數為 24 歲,範圍是 22 到 33 歲。在樣本中,有 65 位(90.3%)觀看了 YouTube 視頻,62 位(87.3%)檢查了答案。 在詢問課程幫助程度的 5 分量表上,中位數是 5 分(「非常有幫助」),範圍是 2 到 5 分。

總結來說,樣本總數為 84。 男性略多於女性,主要是五年級學生,實驗組和對照組的人數相似。 大多數參加了 OSCE 並使用了 YouTube 和答案檢查。 中位數年齡為 24 歲。 大多數認為課程非常有幫助。

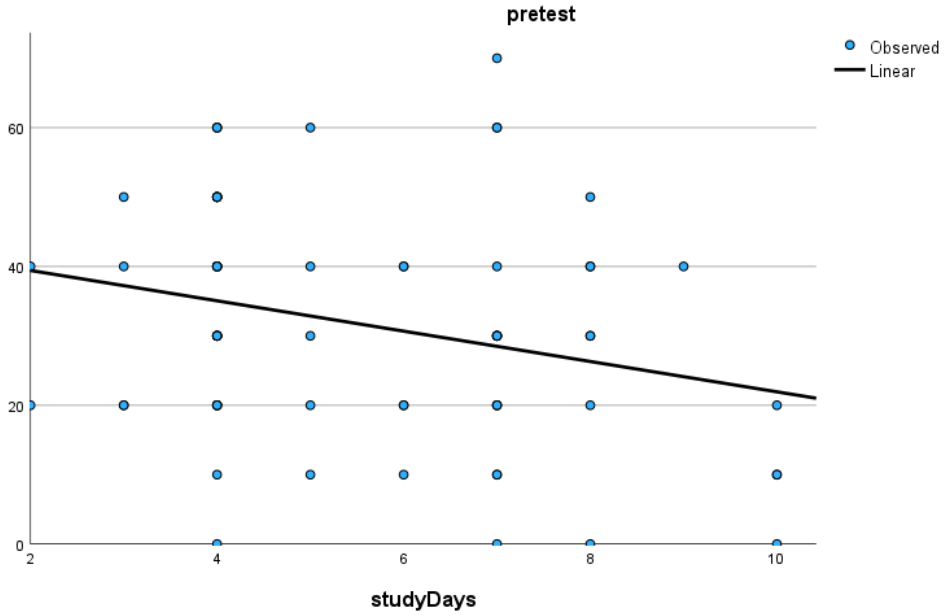
Table 1. Demography of the Students attend the breathing sound course

		N/ Median	% / min,max
		84	100
Gender	Male	47	56
	Female	37	44
Class	5	58	69
	6	26	31
Team	Intervention	43	51
	Control	41	49
OSCE	attend	74	88
	skip	10	12
Age		24	22,33
Teaching Video		65	90.3
Check Answer		62	87.3
Helpful	1,5	5	2,5
		6	2,10

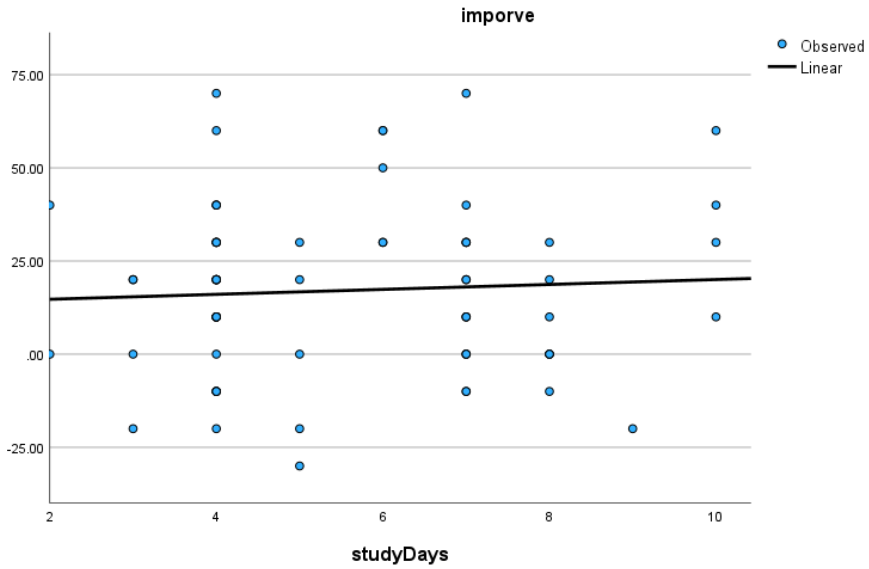
Time pre-,post-tests (days)	Intervention	5	4,10
	Control	7	3, 10

一個有趣的發現是,前測日期是由教師安排,但是後測日期是由學生自行安排,我們發現預測測驗分數越低的學生,需要的時間才會進行事後測驗也越長。

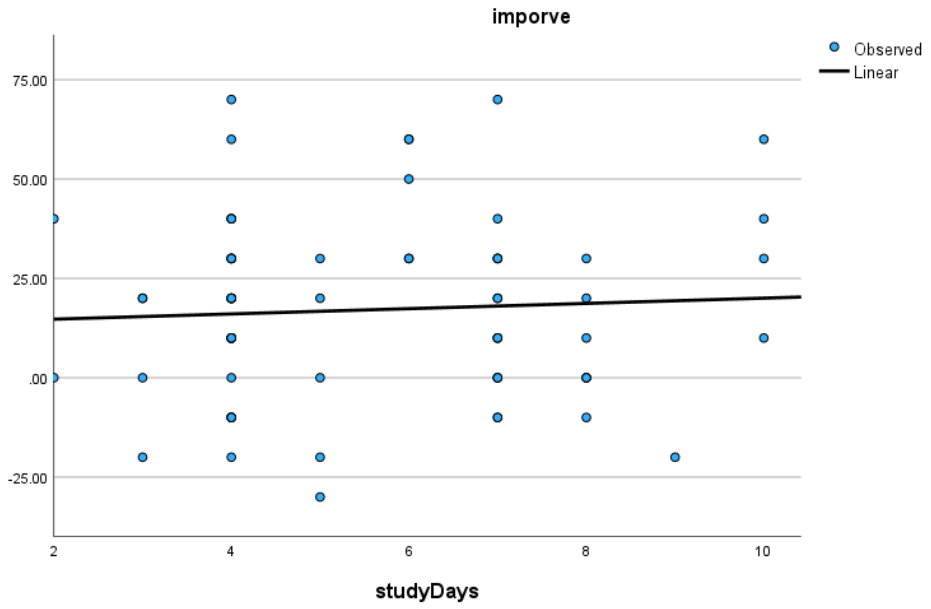
Pre-test Score=-2.186days +43.8 ,p=0.029



Post test score= -1.524 days+ 51.79, p=0.170



Score improvement =0.662days +13.4, p=0.631


imporve
Observed
Linear
75.00
50.00
25.00
.00
-25.00
2
4
6
8
10
studyDays

測驗分數結果

整體而言,前測的中位數分數是 30 分,在後測中提升到 50 分。中位數的進步是 20 分。

分別看實驗組和對照組,實驗組的前測中位數分數是 30 分,後測中位數分數是 40 分,中位數進步了 10 分。對照組的進步更多,前測中位數是 30 分,後測中位數是 55 分,中位數進步了 20 分。兩組在前測和後測之間都顯示了統計上顯著的進步。

參加過 OSCE 課程的學員,其前測和後測的中位數分數都比沒有參加的學員高。參加的學員中位數進步了 20 分,而沒有參加的學員中位數進步了 35 分。

對於觀看過呼吸音教學影片的學員,前測中位數是 30 分,後測中位數是 50 分,中位數進步了 20 分。沒有觀看影片的學員沒有進步。

五年級學員的中位數進步是 20 分,六年級學員是 10 分。前測和後測的分數在兩個年級之間沒有差異。

是否檢討前測答案與後測分數的進步也沒有關係,兩組的中位數進步都是 20 分。

總結來說,課程整體上有效提升了測驗分數,實驗組和對照組也都有顯著進步。觀看教學影片與更大的進步相關。

Table 2. The scores of the breathing sound course.					
			Median	min,max	p
	pretest		30	0,70	<0.001*
	posttest		50	20,90	
	improvement		20	-30, 70	
Intervention	pre-test	I	30	0, 60	0.269
		C	30	10, 70	
	post-test	I	40	10, 90	0.073
		C	55	20, 80	
	pre-post	I			<0.001*
		C			<0.001*
	improvement	I	10	-20, 70	0.539
		C	20	-30, 60	
OSCE	pre-test	1	30	20, 70	0.209
		0	20	10, 30	
	post-test	1	50	20,90	0.339
		0	55	50, 60	
	improvement	1	20	-30, 70	0.871
		0	35	30, 40	
Teaching Video	pre-test	1	30	0, 70	0.565
		0	30	20, 60	
	post-test	1	50	20, 90	0.180
		0	30	20, 70	
	improvement	1	20	-30, 70	0.084
		0	0	-10, 30	
Check Answer	pre-test	1	30	0, 70	0.146
		0	20	20, 80	
	post-test	1	50	20, 90	0.773
		0	50	20, 80	
	improvement	1	20	-30, 70	0.393
		0	20	0, 60	
Class	pre-test	5	30	0, 70	0.775
		6	30	0, 60	
	post-test	5	50	20, 70	0.772
		6	50	20, 70	
	improvement	5	20	-30, 70	0.613
		6	10	-10, 60	
Backward stepwise linear regression					
Teaching Video	β,95%CI		0.19	-2.94, 34.87	0.097
*Paired-Samples Wilcoxon Signed Rank Test					
I intervention, C control.					

ii 教師教學反思

以下是結果討論部份的中文修訂建議:

由於課程只有短短 2 周的時間,時間是個主要的限制和潛在的偏差來源。預測測驗的日期通常安排在實習的第 1 或 2 天,但是事後測驗的日期是由每個學生自行決定,並受到與 OSCE 中心日期衝突的影響。實習課程緊湊以及 OSCE 中心可使用時段有限,導致預測測驗和事後測驗之間的實際間隔僅有 2-10 天。預測測驗分數較低的學生似乎會預留更多時間學習才進行事後測驗。高峰期是第 5 天和第 8 天(星期五和下一個星期一)。這使得許多學生的 14 天課程被壓縮到 7 天,因為有些學生會在其他醫院開始新的實習課程,而 OSCE 中心的可用時段有限。

第二個未預期的限制來自於數位電子聽診器的介入。呼吸音課程教授有 200 多年歷史的古老體檢技巧。引入數位聽診器旨在透過科技提升這個領域,但是也存在一些缺點:1) 數位聽診器比傳統聽診器更沉重,與 Littmann 聽診器等追求輕便易攜的歷史設計理念反向而行,導致學生不願經常攜帶。2) 昂貴的價格使學生使用時小心翼翼。3) 使用需要連結手機,花費更多時間比傳統聽診器。 4) 在我們的臺灣實習環境中,數位聽診器系統不獲准顯示聲學自動分析結果。早期研究顯示此回饋有助學習,但我們的學生沒有此利益,因為相關軟體仍待台灣 FDA 審查通過。因此,很少學生完成 5 次聆聽記錄的任務,且此任務不影響正式成績。數位聽診器創新但實施失敗,導致實驗組和對照組沒有差異-兩組獲得相同教學,進步也相似。

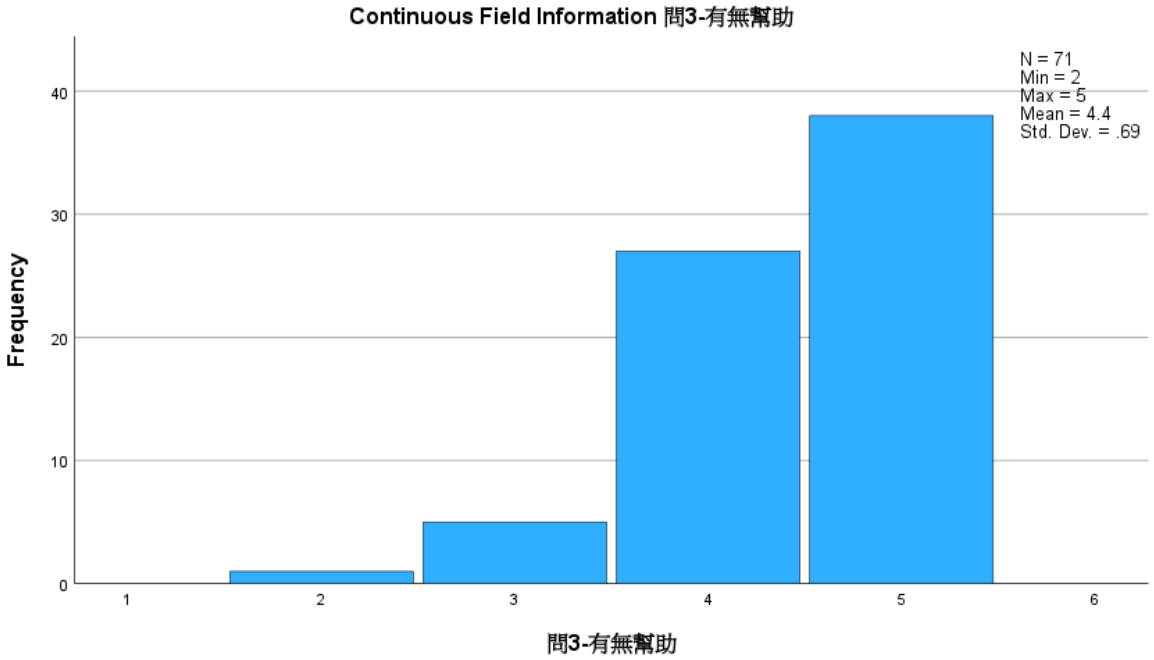
第一天發放的自學呼吸音影片大多數學生都認真學習,這成為影響測驗分數的主要因素。

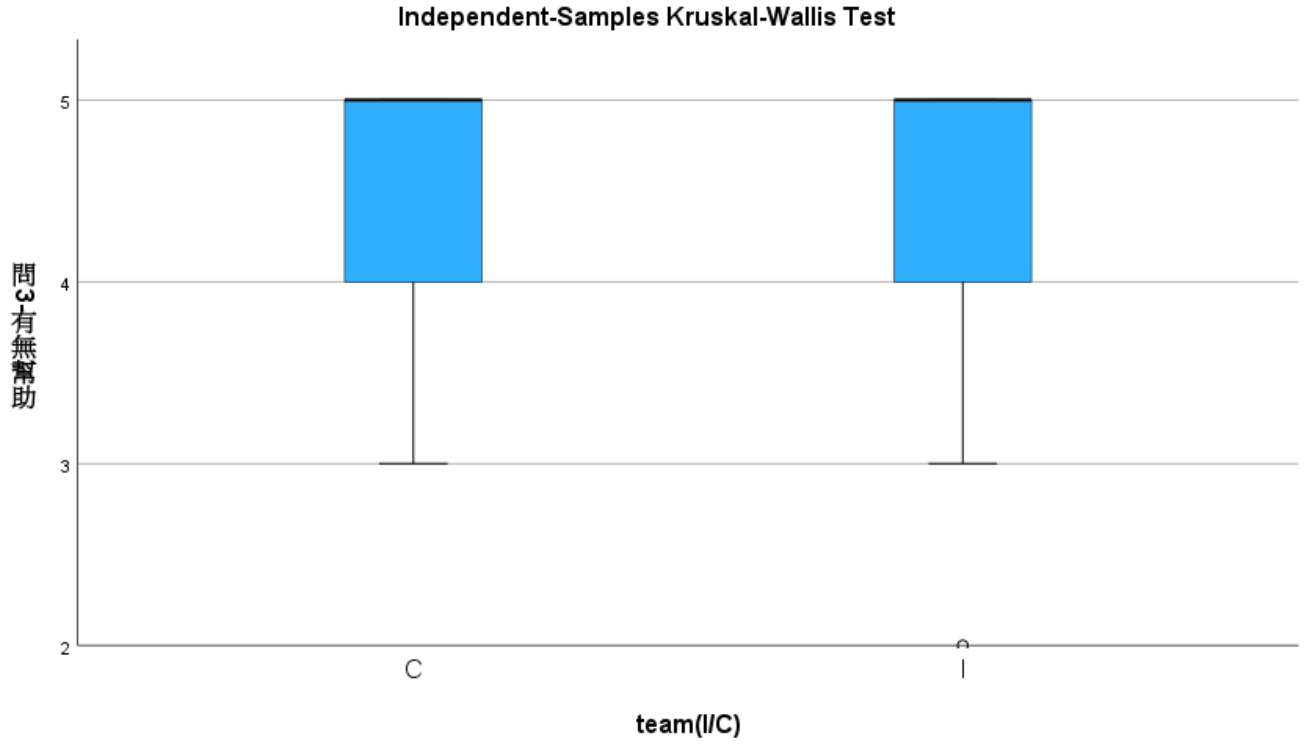
OSCE 中心學習也是由學生自行安排,最後實際上就擇定在事後測驗當天,所以沒有影響分數,但獲正面回饋。

由於數位聽診器作業完成度極低,其對測驗表現沒有影響。需要改良的軟體版本。實驗組和對照組之間無顯著差異的原因在於此項介入失敗。

iii.學生學習回饋

在呼吸音聽診課程中，45.2%的學生認為課程非常有助於他們提升身體檢查技能，32.1%的學生認為有一定幫助。 然而，數位聽診器由於笨重、昂貴、耗時，且缺乏自動分析功能，並未受到廣泛歡迎。組和對照組之間的評估保持一致。





10. 建議與省思 Recommendations and Reflections

正面回饋：超過 77% 的學生 (45.2% "非常有用" 和 32.1% "有用") 認為呼吸音聽診課程對提高他們的體檢技能很有價值，凸顯了其教育潛力。

改善建議

- 數位聽診器：透過探索輕量化版本或縮短操作流程來解決重量、價格和時間問題。 僅在自動分析功能獲得 TFDA 批准並證明有價值後才考慮引入該技術，因為目前台灣並不適合。
- 測試成績和學習：意料之外的低測試成績和自我學習影片後的顯著進步表明需要一個紮實的學習方案。

教學方法

保留：自主學習教材有效，應繼續使用。

改進：考慮使用測試而不是數位聽診器作為更強的激勵因素。

最佳化： ZUVIO 測試模型成功，應進一步利用。

整合：在課程早期實施 OSCE 中心 SAM II。

強調：鼓勵臨床老師優先並整合呼吸音教學融入實習課程。

課程設計

增加實務：增加實務練習以縮小理論與實務之間的差距。

模擬應用： 利用團體模擬練習讓學生在臨床環境中應用聽診技能。

擴大範圍：考慮在各次次專科開設多學科呼吸音課程。

綜合評估實施涵蓋所有相關次專科的測試，以評估學生整體診斷能力。

反思

- 可推廣性： 這項研究代表了中山醫學大學胸腔外科實習生，需要進一步研究評估其在其他醫學教育環境中的適用性。
- 整體評估：需要額外研究評估心音、血管音和腸鳴音教學的有效性。
- 多方面影響：教學效果不僅受方法和工具的影響，也受教師能力和學生學習動機等因素的影響。 因此，應探索教師培訓和學生學習動機策略。

結論：本研究為改善呼吸音聽診教學提供了寶貴的見解。 持續改進方法、工具和評估方法，以及在不同教學環境的探索，對於優化教學成果至關重要。

Application of Digital Electronic Stethoscope in The Teaching Of Breath Sound Auscultation For Medical School Students

I. Content

1. Research Motive and Purpose

The stethoscope has long been a symbol of the medical profession. Auscultation of the chest has been considered an essential part of the physical exam since the time of Hippocrates. However, it was not until the stethoscope was invented by René Laennec in 1816 that it became a widely adopted diagnostic tool in medicine. In the latter half of the 20th century, with advances in imaging technologies like x-ray, CT scans, MRI, and PET scans, medical interest shifted away from lung auscultation towards new techniques that could visualize lung pathology directly.



Nevertheless, history taking and physical examination remain cornerstones of medical diagnosis. The majority of diseases can be diagnosed through a detailed history and careful exam. Thus, all medical educators emphasize their importance, and medical students are expected to practice them daily during clinical clerkships. However, in today's rapidly advancing medical environment, there is a proliferation of new high-tech imaging and diagnostic tests that can distract students' attention away from traditional history taking and physical exam skills. Clinical teachers also struggle to impart these fundamental skills given limited teaching time. Ensuring competency in history and physical examination continues to be an area of concern in medical education.

To nurture well-rounded, competent physicians, we expect students to master physical examination skills. For chest physicians in particular, lung auscultation is paramount - listening to and analyzing breath sounds is a core clinical competency. In today's era of exponential growth in medical technology, it is imperative we develop appropriate teaching methods so students learn this 200-year-old diagnostic art and its quintessential component - respiratory sound auscultation.

Fortunately, technological developments have also created new opportunities for advancing auscultation teaching. Electronic stethoscopes can not only record and analyze lung sounds, but also visualize them as phonopneumogram printouts, lending objectivity to the previously subjective interpretation of auscultation. Capitalizing on these capabilities, respiratory sound teaching can be made more scientific and objective.

Medical students at Chung Shan Medical University currently receive an introductory lecture on

breathing sound auscultation during their 5th year clinical skills course. However, students report the course is too rushed and lacks opportunities to practice on actual patients. During clinical clerkships, there is also minimal guidance from senior clinicians. Given these gaps, developing an innovative and comprehensive respiratory auscultation curriculum leveraging digital stethoscope technology is imperative.

Additionally, with the advent of new educational assessment tools, we can harness assessment software to automatically generate exam questions from audiovisual course materials. Such computerized assessments enable instant feedback on student learning and repetitive testing for detailed evaluation of learning outcomes. Applying this to respiratory auscultation teaching could significantly enhance efficacy.

In summary, we propose developing a novel respiratory auscultation curriculum integrating electronic stethoscopes and computerized assessments. We expect this innovative course will not only enrich preclinical students' comprehension of normal breath sounds, but also provide ample practice to gain auscultation proficiency critical for clerkships, fulfilling the aspirations of medical education to nurture skilled clinicians. If proven effective, this teaching approach could be expanded to other auscultation areas to comprehensively boost students' auscultory competence.

中山醫學大學 Chung Shan Medical University 誠・愛・精・勤

醫五上學期Pre-clerkship
(上午)本校附設醫院臨床實習/(下午)學校上大堂課、臨床技能

臨床實習課程	
臨床課程	學分數(週數)
內科	4
外科	4
婦產	2
兒科	2

大堂課
急診醫學
臨床醫學導論
醫療行政體系
醫事案例分析

臨床技能課程-醫五上實習前預備課程

序號	技能項目	序號	技能項目
1	BLS	6	女性導尿管置入
2	基本傷口縫合技術 (縫合墊)	7	鼻胃管插入
3	胸部理學檢查 (包括聽肺音)	8	導尿管插入
4	心臟理學檢查 (包括心音)	9	氣管內插管
5	腹部理學檢查	10	心電圖操作與判讀

醫師、病人與社會(一)
學生於醫五上附醫12周+各院第一梯8周內完成





2. Research Question

Application of Digital Electronic Stethoscopes for Breathing Sound Auscultation Teaching among Medical Students in Medical School

The focus of this research project is on ” *innovating breathing sound auscultation teaching*”

Study population: medical school clerkship students

Tools : digital electronic stethoscopes and related software applications.

Innovative Digital Stethoscope Breathing Auscultation Course

This course utilizes electronic stethoscopes and Eko auscultation software to construct an innovative curriculum for teaching respiratory sound auscultation. By leveraging advanced electronic stethoscope technology and curriculum design, it aims to increase student interest and improve the currently suboptimal quality of breathing sound auscultation education in medical school clerkships. The goal is to nurture skilled future physicians adept at using breathing sounds to diagnose disease.

An additional benefit is the creation of an audio/ phonopneumogram question bank for assessing students' auscultation proficiency, enabling testing modalities not previously feasible with conventional stethoscope teaching.

Primary Objectives of the Research Project

To evaluate whether the *Innovative Digital Stethoscope Breathing Auscultation Curriculum* can effectively *improve the quality* of breathing sound auscultation teaching and learning outcomes among medical school clerkship students.

The main focus is breathing sound auscultation education for clerkship students, with the innovative electronic digital stethoscope curriculum as the intervention. The outcomes measured are teaching quality and learning effectiveness, assessed via student satisfaction surveys for the former and pre/post-testing for the latter.

3. **Literature Review**

The stethoscope has been a symbol of the medical profession for nearly two centuries!

Medical historian Jacalyn Duffin argues that the invention of the stethoscope marked an important step in redefining disease from a collection of symptoms to viewing disease as an issue of anatomical systems. Duffin contends this reconceptualization occurred in part because there were no non-invasive medical devices for exploring internal anatomy prior to the advent of the stethoscope.

Studies show that medical students' physical examination skills are often in need of improvement. Substantial research from the US, Canada, and the UK in particular has documented this situation. Current educational research provides some evidence for the efficacy of individual physical exam teaching methods. It recognizes the need for further development in physical exam medical education (Mosshammer, Graf et al. 2017, Yale, Tekiner et al. 2021). A study by Kim et al. showed accurate auscultation rates of 60.3% for medical students, 53.4% for residents, 68.8% for fellows, and 80.1% for faculty (Kim, Hyon et al. 2021). That is, the accuracy of diagnosing patients' illnesses by auscultation is unsatisfactory and needs effort to improve. A bicentennial review of the stethoscope also noted that in the latter half of the 20th century, powerful new non-invasive diagnostic modalities led to declining interest in auscultation. As a result, the auscultation skills of trainees and physicians at all levels deteriorated to disappointing lows. Reviewing the literature and considering the clinical setting, including availability of advanced diagnostic facilities, the authors concluded that the venerable stethoscope, despite its limitations, still has value as a patient-friendly, effective, and inexpensive medical instrument. However, new initiatives are needed to train students, physicians, and allied health professionals in auscultation to avoid potential patient harm and added costs from excessive reliance on expensive instrumentation. (Bank, Vliegen et al. 2016, Legget, Toh et al. 2018)

The stethoscope was invented in 1816 by René Laennec at the Hôpital Necker-Enfants Malades in Paris, France (Laennec 1819). It was monaural, consisting of a single wooden tube. Laennec invented the stethoscope because he felt uncomfortable placing his ear directly on women's chests to listen to their hearts (Roguin 2006, Permin and Norn 2016).

In 1840, Golding Bird was the first to publish his ongoing use of a stethoscope with rubber tubing (Bird 1840).

In the 1940s, Rappaport and Sprague designed a new stethoscope that became the benchmark to which other stethoscopes were compared, consisting of two sides - a diaphragm side for respiratory auscultation and bell side for cardiac auscultation.

It was not until the early 1960s that Harvard Medical School professor David Littmann invented a lighter stethoscope with improved acoustics compared to earlier models [U.S. Patent 3,108,652]. Thus the Littmann name became the brand for 3M stethoscopes.

Electronic digital stethoscopes are able to convert sound into an electronic signal which can be further amplified for improved listening (Araj and Cox 2019, Silverman and Balk 2019). Their performance is enhanced by converting heart, lung, and bowel sounds below 50 Hz to a frequency range of 200 Hz without loss of fidelity, which is easily detected by the human ear (Aumann and Emanetoglu 2019). That is, electronic stethoscopes can detect low frequency sounds inaudible with traditional stethoscopes. These electronic signals can be further processed and digitized for transmission to personal or laptop computers, mobile phones, and headsets. Currently, many companies offer electronic stethoscopes. The Eko Core wirelessly transmits sound to smartphones or personal tablet computers. Since sound is transmitted electronically, electronic stethoscopes can be wireless, recording devices, and provide noise reduction, signal enhancement, and visual as well as audio output. Around 2001, Stethographics began displaying heart and lung sounds visually as phonopneumograms in addition to the audio. All these features facilitate telemedicine (remote diagnosis) and teaching functionalities. Most available electronic stethoscopes today allow selection of different frequency modes enabling the listener to better hear sounds from the heart, lungs, and other body sites. Electronic stethoscopes can also suppress environmental and friction noise via various mechanisms to allow the listener to hear sounds as pristine as possible. For example, the 3M® Littmann Range offers a piezoelectric sensor that uses ambient noise reduction for noise cancellation and can amplify sounds up to 24 times.

Because of the above characteristics, many pioneering studies have applied electronic stethoscopes to various fields, raising the standards of medical care.

Research shows digitized sound recordings and phonocardiograms (dPCG) can aid in diagnosing cardiac murmurs, especially for those less experienced in cardiology (Voros, Nolte et al. 2011).

The Use of Digital Stethoscopes in Newborn

Newborns are a very special population. Because they are fragile, can poorly tolerate invasive treatments or diagnostic procedures, and cannot control themselves to cooperate with diagnostic instrumentation, simple non-invasive electronic stethoscopes are considered a boon in the field of newborn diagnosis. Zhou used an electronic stethoscope and computerized respiratory sound analysis to obtain recordings from 26 full term and 26 preterm infants. Zhou found the electronic stethoscope was able to identify significant differences in the acoustic characteristics of breathing in room air between full term and preterm infants (Zhou, Marzbanrad et al. 2020). Ramanathan utilized a digital stethoscope (DS) to assess changes in the characteristics of breath sounds in the first 2 hours of life and their relationship to mode of delivery. The frequency distribution of breath sounds significantly declined from 1 minute to 2 hours, mean(SD) frequency decreasing from 333.74(35.42) to 302.71(47.19) Hz, $p<0.001$, and power ratio(SD) lowest quartile band increasing from 0.27(0.11) to 0.37(0.15), $p<0.001$. At 1 minute, vaginally born infants had slightly higher frequency than cesarean, but no difference at 2 hours. It is known regarding the neonatal pulmonary transition process that clearance of lung liquid and aeration are key processes promoting respiration, and mode of delivery impacts this transition. Electronic stethoscopes provide enhanced auscultation capabilities and have been utilized in pediatric populations for cardiac and pulmonary assessment, to predict development of breath sounds, and to assess for respiratory distress before symptoms arise in newborns (Ramanathan, Marzbanrad et al. 2020). Treston employed an electronic stethoscope, handheld ultrasound, and ECG to immediately assess newborn heart rate after delivery (Treston, Semberova et al. 2019).

The Use of Digital Stethoscopes in Cardiology and Anesthesiology

One of the powerful features of a stethoscope is its ability to explore the sounds produced by blood flowing through a lumen. Therefore, many people apply electronic stethoscopes to the discovery and diagnosis of cardiovascular diseases.

Intracranial aneurysms can generate murmurs within a specific frequency range, and this murmur is greatly affected by wall thickness. Understanding the mechanism of murmur generation may allow us to study aneurysms non-invasively. Four ophthalmic aneurysm patients were studied using a digital electronic stethoscope before and after endovascular treatment. The spectrum of murmurs can be obtained from the digital recordings of both eyes (Jou and Mawad 2010).

Chowdhury proposed a prototype of a real-time digital electronic stethoscope system to monitor the patient's heart sounds in real time and diagnose any abnormalities. There is an unmet need for portable systems for early detection of heart disease (Chowdhury, Khandakar et al. 2019).

Makaryus used a digital electronic stethoscope to detect coronary micro murmurs, which are faint murmurs that cannot be heard with a standard stethoscope, and may provide another method of detecting coronary artery disease. The purpose of his study was to test the accuracy of a new digital electronic stethoscope, the Cardiac Spectral Analyzer (CSA; SonoMedica Model 3.0, SonoMedica, Inc., Vienna, Virginia, USA), compared to the gold standard diagnosis of coronary artery disease using cardiac computed tomography (CT) angiography. The overall sensitivity of the digital electronic stethoscope CSA to identify any major epicardial coronary stenosis >50% was 89.5% ($p < 0.0001$). Gender-specific models based on smaller sample sizes had slightly worse results in men with more chest hair, with lower specificity. Overall, the digital electronic stethoscope CSA showed high sensitivity and specificity for detecting significant early coronary artery disease in the outpatient setting, and represents a new non-invasive device for detecting abnormal coronary blood flow that occurs in coronary artery disease. (Makaryus, Makaryus et al. 2013)

The Use of Digital Stethoscopes in the Operating Room

There are very few medical devices that can be used to detect a patient's condition in the operating room. Because it is very difficult for patients to be moved to another location for testing while they are undergoing open chest and abdominal surgery. During surgery, the patient's physiological state changes greatly and instantly, and often requires continuous real-time monitoring. Therefore, the digital electronic stethoscope is a very good tool that can continuously monitor the patient's condition. Many anesthesiologists have published research on the use of digital electronic stethoscopes in anesthetized patients.

Duck performed basic auscultation procedures on patients under general anesthesia. Since the amplitude (graphic representation of the electronic stethoscope) of the first heart sound (S1) can represent left ventricular function, the correlation between it and cardiac output was studied. In all cases, there was a significant correlation between the amplitude of S1 and the change in CO (cardiac output) (Duck Shin, Hoon Yim et al. 2014).

Klum used a multi-mode patch stethoscope to estimate Einthoven electrocardiogram (ECG) leads I and II from a single 55 mm ECG lead. The ejection pre-period (PEP) and left ventricular ejection time (LVET) were estimated using the stethoscope and ECG subsystems. It was concluded that it is feasible to estimate ECG, PEP, LVET, and respiratory parameters using a wearable multi-modal device, and further research on multi-modal signal fusion to estimate respiratory signals is encouraged (Klum, Urban et al. 2020).

Anesthesiologists have also used digital electronic stethoscopes and digital signal processing software (Goldwave) to monitor ventilation in intubated patients. This preliminary study suggests that this technology may be useful in providing a practical real-time warning system for detecting endotracheal tube malposition (Doyle and Nair 2009).

In addition, anesthesiologists have developed a digital electronic transesophageal stethoscope to detect the condition of patients during cardiac surgery. While retaining the advantages of the traditional esophageal stethoscope, it also makes up for the shortcomings of the traditional esophageal stethoscope. It can not only detect heart sounds and murmurs through the esophageal tube, but also display the amplitude and waveform of heart sounds and murmurs, and measure the patient's body temperature. Therefore, the developed digital electronic transesophageal stethoscope is expected to be used for continuous auscultation of heart sounds during surgery, and to contribute to heart sound research by providing heart sound data (Shin, Lim et al. 2010).

The Advantages and Applications of Digital Stethoscopes

Digital stethoscopes overcome the limitations of traditional stethoscopes by converting sound data into electrical signals that can be amplified, stored, and replayed. More importantly, patients can send their auscultation results to experts and physicians, who can diagnose based on the resulting graphs and sounds, allowing remote patients to receive timely medical guidance and care, making them very useful in telemedicine. (Lakhe, Sodhi et al. 2016)

Digital stethoscopes can digitize sounds and present them as spectrograms, which can be used in conjunction with artificial intelligence (AI) to develop applications that are not possible with traditional stethoscopes. Cardiologists use digital stethoscopes in conjunction with computers and AI auscultation procedures to analyze recorded heart sounds for pathological or harmless heart murmurs (Chorba, Shapiro et al. 2021). In the paper "Time-domain analysis of heart sound intensity in children with and without pulmonary artery hypertension: a pilot study using a digital stethoscope", pediatricians studied 11 children with pulmonary artery hypertension (median mPAp: 55 mmHg [range: 25-97 mmHg]) and 11 children without pulmonary artery hypertension (median mPAp: 15 mmHg [range: 8-24 mmHg]). There were significant differences in the intensity ratios of P2ratioA2 ($P = .0001$) and P2ratioS2 ($P = .0001$) between subjects with and without pulmonary artery hypertension. There was a linear correlation between the intensity ratios of P2ratioS2 and P2ratioA2 and mPAp ($r > 0.7$). We found that the intensity ratios of P2ratioA2 and P2ratioS2 can distinguish between children with and without pulmonary artery hypertension. These findings may help in the development of acoustic devices for the diagnosis of pulmonary artery hypertension (Elgendi, Bobhate et al. 2014). In the study of respiratory sounds, the current overall sensitivity of AI for detecting crackles or rales is 80% (95% CI 72-86%) and the specificity is 85% (95% CI 78-91%)(Gurung, Scrafford et al. 2011, Ali, Hasan et al. 2021, Kim, Hyon et al. 2021). Rheumatic heart disease (RHD) causes significant morbidity and mortality worldwide. To mitigate the harm of RHD, it is important to initiate secondary prevention, namely screening for RHD, in a timely manner. Cardiologists designed a

study to train a deep learning algorithm using waveform data from digital stethoscopes to predict subclinical RHD and determine the frequency of subclinical RHD (Ali, Hasan et al. 2021).

The Use of Digital Stethoscopes in Teaching

Currently, the use of digital stethoscopes in clinical teaching is not widespread, mainly focusing on the auscultation of heart sounds. Mesquita et al. pointed out in their paper that the ability to identify heart sounds was significantly improved in the group using digital stethoscopes (51.9%) compared to the group using traditional stethoscopes (29.5%). Short-term auscultation teaching of heart sounds using digital stethoscopes can significantly improve the ability to identify heart sounds (Mesquita, Reis et al. 2013). Dr. Legget conducted a study on the use of digital stethoscopes in cardiac auscultation teaching. The control group increased from an average of 95% CI to 2.5% [-11.5, 16.5] P = 0.95 from training to validation period, and the intervention group increased by 15.8% [1.7,29.8] P= 0.027. The scores increased by 9.1% [1.82, 16.4] (p = 0.018) between the validation and training courses of the two groups. The mean [95% CI] difference in scores between the control and intervention groups was 1.9% [-5.4, 9.2] (p = 0.59). Cohen's effect size estimate was 0.9. This study concluded that digital stethoscopes are a useful tool for teaching cardiac auscultation (Legget et al. 2018).

Conclusion

In summary, digital stethoscopes can enhance the quality of respiratory auscultation. They can:

* Amplify respiratory sounds
* Convert inaudible frequencies into audible frequencies
* Filter out noise
* Digitize and record sounds
* Convert sounds into spectrograms for analysis and diagnosis with artificial intelligence

Digital stethoscopes have been used in cardiology to improve the quality of heart sound auscultation, in pediatrics to monitor newborns, in anesthesiology to monitor the condition of anesthetized patients, and in telemedicine. They have also been successfully used in heart sound auscultation teaching.

Therefore, we will apply digital stethoscopes to respiratory auscultation teaching. We will first use high-tech digital stethoscopes and the Eko app to arouse students' interest in respiratory auscultation. We will then use courses and textbooks to help students learn more about respiratory auscultation. We will also have students practice on patients and give them feedback to help them gain the correct hands-on experience in respiratory auscultation.

After that, we will continue to lend digital stethoscopes and the Eko app to students in their clerkship courses in other departments to strengthen their learning of respiratory auscultation. This will allow them to continue learning through technology even when they are not in the same department.

We expect that this will achieve good teaching results, improve students' interest in learning respiratory auscultation, and achieve good teaching quality and assessment.

In the future, we can also can enhance this teaching model to cardiology, anesthesiology, pediatrics, and other clinically relevant departments to make a positive contribution to the cultivation of the next generation of excellent doctors and medical professionals.

4. Teaching Planning

Innovative Course Proposal

Course Name: **Respiratory Auscultation with Digital Stethoscopes**

(1) Teaching Design and Planning

Teaching Objectives

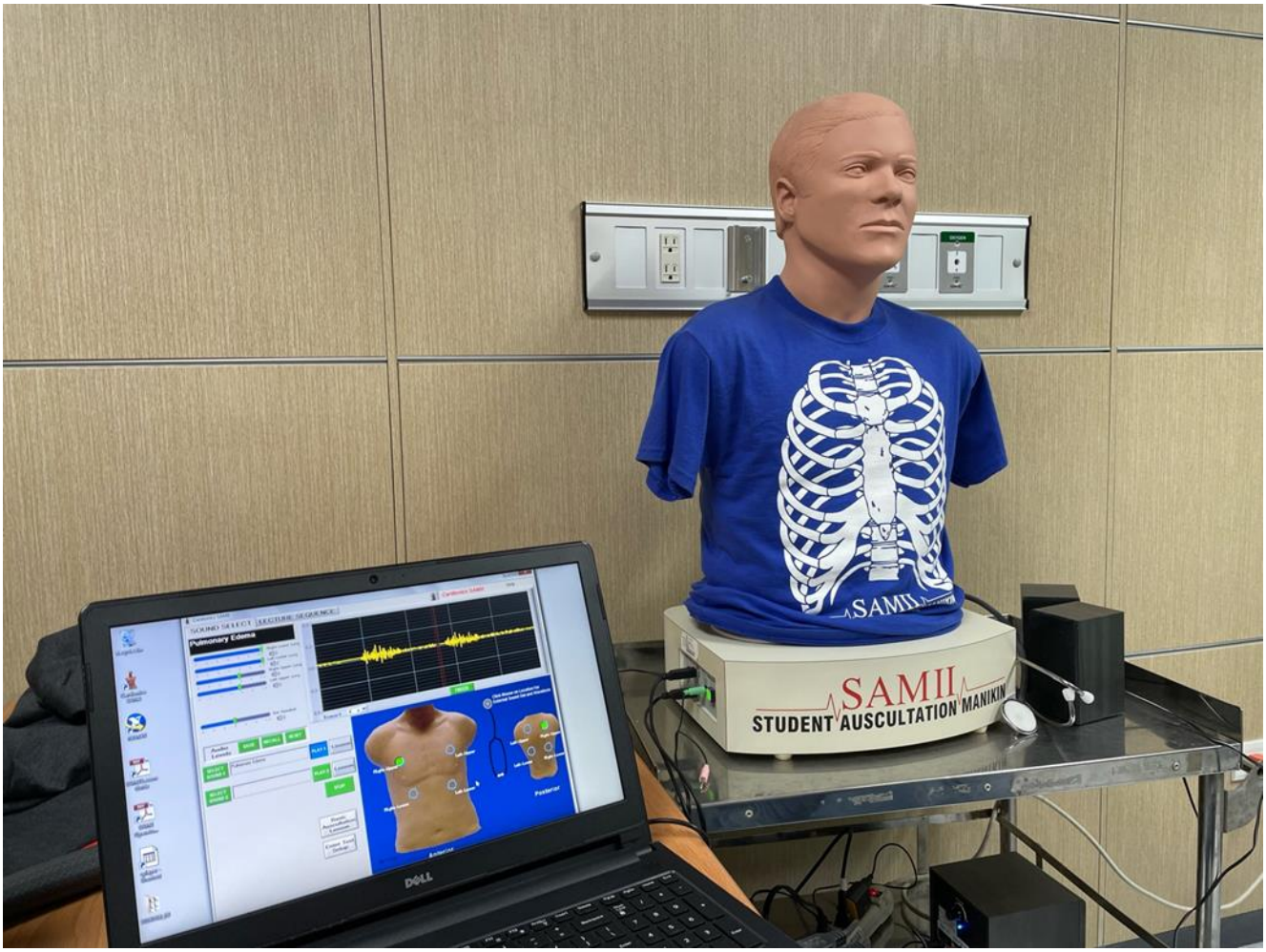
To teach fifth- and sixth-year medical students at the School of Medicine to perform respiratory auscultation at a proficient level.

Teaching Methods

* Clerkship courses are designed for learning by doing. This course will also adopt a hands-on approach to allow medical students to apply respiratory auscultation teaching. The following methods will be used:

i) Clinical Skills Center (OSCE Center)

Students will use the SAM II respiratory sound simulator at the OSCE center to learn about ten different respiratory sounds. SAM II allows students to perform auscultation on a physical model using a stethoscope. It also provides sounds and spectrograms for learning.



ii) Respiratory Auscultation Teaching Videos

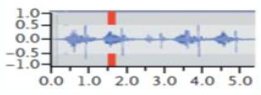
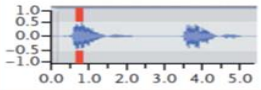
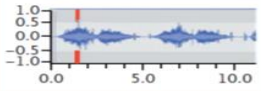
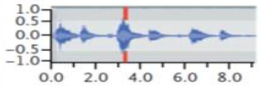
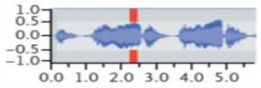
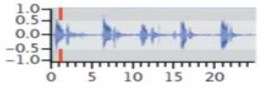
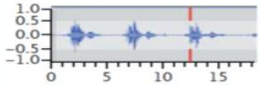
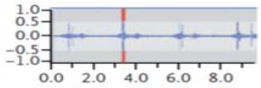
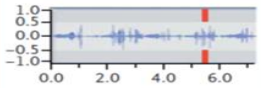
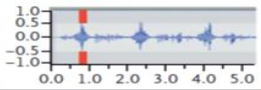
Students will then be given learning materials, including paper and YouTube materials, as follows. These materials were covered in the fourth year of medical school, so they will not be covered again. Students are asked to review them on their own.

* https://www.youtube.com/watch?v=eWGxuwVk3gs

* https://www.youtube.com/watch?v=TlgP8MzlMaw

* https://www.youtube.com/watch?v=TlgP8MzlMaw

* https://www.youtube.com/watch?v=LHqqvrm2j6g Fine Crackles (Rales)

Respiratory Sound	Amplitude–Time Plot	
Acoustics	Unexpanded time	Expanded time
A Tracheal Sound White noise Typical frequency, 100–5000 Hz Drop of energy at 800 Hz		
B Normal (Vesicular) Lung Sound Low-pass-filtered noise Typical frequency, 100–1000 Hz Drop of energy at 200 Hz		
C Bronchial Breathing Strong expiratory component An intermediate sound between tracheal and normal breathing		
D Stridor Sinusoid Fundamental frequency, >500 Hz		
E Wheeze Sinusoid Typical frequency, >100–5000 Hz Typical duration, >80 msec		
F Rhonchus Sinusoid Typical frequency, about 150 Hz Typical duration, >80 msec		
G Fine Crackle Rapidly dampened wave deflection Typical frequency, about 650 Hz Typical duration, about 5 msec		
H Coarse Crackles Rapidly dampened wave deflection Typical frequency, about 350 Hz Typical duration, about 15 msec		
I Pleural Friction Rub Rhythmic succession of short sounds Typical frequency, <350hz Typical duration, >15 msec		
J Squawk Sinusoid Typical frequency, 200–300 Hz Typical duration, about 200 msec Followed or preceded by crackles		

* A. Tracheal Sound: Normal tracheal sounds can be clearly heard in both phases of the respiratory cycle.

* B. Normal (Vesicular) Lung Sound: The normal frequency of lung sounds is 100 to 1000 Hz. Normal lung sounds can only be heard during the early phases of inspiration and expiration.

* C. Bronchial Breathing

* D. Stridor: High-pitched.

* E. Wheeze: 100 to 5000 Hz. Can be heard during inspiration, expiration, or both, and is essentially musical in nature, with a high pitch.

* F. Rhonchus: 150 Hz. Can be heard during inspiration, expiration, or both. It is essentially a low-pitched snoring sound.

* G. Fine Crackle: 650 Hz. A fine crackling sound can be heard in the mid-to-late phase of inspiration and may be heard during expiration. It usually does not transmit to the mouth and is not affected by coughing.

* H. Coarse Crackles: 350 Hz. Heard in early inspiration and throughout expiration, affected by coughing, and transmitted to the mouth.

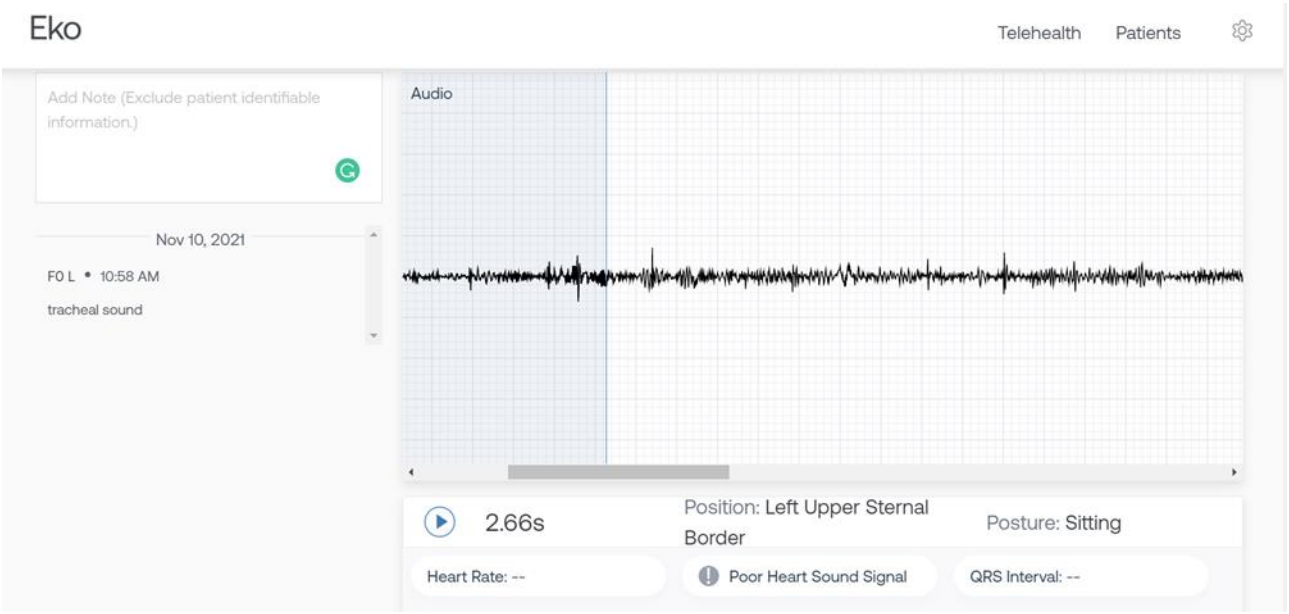
* I. Pleural Friction Rub: Explosive.

* J. Squawk (short wheezes): 10 to 100 ms, 200 and 800 Hz.

iii) Respiratory Auscultation Assignment**

Before the end of their clerkship in the department, students must submit electronic records of five respiratory sounds, along with a description of the location and name of the respiratory sound heard.

* An example is as follows:



If students have results, we can provide them with online feedback.

The graphs can also be converted to PDF files.



Grading

The instructor will provide immediate feedback and grading on the students' respiratory auscultation assignments. Each respiratory sound assignment will be worth 20 points.

iv) Weekly Course Schedule

The clerkship course in thoracic surgery at the School of Medicine is a two-week rotation course. The respiratory auscultation course will be arranged as follows during these two weeks:

a). The materials for respiratory auscultation will be distributed on Monday of the first week.

b). Digital stethoscopes will be distributed.

c) A respiratory auscultation assignment will be given. The assignment will be submitted in digital format.

d) The instructor will provide immediate feedback and grading on the online digital assignments.

V. Learning Outcome Assessment Tools**

* Zuvio IRS

vi) Teaching Location**

* Thoracic surgery teaching ward and clinic.

5. Research Methodology

A. Research Framework

This study adopts an experimental research method. It is an interventional, longitudinal, controlled, single-center, and randomized experimental study.

Interns from the Department of Thoracic Surgery,CSMU were divided into two groups.

The intervention (I) group was given an electronic stethoscope and assigned a stethoscope assignment.

The control group learned respiratory auscultation in their original learning environment.

The learning outcomes of the two groups were compared before and after the test.

The teaching satisfaction of the two groups was compared.

B. Research Questions/Consciousness

Can the use of an electronic digital stethoscope respiratory auscultation course effectively improve the auscultation skills of medical students?

The implementation and testing of respiratory auscultation teaching in physical examination.

C. Research Scope

The scope of this study is respiratory auscultation teaching in the surgical clerkship of thoracic surgery.

The teaching materials used are:

- Introduction of electronic stethoscope to quantify auscultation teaching.
- Introduction of Eko digital stethoscope platform https://www.ekohealth.com/. and App
- Teaching resources application and evaluation tools: Zuvio Interactive response system (IRS). SCMU has subscribed to Zuvio IRS interactive teaching real-time feedback system. In addition to randomize students in class, the testing function is more powerful, and it can randomly change the order, score and statistic students' score performance. More importantly, it is a testing platform that can use audio and video files. For us who need to test audio files, it is a very suitable platform.
- Community teachers and collaboration methods: We can hold results share to organize an electronic stethoscope teacher community and promote it to relevant medical schools and medical departments.

D. Research Subjects and Fields

The subjects to be taught are medical students from Medical School, SCMU who have clinical clerkships in the Department of Thoracic Surgery, Chung Shan Medical University Hospital(CSMUH).

The data collection site is the clerkship site: the ward and clinic of the Department of Thoracic Surgery Chung Shan Medical University Hosptial.

Medical students come into contact with patients every day and perform non-invasive examinations and treatments under the guidance of teachers. Through learning, students can learn the diagnosis and treatment of thoracic surgery patients. Among them, respiratory auscultation is an important part of the clerkship course. It is a non-invasive diagnostic method. We will guide students to perform respiratory auscultation in the clerkship field and collect data on the students' respiratory auscultation status.

E. Research Methods and Tools

This study adopts an experimental research method. It is an interventional, longitudinal, controlled, single-center, and randomized experimental study.

Interns from the Department of Thoracic Surgery, SCMUH were divided into two groups.

The intervention (I) group was given an electronic stethoscope and assigned a stethoscope assignment.

The control group (C) learned respiratory auscultation in their original learning environment.

The learning outcomes of the two groups were compared before and after the test.

(1) This experiment uses Zuvio IRS to conduct pre- and post-tests on students to compare the changes in scores of students in the intervention group and the control group.

(2) The clinical teaching satisfaction survey in the medical clinical education learning passport of our school was used to analyze and compare the satisfaction of students in the intervention group and the control group, in order to verify whether the teaching quality was effectively improved.

F. Data Processing and Analysis

It is planned to use IBM SPSS

Kolmogorov-Smirnov test to see if the students score and teaching satisfaction are normally distributed.

Student t test or Mann-Whitney test to compare the scores and teaching satisfaction of the intervention group and the control group.

Paired Students t- test/ Wilcoxon signed-rank test to compare the scores before and after the course.

Regression tests to compare the scores of assignments and tests and teaching satisfaction.

Chi-square test to compare the proportion of students in the intervention group and the control group who rented electronic stethoscopes after the course to see their interest in the auscultation course and their acceptance of electronic stethoscopes, indirectly reflecting the teaching effect.

G. Implementation Procedure

I. Electronic Stethoscope Respiratory Auscultation Course

The clerkship course is originally a learning-by-doing course. This course also adopts the method of learning by doing, so that medical students can implement the teaching of listening. The implementation methods are as follows:

1. Provide students with learning materials, including paper materials and YouTube materials, as follows. Since these materials have been mentioned in the fourth year of medical school, they will not be explained again. Please review them by yourself.

2. Respiratory auscultation assignment

Before the end of the clerkship in this department, students must submit five records of respiratory sounds, and describe the location and name of the respiratory sounds heard in the file.

II. Pre-test and Post-test

Use Zuvio IRS to create questions

1. Establish a question bank of 50 respiratory sound audio files

2. Randomly generate questions with Zuvio IRS

This teaching experiment is a cycle-based training course with a period of two weeks.

1. Sign the teaching experiment consent form on the first day of the clerkship in the Department of Thoracic Surgery, SCMUH.

2. Give a pre-test. Use the random question function of Zuvio to draw 10 questions from the respiratory sound bank for the test. The test time points are Monday of the first week and Friday of the second week.

3. After the pre-test, the experimental group is given the teaching materials of electronic stethoscope respiratory auscultation, Eko App, and respiratory auscultation assignment.

4. The instructor will provide clinical real-time feedback teaching in the next two weeks.

5. The experimental group and the control group will conduct a post-test on the last two days of the clerkship in this department.

6. Students in the experimental group and the control group can borrow electronic stethoscopes from the department for further use before leaving the department.

6.Teaching and Research Outcomes

i. Teaching course and results

The total sample size was 84 participants. Regarding gender, there were 47 males (56%) and 37 females (44%). For class, 58 were in Class 5 (69%) and 26 were in Class 6 (31%). The intervention team had 43 participants (51%) and the control team had 41 (49%). Most (74; 88%) attended the OSCE course while 10 (12%) skipped it.

The median age was 24 years, ranging from 22 to 33. Of the sample, 65 (90.3%) watched the YouTube videos and 62 (87.3%) checked answers. On a 5-point scale of course helpfulness, the median was 5 ("very helpful"), ranging from 2 to 5.

In summary, the total N was 84. There were slightly more males than females, mostly Class 5 students, and similar numbers in the intervention and control teams. Most attended the OSCE and engaged with the YouTube and answer checking. The median age was 24 years old. Most found the course very helpful.

Conclusion

The tests redesign as YouTube (+/-) may enough.

Table 1. Demography of the Students attend the breathing sound course

		N/ Median	% / min,max
		84	100
Gender	Male	47	56
	Female	37	44
Class	5	58	69
	6	26	31
Team	Inter-vention	43	51

	Control	41	49
OSCE	attend	74	88
	skip	10	12
Age		24	22,33
Teaching Video		65	90.3
Check Answer		62	87.3
Helpful	1,5	5	2,5
		6	2,10
Time pre-,post-tests (days)	Inter-vention	5	4,10
	Control	7	3, 10

The analysis of the test scores

Overall, median pretest score was 30, improving to 50 on the posttest. The median improvement was 20 points.

Looking at the intervention and control groups separately, the intervention group improved from a median pretest of 30 to a median posttest of 40, with a median improvement of 10 points. The control group improved more, from a median pretest of 30 to a median posttest of 55, with a median improvement of 20 points. Both groups showed statistically significant pre-post improvements.

Participants who attended the OSCE course had higher median pretest and posttest scores compared to those who skipped it. Those who attended improved by a median of 20 points while those who skipped improved by 35 points.

For participants who watched the breathing sound teaching videos, median pretest was 30 and posttest was 50, with 20 points of improvement. Those who did not watch YouTube had no improvement.

Class 5 had a median improvement of 20 points, versus 10 points for those of class 6.

There was no difference in pretest or posttest scores between Checking answers of pre-tests and or not. Both improved by a median of 20 points.

In backward linear regression, watching YouTube videos had a positive but non-significant association with posttest scores.

In summary, the course was effective in improving test scores overall and for both intervention and control groups. Breathing sound teaching video watching were associated with greater improvements.

Table 2. The scores of the breathing sound course.

			Median	min,max	p
	pretest		30	0,70	<0.001*
	posttest		50	20,90	
	improvement		20	-30, 70	
Intervention	pre-test	I	30	0, 60	0.269
		C	30	10, 70	
	post-test	I	40	10, 90	0.073
		C	55	20, 80	
	pre-post	I			<0.001*
		C			<0.001*
	improvement	I	10	-20, 70	0.539
		C	20	-30, 60	
OSCE	pre-test	1	30	20, 70	0.209
		0	20	10, 30	
	post-test	1	50	20,90	0.339
		0	55	50, 60	
	improvement	1	20	-30, 70	0.871
		0	35	30, 40	
Teaching Video	pre-test	1	30	0, 70	0.565
		0	30	20, 60	
	post-test	1	50	20, 90	0.180
		0	30	20, 70	
	improvement	1	20	-30, 70	0.084
		0	0	-10, 30	

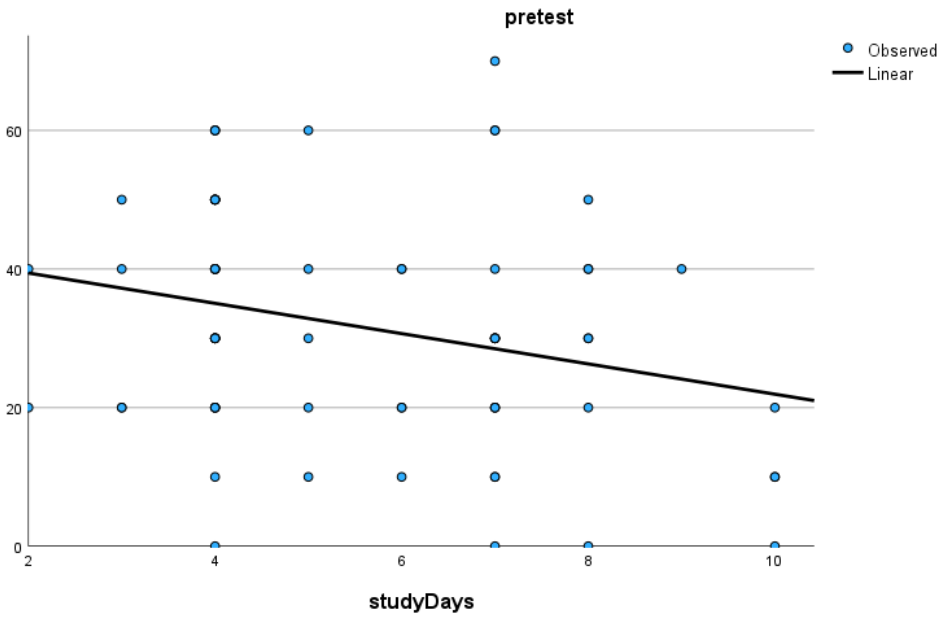
Check Answer	pre-test	1	30	0, 70	0.146
		0	20	20, 80	
	post-test	1	50	20, 90	0.773
		0	50	20, 80	
	improvement	1	20	-30, 70	0.393
		0	20	0, 60	
Class	pre-test	5	30	0, 70	0.775
		6	30	0, 60	
	post-test	5	50	20, 70	0.772
		6	50	20, 70	
	improvement	5	20	-30, 70	0.613
		6	10	-10, 60	
Backward stepwise linear regression					
Teaching Video	b,95%CI		0.19	-2.94, 34.87	0.097

*Paired-Samples Wilcoxon Signed Rank Test

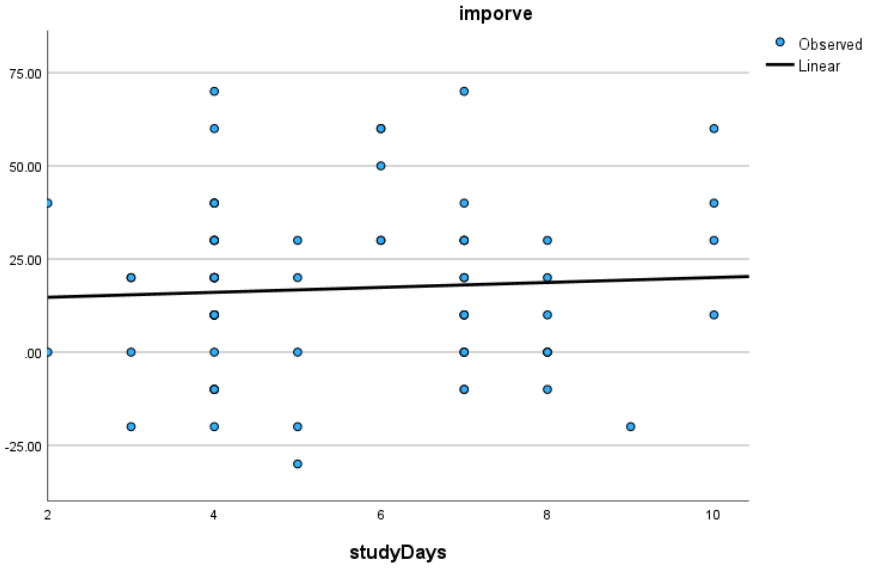
I intervention, C control.

An interesting finding was noted. The pre-test day was arranged by teacher, but the post-test day was scheduled by the student, we found that the lower the pre-test score, the longer time to get post-test was needed.

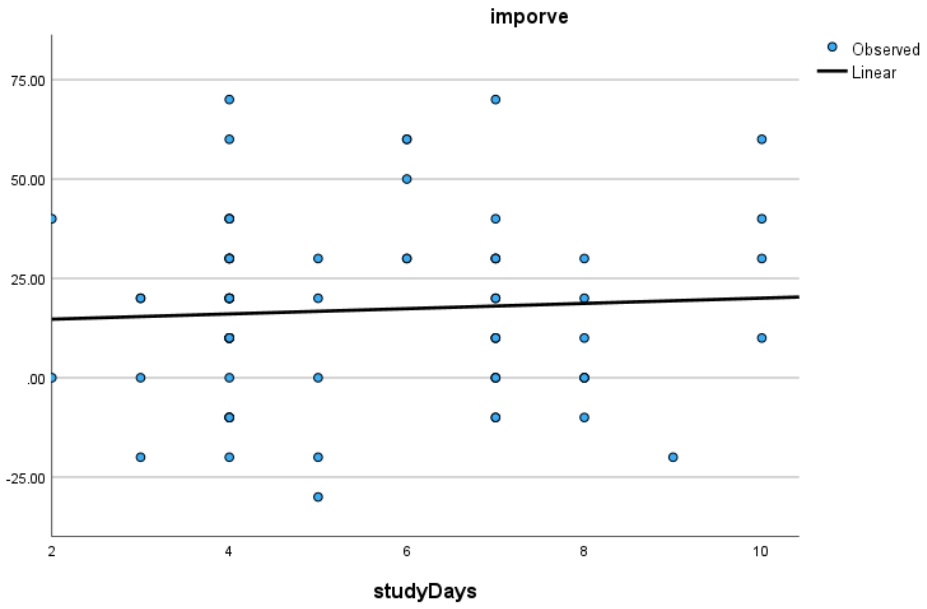
Pre-test Score=-2.186days +43.8 ,p=0.029



Post test score= -1.524 days+ 51.79, p=0.170



Score improvement =0.662days +13.4, p=0.631


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ii. Teacher reflection on teaching

Due to the short 2-week course duration, time was a major limitation and potential source of bias. The start date and pre-test were usually scheduled for the 1st or 2nd day of the clerkship. However, the post-test date was determined by each student, and compromised by scheduling conflicts with the OSCE center date. The packed clerkship schedule and OSCE center availability resulted in actual intervals between pre-test and post-test ranging from only 2-10 days. Students with lower pre-test scores seemed to allot more time for learning before taking the post-test. The peak days were day 5 and day 8 (Friday and the following Monday). This essentially compressed our 14-day course to 7 days for many students, as some started new clerkship courses at other hospitals, and the OSCE center had limited availability.

A second unexpected limitation arose with the electronic digital stethoscope intervention. The breathing sound course teaches an ancient physical exam skill practiced for over 200 years. Introducing the digital stethoscope aimed to advance this field through technology. However, there were downsides: 1) The digital stethoscope is heavier than a regular one, contrary to historical design trends like Littmann's stethoscope that prioritized lightweight portability. This made students reluctant to carry it routinely. 2) The high price made students handle it very cautiously. 3) Using it requires connecting to a phone, taking more time than a traditional stethoscope. 4) In our setting in Taiwan, digital stethoscopes cannot reveal their automated acoustic analysis results. In prior studies, this feedback helped students learn, but our students lacked this benefit since software approval is still pending from Taiwan's FDA. Consequently, very few students completed the 5 listening recordings assignment, since it was optional without impact on formal grades. The digital stethoscope intervention was novel but failed in implementation. This resulted in no differences between the intervention and control groups - both received the same education and showed similar progress.

The self-learning breathing sound videos distributed on day one were well-studied by most students, making video-watching the key factor determining test scores.

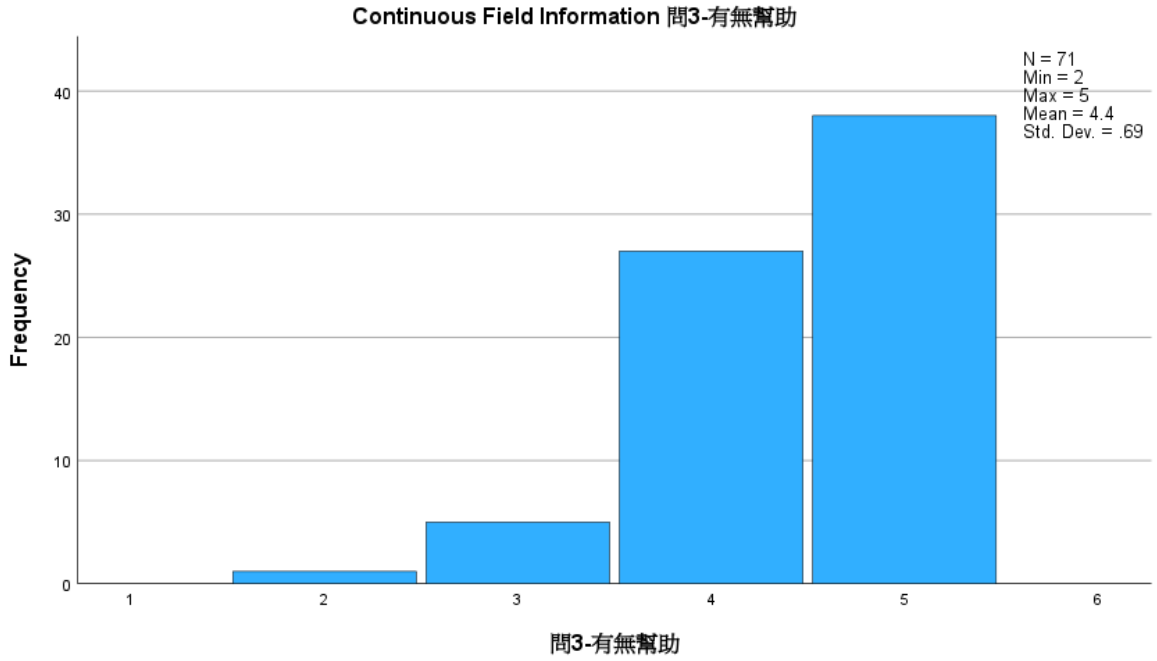
The OSCE center learning was also student-scheduled, ending up on the post-test date. So it did not impact scores but had positive feedback.

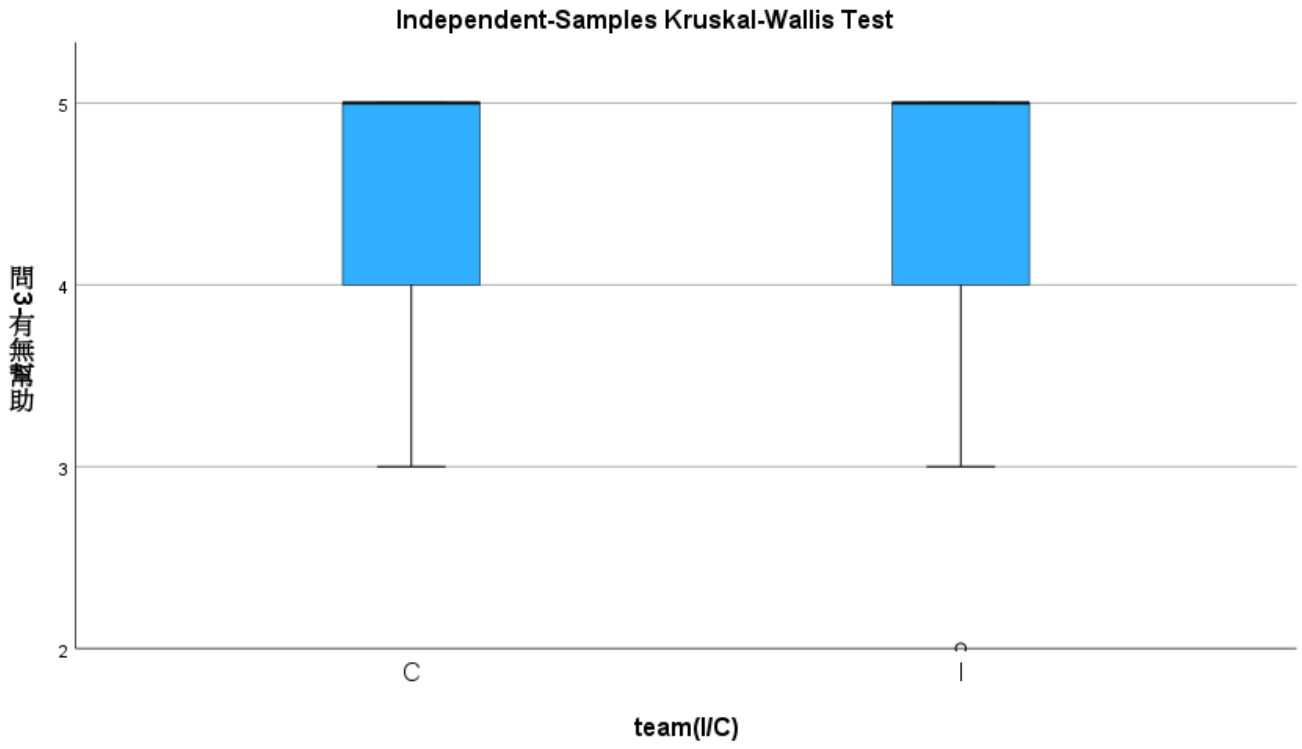
Since the digital stethoscope assignment completion was poor, it had negligible effect on test performance. Improved software versions are needed. The lack of significant score differences between

groups stemmed from this failed intervention.

iii. Student learning feedbacks

. 45.2% of students rated the breathing sound course as "very helpful" in improving their physical examination skills, while 32.1% found it "helpful". However, the digital stethoscope received mixed reviews due to its weight, cost, time needed for use, and lack of an auto-analysis function. Notably, there were no significant differences in feedback between the intervention and control groups.




Independent-Samples Kruskal-Wallis Test
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6. Recommendations and Reflections

Improving the Effectiveness of Respiratory Sound Auscultation Teaching

Refined English Version:

Positive Feedback: Over 77% of students (45.2% "very helpful" and 32.1% "helpful") found the respiratory sound auscultation course valuable in improving their physical examination skills, highlighting its educational potential.

Recommendations for Improvement:

- **Digital Stethoscope:** Address weight, price, and time concerns by exploring lightweight versions or shorter procedures. Consider introducing the technology only after an automatic analysis function is approved and proven valuable, as it's currently not suitable in Taiwan.

- **Pre-test Scores and Learning:** The unexpectedly low pre-test scores and significant improvement after self-learning videos demonstrate the need for a solid learning program.

- **Teaching Methods:**
  - **Retain:** Self-learning materials were effective and should be continued.
  - **Refine:** Consider traditional tests instead of the digital stethoscope as a stronger motivator.
  - **Optimize:** The ZUVIO testing model was successful and should be further utilized.
  - **Integrate:** Implement the OSCE center's SAM II earlier in the curriculum.
  - **Emphasize:** Encourage clinical teachers to prioritize and integrate respiratory sound teaching into clerkships.

- **Course Design:**
  - **Increase Practice:** Increase practical exercises to bridge the theory-practice gap.
  - **Simulate Application:** Utilize group simulation exercises for students to apply auscultation skills in clinical settings.
  - **Expand Scope:** Consider a multi-disciplinary respiratory sound course across various subspecialties.

- **Comprehensive Assessment:** Implement pre- and post-tests encompassing all related sub-specialties to evaluate students' overall diagnostic ability.

Reflections:

- **Generalizability:** This study represents CSMU thoracic surgery interns, and further research is needed to assess its applicability to other medical education contexts.

- **Holistic Evaluation:** Additional studies are required to evaluate teaching effectiveness for heart sounds, vascular sounds, and bowel sounds.

- **Multifaceted Impact:** Teaching effectiveness is influenced by factors beyond methods and tools, including teacher competence and student motivation. Hence, teacher training and student motivation strategies should be explored.

Conclusion: This study provides valuable insights for improving respiratory sound auscultation teaching. Continuous improvement of methods, tools, and evaluation methods, alongside exploration in diverse teaching environments, is crucial for optimal teaching outcomes.

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三、附件 Appendix

IRB proof

中山醫學大學附設醫院第一人體研究倫理審查委員會
The Institutional Review Board
Chung Shan Medical University Hospital
No.110, Sec.1, Chien-Kuo N. Road, Taichung, Taiwan 402
Phone: 04-24739595 Fax: 04-35073516

研究計畫許可書

CSMUH No: CS1-22134

計畫名稱：數位電子式聽診器於醫學大學醫學系學生呼吸音聽診教學之應用

計畫編號：PMN1110052

計畫主持人及隸屬機構：林巧峯／中山醫學大學

經費來源：教育部

會議日期：民國 111 年 07 月 28 日

版　　本：【教育部教學實踐研究計畫：V1.0，日期：2021/12/6；研究對象同意書：1.2，日期：2022/7/29】

許可書有效期間：自民國 111 年 08 月 02 日至民國 112 年 08 月 01 日

期中報告繳交頻率：每年(12 個月)繳交一次，若需申請延長試驗，請於效期屆滿前申請。

上述計畫已於 111 年 08 月 02 日經本院人體研究倫理審查委員會依據一般(全會)審查作業基準同意執行。有關計畫主持人的職責、義務、及注意事項均詳列於背面，請參閱並遵守。

中山醫學大學附設醫院 第一人體研究倫理審查委員會

主任委員

中　華　民　國　一　百　十　一　年　八　月　二　日

Permission of Research Proposal
Chung Shan Medical University Hospital

Date: Aug 02, 2022

Protocol Title: Application of digital electronic stethoscope in the teaching of breath sound auscultation for medical school students

Protocol No: PMN1110052

Principal Investigator & Affiliated Institution: Frank Cheau-Feng Lin／Chung Shan Medical University

Date of meeting: 2022/07/28

Version: 【see above】

Effective duration approved: 2022/08/02 to 2023/08/01

Frequency of Interim Report: every 12 months. Please file an extension before the expiry date, if you need.

Above study has been approved with the full-board review by Institutional Review Board of the Chung Shan Medical University Hospital on Aug 02, 2022. About the essential duties, obligations and responsibilities of the principal investigator please refer to the back page.

Chung Shan Medical University Hospital The 1st Institutional Review Board

Thomas Chang-Yao TSAO, MD/PhD.
Chairman
The Institutional Review Board

本委員會組織與執行皆符合 ICH-GCP 規範及赫爾辛基宣言之精神
This Committee has been organized and operated in conformance with ICH-GCP requirements and the essence of Declaration of Helsinki.

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三、附件 Appendix

IRB proof

中山醫學大學附設醫院第一人體研究倫理審查委員會
The Institutional Review Board
Chung Shan Medical University Hospital
No.110, Sec.1, Chien-Kuo N. Road, Taichung, Taiwan 402
Phone: 04-24739595 Fax: 04-35073516

研究計畫許可書

CSMUH No: CS1-22134

計畫名稱：數位電子式聽診器於醫學大學醫學系學生呼吸音聽診教學之應用

計畫編號：PMN1110052

計畫主持人及隸屬機構：林巧峯／中山醫學大學

經費來源：教育部

會議日期：民國 111 年 07 月 28 日

版　　本：【教育部教學實踐研究計畫：V1.0，日期：2021/12/6；研究對象同意書：1.2，日期：2022/7/29】

許可書有效期間：自民國 111 年 08 月 02 日至民國 112 年 08 月 01 日

期中報告繳交頻率：每年(12 個月)繳交一次，若需申請延長試驗，請於效期屆滿前申請。

上述計畫已於 111 年 08 月 02 日經本院人體研究倫理審查委員會依據一般(全會)審查作業基準同意執行。有關計畫主持人的職責、義務、及注意事項均詳列於背面，請參閱並遵守。

中山醫學大學附設醫院 第一人體研究倫理審查委員會

主任委員

中　華　民　國　一　百　十　一　年　八　月　二　日

Permission of Research Proposal
Chung Shan Medical University Hospital

Date: Aug 02, 2022

Protocol Title: Application of digital electronic stethoscope in the teaching of breath sound auscultation for medical school students

Protocol No: PMN1110052

Principal Investigator & Affiliated Institution: Frank Cheau-Feng Lin／Chung Shan Medical University

Date of meeting: 2022/07/28

Version: 【see above】

Effective duration approved: 2022/08/02 to 2023/08/01

Frequency of Interim Report: every 12 months. Please file an extension before the expiry date, if you need.

Above study has been approved with the full-board review by Institutional Review Board of the Chung Shan Medical University Hospital on Aug 02, 2022. About the essential duties, obligations and responsibilities of the principal investigator please refer to the back page.

Chung Shan Medical University Hospital The 1st Institutional Review Board

Thomas Chang-Yao TSAO, MD/PhD.
Chairman
The Institutional Review Board

本委員會組織與執行皆符合 ICH-GCP 規範及赫爾辛基宣言之精神
This Committee has been organized and operated in conformance with ICH-GCP requirements and the essence of Declaration of Helsinki.