Confronting the challenges of anatomy education in a competency-based medical curriculum during normal and unprecedented times (COVID – 19 pandemic): Gagne, Peyton and Mento to the rescue

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Abstract

Background: Anatomy is considered one of the keystones of undergraduate medical education. However, recently, there has been drastic reduction, both in the gross anatomy teaching hours and its context; decrease in the number of trained anatomists; and an increase in the costs of human cadavers, causing a diminution of cadaveric dissection in Anatomy teaching.

Objective: To address these challenges there is an ardent need for a pedagogical framework such that anatomy education can be disseminated through active-learning principles, within a fixed timeframe; using a small team of anatomists; employing small number of cadaveric specimens (for live on-site sessions) and using collaborative learning principles (when anatomy education is delivered through distance learning modality, as is the case for the situation during the COVID-19 pandemic).

Methods: Here, we have blueprinted a pedagogical framework blending the instructional design models of Gagne's nine-events of instruction with Peyton's four-step approach. The framework's applicability was validated through the delivery of anatomical concepts, using an exemplar from the Head and Neck course during normal and COVID – 19 mandated lockdown periods, employing the archetype of Frey's Syndrome. Preliminary evaluation of framework was pursued using student feedback and end of course feedback responses. Efficiency of the framework in knowledge transfer was also appraised.

Results: The blueprinted instructional plan designed to implement the pedagogical framework was successfully executed in the dissemination of anatomy education, employing a limited number of cadaveric specimens (during normal times) and a social media application integrated 'interactome' strategy (during the mandated COVID-19 lockdown). Students' response to the framework was positive. However, reluctance was expressed by majority of concerned faculty in adopting the framework for anatomy education. To address this aspect a strategy has been designed using Mento's 12-step change management model. The long-term benefits for any medical school to adopt the blended pedagogical framework have also been explicated applying Bourdieu's Theory of Practice. Additionally, through the design of a 'social-media application interactome model', the framework's applicability in delivery of anatomy education/content during the ongoing COVID-19 pandemia has also been founded.

Conclusions: In conclusion, the study effectively tackles some of the contemporary key challenges associated with the delivery of corpus of anatomy content in medical education during normal and unprecedented times. Clinical Trial: This study is not a clinical trial and therefore doesn't have a trial registration identifier.

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To address these challenges there is an ardent need for a pedagogical framework such that anatomy education can be disseminated through active-learning principles, within a fixed timeframe; using a small team of anatomists; employing small number of cadaveric specimens *(for live on-site sessions)* and using collaborative learning principles *(when anatomy education is delivered through distance learning modality, as is the case for the situation during the COVID-19 pandemic).*

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Here, we have blueprinted a pedagogical framework blending the instructional design models of Gagne's nine-events of instruction with Peyton's four-step approach. The framework's applicability was validated through the delivery of anatomical concepts, using an exemplar from the Head and Neck course during normal and COVID – 19 mandated lockdown periods, employing the archetype of Frey's Syndrome. Preliminary evaluation of framework was pursued using student feedback and end of course feedback responses. Efficiency of the framework in knowledge transfer was also appraised.

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The blueprinted instructional plan designed to implement the pedagogical framework was successfully executed in the dissemination of anatomy education, employing a

limited number of cadaveric specimens (during normal times) and a social media application integrated ‘interactome’ strategy (during the mandated COVID-19 lockdown). Students’ response to the framework was positive. However, reluctance was expressed by majority of concerned faculty in adopting the framework for anatomy education. To address this aspect a strategy has been designed using Mento’s 12-step change management model. The long-term benefits for any medical school to adopt the blended pedagogical framework have also been explicated applying Bourdieu’s Theory of Practice. Additionally, through the design of a ‘social-media application interactome model’, the framework’s applicability in delivery of anatomy education/content during the ongoing COVID-19 pandemia has also been founded.

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In conclusion, the study effectively tackles some of the contemporary key challenges associated with the delivery of corpus of anatomy content in medical education during normal and unprecedented times.

Keywords

Undergraduate Medical Education; Anatomy education; Gagne’s nine-events of instruction; Peyton’s four-step approach; Mento’s 12-step change management model; Bourdieu’s Theory of Practice; social-media application interactome; COVID-19

Introduction

Anatomy education is an essential stipulation for medical students, general practitioners, surgeons and for all those involved in invasive diagnostic and therapeutic procedures [1]. In the recent years, numerous factors are disadvantageously impacting anatomy education in medical specialties. These factors include, but are not limited to: A. a drastic reduction; B. both in the gross anatomy teaching hours and its context; C. a decrease in the number of trained anatomists; and D. an increase in the costs of human cadaveric dissections and the related ethical uncertainties surrounding the use of human cadavers.

The COVID-19 pandemic has added to these challenges, as most medical schools have suddenly shifted from face-to-face teaching to distance learning (DL) modality, requiring the design of innovative strategies which will allow the delivery of anatomy education through DL [2].

One of the approaches to effectively address these challenges, is to design a 'student-centred teaching-framework' (*easily implementable for both face-to-face and DL modalities*), where the essential "nuts and bolts" of anatomy can be delivered effectually: I. within a limited and fixed timeframe; II. using a small team of trained anatomists; III. using a small number of cadaveric specimens; and IV. will integrate principles of active learning, collaborative learning, feedback and student autonomy.

Moreover, designing a pedagogical framework alone will not address the challenges of anatomy education. The designed teaching approach needs to be implemented in the delivery of anatomy education and then evaluated. Further, a change management strategy needs to be adopted such that the pedagogical framework is able to initiate a change in pedagogical philosophy in anatomy education.

Here, we outline a pedagogical framework to tackle the aforementioned challenges of anatomy education in a competency-based medical curriculum (CBMC). The pedagogical framework was designed, blending Gagne's [3] and Peyton's [4-6] instructional design models. We have also demonstrated how this pedagogical framework can be effectively employed in the delivery of anatomical concepts using an exemplar from the structure-function course of Head and Neck (H&N) offered to first-year medical students in the preclinical phase of the undergraduate medical curriculum at MBRU. Further, we have outlined a social media application (SMA) - integrated strategy (*a SMA interactome*), whereby the designed pedagogical framework could be employed in anatomy education during the COVID-19 pandemic. The efficiency of the framework in knowledge transfer has been evaluated by comparing the performance of the

cohorts who were exposed to the pedagogical framework: A. through face-to-face teaching; and B. through DL modality during the COVID – 19 lockdown. A preliminary evaluation with regards to perception of students towards the pedagogical framework was also conducted based on end-of-course feedback. Although, the students responded positively to the pedagogical framework for both face-to-face and DL deliveries, there was reluctance in adopting the framework for anatomy education across all anatomy courses by concerned instructors. To address, this we have blueprinted a change-management approach employing Mento's change-management model [7], which will allow anatomy educators to implement the designed pedagogical framework in any CBMC. This manuscript primarily focuses on the description of the frameworks, and initial observations and reflections following their execution.

Methods

Study landscape

The CBMC at MBRU has three phases (Fig 1). Each phase of the curriculum includes integrated courses and builds on the preceding one, such that the curriculum is a "spiral" [8, 9], and the students repeat concepts relating to a subject, where with each successive encounter, concepts build on the previous one. The medical school caters to a student population, drawing students from more than 19 different countries, and from 20 different high school curricula. Approximately 75% of the students are females [10]. The designed pedagogical framework was implemented in the delivery of gross regional anatomy in the form of Structure-Function courses occurring primarily in the Phase – 1 of the curriculum (Fig 1). Four Structure-Function courses with specific timelines are delivered in semester – 2 of Phase – 1, over a 15-week period:

1. Limbs and Spine: Weeks 1 – 4
2. Thorax: Weeks 5 – 7
3. Abdomen, Pelvis and Perineum: Weeks 8 – 11
4. Head and Neck: Weeks 12 – 15

The Structure-Function courses are designed to provide students with in-depth understanding of the normal human anatomy, and resulting physiological roles, with a focus on essential radiology and basic clinical correlation. Case in point, the Structure-Function course of H&N where the pedagogical framework was implemented provides students with functional knowledge of the structure of head and neck region that will enable further understanding of

organ-system courses in Phase – 2 (Fig 1) . The course also introduces the concept of “living anatomy of the Head and Neck” as visualized on conventional medical imaging and on the living human body. At the end of the course, students should be able to describe the major features of the skull, the main structures present in the neck, face, temporal and infratemporal regions. They should also be able to identify the main anatomical features of the face, nose, oral cavity and tongue, pharynx, soft palate, and larynx. They should explain the basis of cranial nerve testing. They should also be able to explain the anatomical basis of upper airway obstruction, cervical swellings, facial nerve palsy, Frey’s syndrome, epistaxis, and dysphagia. Also, through the course, students should be able to develop an attitude of collaborative learning and autonomy.

Design of the pedagogical framework

In order to design the pedagogical framework, we employed the instructional design models of Gagne [3] and Peyton [4, 11]. Gagne’s nine-step instructional model is based on behaviourist approach to learning, whereas Peyton’s 4-step approach avails a task-centred approach. Our pedagogical framework availed a blended approach similar to that of Tambi et al [10], which allowed us to disseminate both cognitive and non-cognitive skills. These models were selected based on a pilot study conducted at MBRU, where the learning approaches of MBRU students were mapped using the Approaches and Study Skills Inventory for Students (ASSIST) learning approach investigation tool [12]. The pilot study indicated that most MBRU students avail deep/strategic learning approaches, suggesting that they favoured constructivist learning approaches or strategies [12]. Therefore, we adopted Gagne’s and Peyton’s instructional design models to design our pedagogical framework, as these models support deep/strategic learning approaches [6, 13-15].

Results

Implementation and design of the pedagogical framework

The individual steps of the instructional plan associated with the pedagogical framework are described below (Fig 2).

A. Learning environment for implementation of the instructional plan

For the implementation of the instructional plan anatomy dissection hall was chosen (Fig 3). The dissection hall is a rectangular light-flooded room situated on the ground floor, with floor-to-ceiling windows spanning the length of two perpendicular-lying walls. It consists of two

dedicated teaching areas: dissection area; and medical imaging and case-based discussion area (Fig 3).

B. Prerequisites for the implementation of the instructional plan

In preparation for the session, students were requested to review the following concepts: A. boundaries and contents of the parotid region and; B. the structural and functional aspects of the course and distribution of the facial nerve. Also, for the instructional plan, we decided to use the exemplar of the clinical case associated with Frey's syndrome. In line, by reviewing the above concepts we believed students would be better prepared to tackle the questions accompanying the case.

Learning material in the form of PowerPoint slides, medical images, and reading material pertaining to the above concepts were uploaded on the learning management system[16] a week prior to the session. These prerequisites enabled students to be adequately prepared for the session to successfully execute the tasks outlined in each step of the instructional plan. The activities and timeframe pertaining to each step of the instructional plan are depicted in Fig 2.

C. Dissemination of individual steps of the instructional plan

The steps were tailored employing a "blended" methodology in which Gagne's instructional model was "blended" with Peyton's four-step approach (Fig 2).

I. Step 1: Gain attention

The instructor applied the "pattern interrupt phenomenon" [17], to draw the attention of the students. The resounding ring of a doorbell was used as the sudden auditory stimulus. This was followed by the Socratic method of delivery [18], whereby the instructor posed the question: "*How would you describe Frey's Syndrome to your younger brother?*".

A video available on The Doctors TV titled Frey's Syndrome [19], was also shown to the students. This technique concurrently addressed visual, auditory, and kinaesthetic learning styles [20, 21].

II. Step 2: Inform the students about the learning objectives

Students were then provided with set learning objectives which they were expected to achieve at the conclusion of the instructional plan (Fig 2).

III. Step 3: Stimulate recall of prior learning

Students participated in a group discussion to determine and evaluate the safest dissection approach when resecting the parotid gland. This enabled students to revise concepts related to gross, variational, functional and living anatomy and assisted them to appreciate how these

contributed to the accurate interpretation of imaging anatomy, safe clinical practice and successful surgical outcomes. This step touched on the theories of multiple intelligences [22], social learning [10], and team-based learning [23], as it incorporated peer-assisted learning in the instructional plan.

IV. Step 4 (Blended): Present content material

Students were then presented with a clinical case (Fig 3). The detailed steps involving the resection of the parotid gland and identification of the intact facial nerve were summarized by means of a flowchart and presented as a PowerPoint presentation (S2 File.). Step 1 of Peyton's model was integrated in this step, which involved a demonstration of the steps involved in the dissection procedure.

V. Step 5 (Blended): Provide learning guidance

Principles of steps 2 and 3 of Peyton's 4-step model was integrated in this step. Interactive learning was emphasized in this step. The instructor explained the individual steps for the activity (i.e. dissection procedure) and provided clarity on the rationale behind it. The instructor then analysed each step thoroughly, highlighting the essential "dos" and "don'ts" and provided a few practical tips (Peyton's Principle #2). Students were encouraged to ask questions to clarify any doubts. This was followed by a conceptual phase during which philological and kinaesthetic learning styles were encouraged as students were entreated to elucidate each step of the dissection procedure, while the instructor followed the guidelines (Peyton's Principle #3). Such a practice enabled students to articulate the dissection procedure gradually, concomitantly allowing the instructor to assess their understanding.

VI. Step 6 (Blended): Elicit performance

This step corresponds to Peyton's Principle #4. In this step students were provided with the opportunity to reinforce their learning through performance; therefore, a larger amount of time was allocated to this step. The class was divided into 12 groups (*approximately five students/group*). Each group was assigned a cadaver and a dissection station (five cadavers in total). In their designated groups, students attempted to perform the dissection procedure of the parotid gland as described by de Ru et al [24]. Students executed the dissection steps sequentially, followed by a group discussion on the results to ensure accuracy. This facilitated peer-assisted learning as it incorporated elements of interaction and collaboration [25]. Additionally, this step allowed the students to practice skills associated with the dissection of

the parotid gland. Such dedicated practice of procedural dissection skills has been shown to increase students' confidence in anatomy education [26].

In this step, the student groups were also asked to address the questions listed under deliverable in the clinical case of Frey's syndrome (Fig 2). Each group presented one of the listed questions. Since the clinical case and deliverable were uploaded a week prior to the dissection session, students had an opportunity to prepare their responses. This fostered self-directed learning and student autonomy [27]. Additionally, some of the student groups presented their responses using research articles related to the questions. These presentations followed a guide plan similar to the 6D-Approach, a pedagogical framework previously designed by us [28].

VII. Step 7: Provide informative feedback

Informative feedback was provided employing the framework of Pendleton's feedback model [29]. In their own group, students were able to provide feedback to their peers, i.e. peer-feedback [30]. This activity aimed at refining the student's own understanding of where things stand; a so-called "reality check" that concurrently provides a clear direction of travel, in terms of improving behaviours, attitudes and skills. While students conducted their own peer-to-peer feedback within their designated groups, the instructor visited each group and provided individual assistance and instantaneous feedback such that it didn't lead to any false assessment on the part of the student with regard to their own skills and abilities. Students were also advised to clarify and discuss any uncertainties and/or questions as they emanate within their entire class. To conclude this step, students provided feedback about the activity by addressing the following: "*What do you think went well?*"; "*What do you think could be done differently?*"; "*What could be further improved?*" and; "*How can this be achieved?*".

VIII. Step 8: Assess performance

In this step, students prepared a reflective report on their dissection experience and how that experience helped them to better understand the anatomical changes associated with Frey's syndrome. The students prepared their report using Gibbs reflective cycle framework [31]. The report was uploaded by the students onto the learning management system [16], and contributed 5% to the total assessment component in the H&N course. This step encouraged students to think critically about the content disseminated, concomitantly augmenting their writing skills.

IX. Step 9: Enhance retention and transfer

Following submission of the report, students were required to assess a clinical scenario similar to Frey's Syndrome (viz. facial nerve paralysis) using the sequential steps of the dissection procedure, which they were exposed to earlier [24], to grasp the learning activity, which concluded by reviewing the learning objectives and resolving any uncertainties.

The SMA – interactome strategy to implement the pedagogical framework during the COVID -19 pandemic

Currently, with the COVID-19 pandemia sweeping across the globe, many medical schools have switched to the distance learning modality. So, we asked ourselves "Can our teaching framework adopt to this new pedagogical strategy?" We have applied this framework again to the structure-function course of H&N delivered through DL modality. To apply this framework, we designed a social media application (SMA) 'interactome' (Fig 4), such that different steps of the blended framework can be implemented using different SMA. In fact, a pilot study at MBRU showed us that our students prefer the integration of SMA such as YouTube and WhatsApp in their learning process [10]. Didactic sessions were delivered in form of screencast using Microsoft (MS) Teams. For specific sessions, flipped teaching approach was adopted, where students were provided with pre-recorded lectures, which were uploaded at least a week prior to the session on the learning management system (https://lms.mbru.ac.ae/d2l/login). In-session activity for sessions which adopted flipped teaching comprised of treatise, focusing on the discussion of relevant clinical case(s) in small groups (consisting of 15 to 20 students in each discussion group), using MS Teams platform where the instructor (NN) was able to participate as well as moderate the discussion across several groups. Students were also encouraged to participate in discussion with their peers in designated WhatsApp group, which were created and moderated by the instructor. Such discussion primarily focused on tackling questions which couldn't be addressed in-depth during the SMA integrated distance learning teaching sessions because of time constraints. Additionally, students were often directed to relevant podcasts and videos specifically on YouTube, especially for the effective demonstration of dissection procedures. Case in point, for dissemination of our pedagogical framework during the COVID – 19 mandated lockdown using the SMA interactome, we substituted the demonstration of parotid gland dissection (which could not be conducted because of the closure of laboratories), with podcast videos available from different universities on YouTube [32], whereas the discussion associated with the clinical scenario of Frey's syndrome was

organized using MS Teams and WhatsApp. Further, for formative assessments, the instructor (NN) employed the resources available from University of Michigan [33].

Efficiency of the of the pedagogical framework in knowledge transfer

The efficiency of the pedagogical framework in knowledge transfer was investigated by comparing the performance of students in the summative assessment of H&N course across three cohorts Fig. 5 : A. Cohort where the course was delivered using traditional didactic pedagogy (N = 58; Mean score out 100 = 64.9 (11.2)) ; B. Cohort where the course was delivered using pedagogical framework, but with incorporation of dissection sessions (N = 58; Mean score out 100 = 70.0 (11.6)) ; C. Cohort where the course was delivered using pedagogical framework, but involved the use of SMA interactome strategy (N = 56; Mean score out 100 = 77.7 (11.1)) . As evident from Fig. 5 as well as the calculated mean scores, implementation of the pedagogical framework in the delivery of anatomy education led to better performance, with the cohort which used the pedagogical framework along with SMA having the highest success amongst students (a mean score, 19.7% higher than the control cohort). Further, Kuder and Richardson formula 20 (ρ_{KR20}) reliability values calculated for the MCQ component (accounting for 75% of a typical summative assessment) for all the three summative assessments for the three cohorts was higher than 0.75. This indicates that the summative assessments had high reliability, which further confirms our observation that implementation of the pedagogical framework in the delivery of anatomy education leads to better performance, and hence augmented knowledge transfer. However, more dedicated studies are warranted to better comment on the aspect of knowledge transfer. These future studies will focus on learners' perception to the pedagogical framework assessed using validated tool and learning behaviour/styles of learners while being exposed to the pedagogical framework.

Preliminary evaluation of student's perception towards the pedagogical framework

In the present work, our focus was on the design and implementation of the pedagogical framework. An elaborate evaluation of the perception of students towards the pedagogical framework is still pending and will be addressed in our future work. The evaluation presented here is only preliminary.

The pedagogical framework was evaluated informally following Pendleton's approach [29] (*Step 7 of the teaching plan*). A measure with regard to the instructional plan's facilitation in knowledge retention was obtained by reviewing the students' reports at the conclusion of the course. We also reviewed the student-feedback obtained at the end of the H&N course.

The pedagogical framework was received positively by the students, who exhibited enthusiasm in both organizing and in participating in the event. Points of note:

I. Students from different academic backgrounds effectively functioned as a group.

II. Reading habits of students improved significantly following their participation in the activity through the increase in the depth and content of the questions posed by the students during discussion. This observation is in line with the findings of Miner et al [34].

III. Student autonomy was augmented, as many of them prepared concept/mind maps to correlate their understanding of the delivered concepts to their clinical significance.

Specific limitations that students believe need to be addressed:

I. The time allocated for discussion (*Step 6 in the instructional plan*) was insufficient. The way to overcome this insufficiency is to integrate SMA in the delivery of the specific steps of the instructional plan, especially the ones that entail collaborative learning - similar to one of our previous studies [10].

II. Students had difficulty in accessing specific journals with regard to the workings of Step 6 of the instructional plan (as they were not subscribed by the institution). One of the ways to side-step this limitation is to encourage students to refer to articles in open access journals of repute.

Formal student feedback for the H&N course was obtained by using an institution approved questionnaire for the cohorts where the pedagogical framework was implemented. The feedback for the course indicated that students expressed satisfaction with the instructional plan employed in the course, with ~ 79% of the students in both cohorts where the pedagogical framework was implemented, strongly agreeing with the highest grading score "extremely satisfied".

However, majority of the students (~71%) in both the cohorts where the pedagogical framework was implemented, indicated in open-ended comments that the instructional plan that was integrated in the H&N course should be implemented across all structure-function courses in anatomy education, and if possible, especially in practical sessions involving dissection or discussion of clinical scenarios. Further, while evaluating the reports of the students, the instructor found that most of the students, while reflecting on their

experience with regards to the instructional plan, identified that the pedagogical framework augmented their knowledge in anatomy pertaining to the session learning objectives, as well as facilitated them to grasp the clinical relevancy of the concepts.

DISCUSSION

In this study, we have blueprinted a pedagogical framework blending Gagne's nine-events of instruction and Peyton's four-step teaching approach and employed the framework in the dissemination of anatomy education both during normal and COVID – 19 mandated periods. The framework was positively received by the students, and they suggested its integration across all other structure-function courses in Phase – 1. Based on this feedback, the director of phase – 1 (YB) and the instructor who implemented the pedagogical framework (NN), approached other instructors in the structure-function courses (*Refer above for the list of courses*) bidding them to adopt the framework in their pedagogy. However, initial discussions indicated that instructors were reluctant to adopt the framework as it entailed elaborate modifications of their teaching approaches, which involved conformist strategies employed in anatomy education. However, this observation is not unique to our institution, and similar barriers have been encountered in medical education [35].

In line, we decided to design a change management approach to integrate the pedagogical framework across all structure-function courses. This design of the approach involved the use of Mento's change management model. We selected this model as this framework was previously used successfully to initiate change in pedagogical philosophy to implement active learning strategies in the medical curriculum, specifically in the courses of Biochemistry and Molecular Biology [7]. The approach in which Mento's model will be used in implementing the pedagogical framework in anatomy education is shown in Table 1. Details regarding the individual steps of Mento's model have been discussed elsewhere, readers are requested to refer to the article by Banerjee et al for further information [7]. We firmly believe that the versatility of both the pedagogical framework and the proposed change-management framework to implement it, will allow anatomy instructors to implement/integrate the framework in any CBMC milieu.

Table 1. Guidance plan outlining the activities and timeline corresponding to each step of Mento's Change Model in the integration of blended instructional model of Gagne and Peyton in all structure-function courses

Step No.	Steps of Mento's Model of Change	Activity to facilitate/implement the change	Timeline
1	The idea and its context	Preliminary results from the HNSF course in Phase 1, Semester 2 showed that the blended instructional model of pedagogy facilitates better learning in UME. The idea is to integrate the blended instructional model throughout all structure-function courses in Semester 2, Phase 1.	N/A
2	Define the change initiative	Present to the concerned stakeholders: • What are the attributes of the blended teaching approach of Gagne and Peyton? • Benefits of the blended instructional model of Gagne and Peyton. • Planning of the teaching approach. • Successful case-studies of the blended instructional model (i.e. results of this study; PMID: 30361192).	Four-weeks prior to course initiation
3	Evaluate the climate for change	Assess the necessary resources, prior knowledge of stakeholders and technological proficiency required to successfully implement the blended instructional model in the structure-function courses through SWOT analysis.	Four-weeks prior to course initiation
4	Develop a change plan	Work with technology-enhanced learning (TEL) and Smart Learning Hub (SLH) teams at MBRU to develop a faculty development plan to train the stakeholders about the strategies to implement the blended instructional model of Gagne and Peyton in structure-function courses.	Three-weeks prior to course initiation
5	Find and cultivate a sponsor	Schedule meetings with MBRU academic leadership (Dean/Associate Deans/Departmental Chairs, Phase Directors) to inform them about the benefits of the blended instructional model and the resources	Three-weeks prior to course initiation

		required.	
6	Prepare your target audience	• Organize faculty development workshops in collaboration with the TEL and SLH teams to inform stakeholders about “how” to implement the blended teaching approach in structure-function courses. • Circulate nano-lectures on active learning to stakeholders over WhatsApp.	Two-weeks prior to course initiation
7	Create the cultural fit	Create linkage between students’ learning approaches and the blended teaching approach to explain to the concerned stakeholders “why” there is a necessity to create a culture of innovative pedagogy in UME.	Two-weeks prior to course initiation
8	Develop and choose a leader team	Create an informal “Leader Team” consisting of the course coordinator and instructors of HNSF course and digital advisors from TEL and SLH teams, such that they can guide and encourage the stakeholders to implement blended teaching approach in the structure-function courses. (at least nine blended teaching sessions over five weeks)	One-five weeks into the course
9	Create small wins for motivation	Identify the stakeholders who successfully integrated blended teaching approach in their courses and request them to present their experiences in this effort to the MBRU academic leadership and other concerned stakeholders.	Four-five weeks into the course
10	Constantly and strategically communicate the change	During the whole transformation process: • Create a “Learning community” such that stakeholders can learn from each other about strategies to successfully implement the blended teaching approach in pedagogy. • Try to address hurdles that are faced by stakeholders in their endeavour by	One-five weeks into the course

		communicating the change process to Sponsors	
11	Measure progress of the change effort	• Refer to the updated pedagogical techniques of concerned courses to appraise the number to teaching sessions where blended teaching was implemented. • Evaluate the attitude of stakeholders towards blended teaching following the transformation initiative using ADKAR framework. • Assess the performance of the students in the structure-function courses to identify if blended teaching was beneficial over traditional method. • Conduct student feedback to assess the perception of students towards blended teaching.	Six weeks into the course following the Mid-term assessments
12	Integrate lessons learned	Using a reflective framework conduct an After-Action Review to: • Map the transformation process • Identify hurdles that further required to be tackled such that blended teaching can be successfully integrated in other courses.	Six weeks into the course following the Mid-term assessments
Preparatory time for implementing the transformation: four-weeks **Time required for implementing/assessing the transformation: five-weeks** **Total study duration (preparation + implementation + assessment): nine-weeks**			

Also, the benefit of the pedagogical framework being adopted by a medical school can be elaborated using Bourdieu's Theory of Practice [36]. Bourdieu has developed three intimately related concepts: *field, capital, habitus* (Refer to Fig 6 for details of the individual concepts). Applying Bourdieu's Theory of Practice, the designed pedagogical framework when integrated in a CBMC, will allow schools in medical education, to attract high achieving students (*academic capital*), as well as allow a more effective delivery of anatomy teaching with a limited number of cadavers (*only five cadavers were used in the delivery of the teaching plan, whereas*

the ideal cadaver to student ratio in some of the top medical schools such as UCLA and University of Washington is 5:1 and 4:1, respectively, therefore requiring 12 and 15 cadavers respectively for a similar student population) (*economic capital*) . This endeavour will augment the ranking of the medical school, which has adopted the teaching framework (*symbolic capital*), as well as facilitate the school in applying and receiving more funding or emoluments (*economic capital*) in the field of medical education and health professions education research. These aspects cumulatively will impact the medical school's values, primacies and curricula (*habitus*). Furthermore, all the above will be reflected in students the medical school will attract and train (*habitus*).

The fact that our pedagogical framework requires only a limited number of cadaveric specimens is pivotal especially for medical schools in the Middle East, where religion may play an imperative role in the number of cadavers available for dissection (*Naidoo et al unpublished results*). Although, Elamrani and colleagues [37] reason that, from a theological viewpoint, Islam does not prohibit dissection nor body donation, they posit that "the problem is actually cultural, societal and legislative and not religious". Whatever may be the reason, the availability of cadavers for dissection in Middle Eastern medical schools is limited, and most schools import cadavers from the United States (usually donated bodies); from India (usually unclaimed bodies); or, from the Philippines (source of bodies unclear) [38]. This is not only expensive, but also unwieldy (as apart from the price of the cadaver, there is a myriad of paperwork that need to be tackled while cadavers are imported) [39]. In addition, import of cadavers also raises disquiets regarding an international "trade" of dead bodies, with an often debateable ethical foundation [40].

Apart from the above, body donation programs in many countries are also affected by local and political history [41] [42]. Take for example, Kramer and Hutchinson indicate that in South Africa, black Africans are disinclined more than other ethnic groups to donate their bodies for medical education and research, which is not only related to their "cultural beliefs" but also to the country's tumultuous "political history", where bodies of the black Africans were exploited for the education of white students [42]. Analogous reasons may also be behind the qualms of African Americans toward body donation in the United States [41]. Therefore, our pedagogical framework will not only be beneficial for medical schools in the Middle East, but also for schools who want to integrate anatomy dissection in their curriculum but have limited access to cadavers.

Conventionally, anatomy is often perceived as an uninteresting, labour-intensive discipline,

taught using surface-learning strategies and rote memorization [43]. In line, students are often unable to translate how the anatomical concepts can inform their clinical practice, creating a so-called “integration gap” [44]. Our pedagogical framework integrates a real clinical scenario (the clinical scenario was developed around a real clinical case of Frey’s syndrome [45]) and implements student-centric active learning strategies. This will not only address the integration gap, but also promote students to take an active role in learning and utilizing their own creativity, curiosity, and intelligence.

Reflecting on our pedagogical framework against Harden’s integration ladder [46], we find that it attests to the correlation step of the ladder. Harden postulates that curricular integration can be viewed as a ladder, with discipline-based teaching (isolation) at the bottom of the ladder and full integration (trans-disciplinary teaching) at the top. Harden’s integration ladder has eleven steps from subject-based to integrated teaching and learning. In the first four steps (isolation, awareness, harmonization and nesting) on the ladder, the emphasis is on the subjects or disciplines. As one climbs the ladder, the following six steps (temporal coordination, sharing, correlation, complementary, multidisciplinary and interdisciplinary) underscore integration across multiple disciplines. In the final step (transdisciplinary), the students take responsibility for the integration and are given the tools to do so [46]. With regard to the correlation step in the ladder, an integrated teaching session is presented in addition to the subject-based teaching. Our pedagogical framework attests to integrated teaching during dissection sessions, additionally during in-class sessions, the instructor(s) can pursue subject-based teaching. Generally, in the early phases of a CBMC, integration is difficult to achieve [47]. The framework addresses this gap.

In recent times, anatomy teaching has undergone a paradigm change from “instructor-centred” to “student-centred” approaches [48-50]. Our teaching framework attests to this ‘paradigm change’ as it mitigates two key challenges: (a) dearth of trained anatomists for teaching anatomy (the dissemination of the framework required only one trained anatomist (NN)); and (b) delivery of a large corpus of anatomy content within a limited time-frame. These two benefits further advocate to Bourdieu’s *economic capital* (as anatomy concepts can be disseminated with a limited number of trained anatomists) simultaneously attracting academic high achievers (*academic capital*) to the medical school, that adopts this framework.

During the mandated COVID-19 lockdown we were able to implement the pedagogical framework through the integration of SMA. This furthers attests to the versatility of our teaching framework, which can be tailored according to the demands of a given situation. Of

course, the detailed analysis with regard to students' perception of this distance learning adoption of our pedagogical framework is still pending and will form the basis of our future studies.

Although, our pedagogical framework has several inherent benefits (discussed above), our framework also has several limitations as indicated below:

A. Our pedagogical framework integrates only real dissection. However, studies have indicated that integrating real dissection and radiology using three-dimensional image post-processing tools provide a more enriching learning experience, as such a pedagogical strategy imparts familiarity with imaging and image post-processing techniques and also improves anatomical understanding, radiological diagnostic skills and three-dimensional appreciation [51]. Will the presented teaching framework allow the blending of real dissection with virtual dissection within a limited duration of time? This aspect needs to be addressed. Unfortunately, MBRU is a new medical school, where the anatomy teaching team does not comprise of a trained radiologist, which prevented us from addressing this question.
B. The dissemination of this pedagogical framework requires extensive instructor preparation, which may not allow instructors to adopt it, especially instructors who teach anatomy using conventional strategies. Our proposed change management framework may aid in mitigating this limitation.
C. The pedagogical framework integrates the precepts of PAL in several steps. However, this may be disadvantageous for some students, many of whom may feel they would learn better when they relate to the instructor. Additionally, students learning in a group can encounter problems, especially if they find themselves working with members in a group with whom they are not keen on collaborating. Furthermore, students working in a group may veer away from the point of an exercise, discussing irrelevant topics of interest. These aspects may be effectively addressed by involving peer-tutors in the dissemination of the teaching-framework.
D. Our pedagogical was implemented in only one structure-function course, that too in the delivery of anatomy teaching. However, implementation of this framework across all structure-function courses, may lead to cognitive overload [52], as our teaching framework necessitates students to adopt and practice self-directed learning.
E. A typical cohort in MBRU has 50 to 70 students. Dissemination of our pedagogical framework was successful with limited student numbers. However, many medical

schools have 150 to 200 students in a cohort, and there is a possibility that this pedagogical framework may not work as effectively in such large cohorts. This may be because organizing group-based activities required for the implementation of the pedagogical framework with a larger cohort may pose a challenge.

F. Implementation of the framework requires instructor(s) to be conversant with theoretical underpinnings of the instructional design models that were employed in blueprinting the framework. This may not be the case for all medical schools, especially the ones who use adjunct or part-time faculty members for the delivery of anatomy content. One way to address this gap, will be to organize CPD modules for anatomy instructors, where the advantages of integrating the framework in anatomy teaching and the theoretical foundations of the framework can be elucidated.

G. In this study we have provided the initial evaluation of our pedagogical framework. However, the detailed evaluation of this framework is still pending. This also raises the question, “What evaluation model will be best-suited to appraise the framework?” Our framework predominantly employs PAL at multiple steps, which functions on the theoretical foundation of social and cognitive congruence [53]. Based on this, we believe the teaching framework can be best evaluated by Stake’s Congruence-Contingency Model [54]. However, this needs to be explored further through dedicated studies. Also, we can employ Kirkpatrick’s framework to evaluate the pedagogical framework. However, this also warrants further long-term investigations.

In conclusion, in this study we have delineated a pedagogical framework to teach anatomy during normal and unprecedented times, blueprinted employing a blended approach exercising the instructional design strategies of Gagne and Peyton. The designed strategy integrates active learning principles and initiates a shift from the “sage on the stage” to “guide on the side” mode of delivery. Additionally, we have demonstrated the use of this framework in the successful delivery of anatomy concepts in a structure-function course in a CBMC both during normal and mandated COVID – 19 lockdown periods. Although, our framework was well received by students, anatomy instructors at our medical school were reluctant to adopt the framework (a challenge that others may also face), to counter which, we propose a strategy designed using the change management model of Mento. We have also elaborated on the benefits to a medical school that adopts the pedagogical framework, which have been explicated through the use of Bourdieu’s Theory of Practice. We firmly believe that the delineated pedagogical framework

will allow instructors to efficiently and effectively deliver concepts in anatomy education using cadaveric dissection or through the effective use of clinical scenarios, in a limited span of time, which will not only benefit students, but will also be advantageous for the medical school.

Conflict of Interest

None declared

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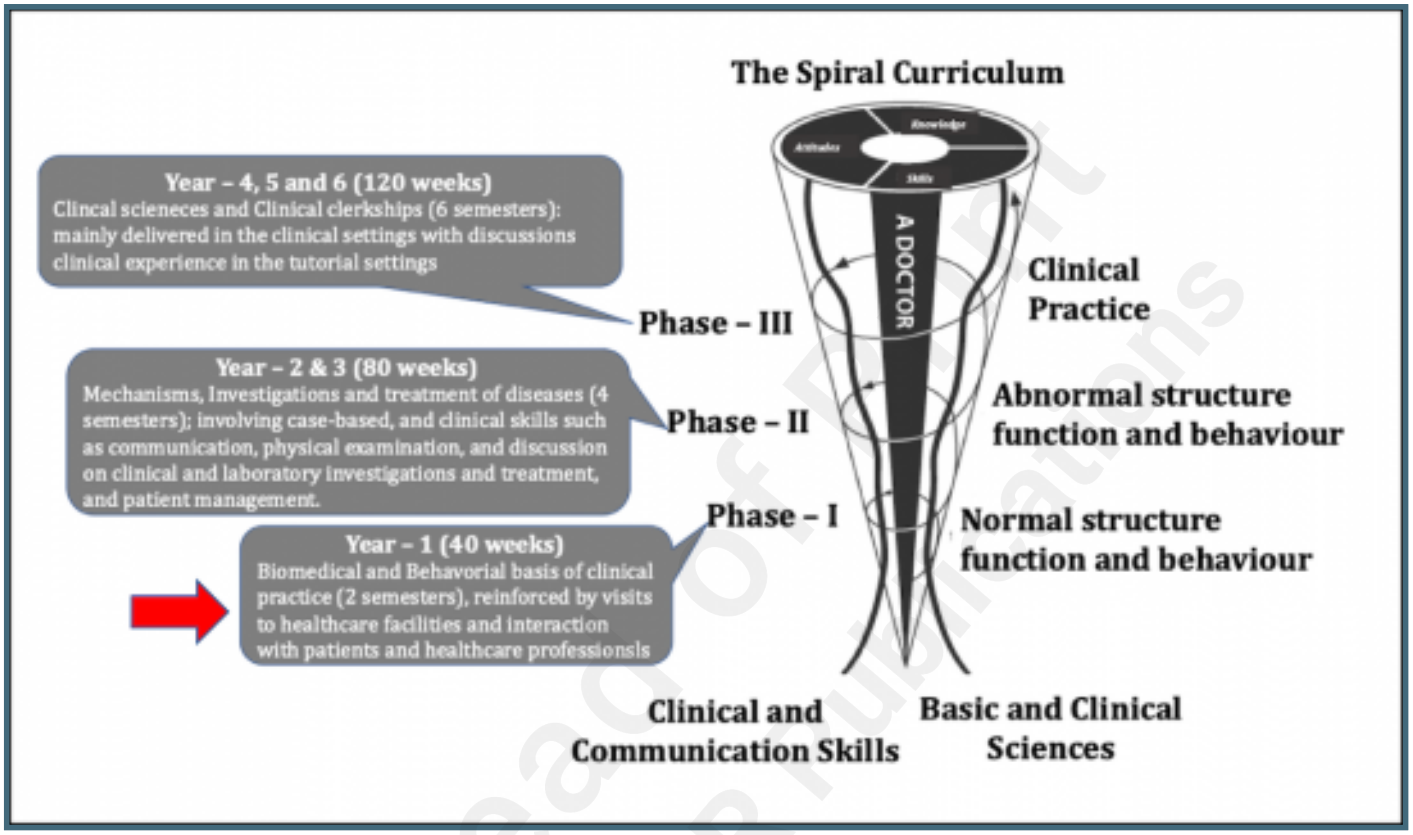
Supplementary Files

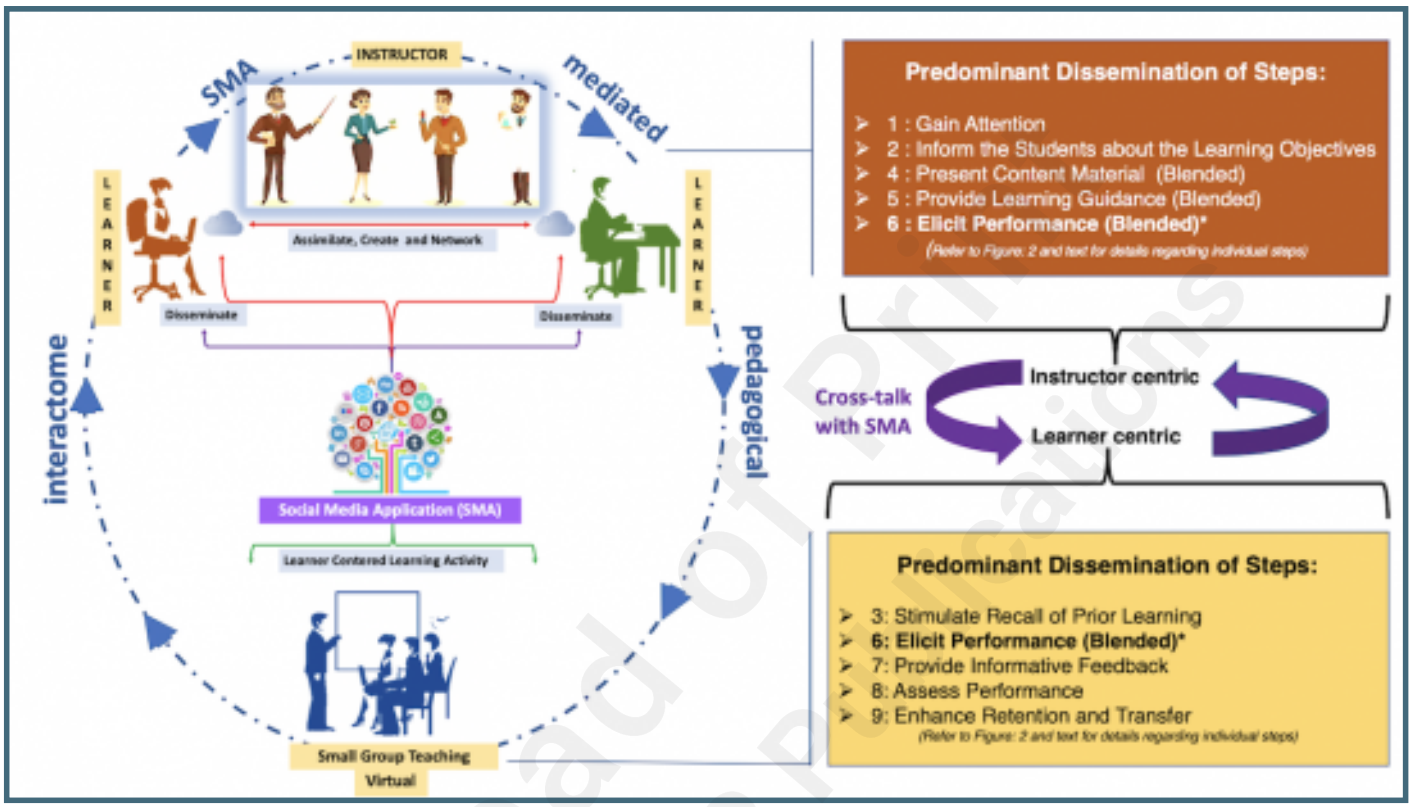
Figures

The undergraduate medical curriculum at Mohammed Bin Rashid University of Medicine and Health Sciences (MBRU). The curriculum is divided into three phases and spans over six years. (Note: Each phase of the undergraduate medical curriculum includes integrated courses and builds on the preceding one, such that the curriculum is a “spiral,” and the students repeat the study of a subject, each time at a higher level of difficulty and in greater depth.) (Note: the phase in which the teaching framework was implemented is indicated with a red arrow).

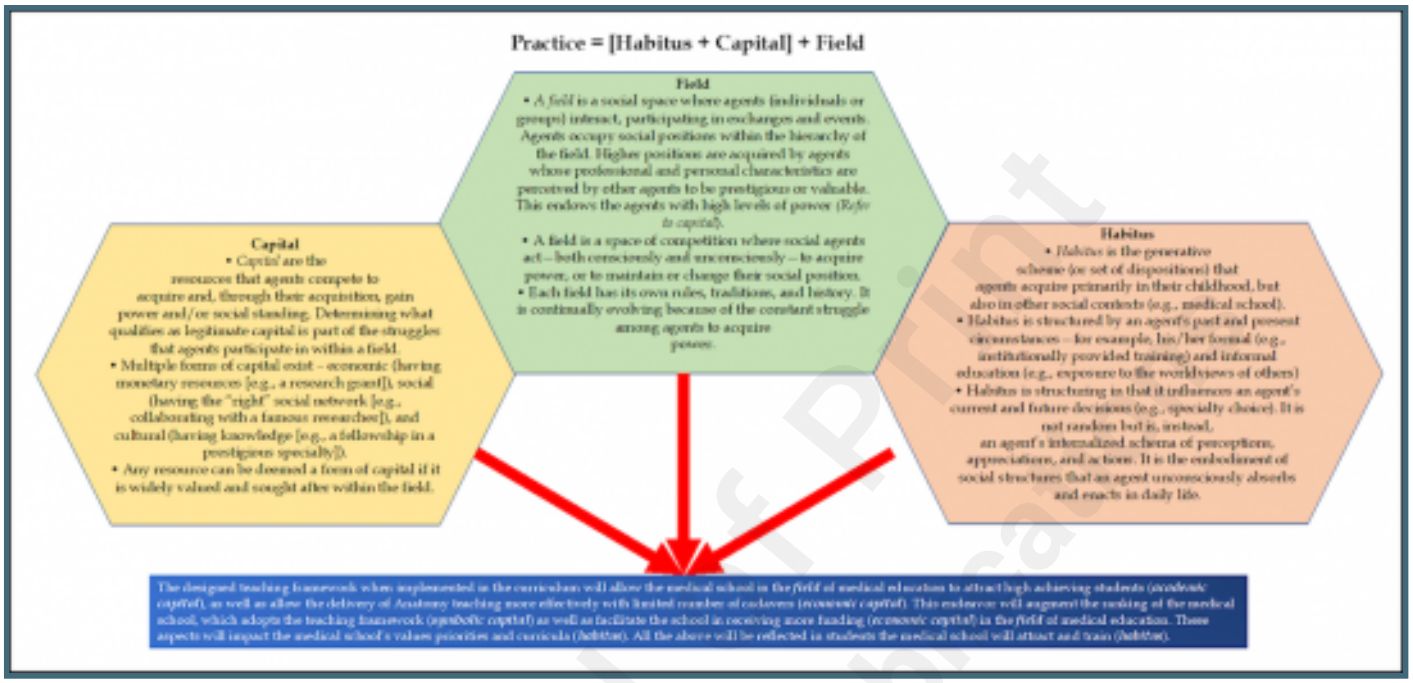


Anatomy dissection facilities at MBRU. A. Dissection Area showing the dissection stations (Each station comprises of an adult cadaver placed in the supine position on a removal tray situated on the dissection table); B. Medical Imaging and Case-based Discussion Area; C and D. pro-section areas.

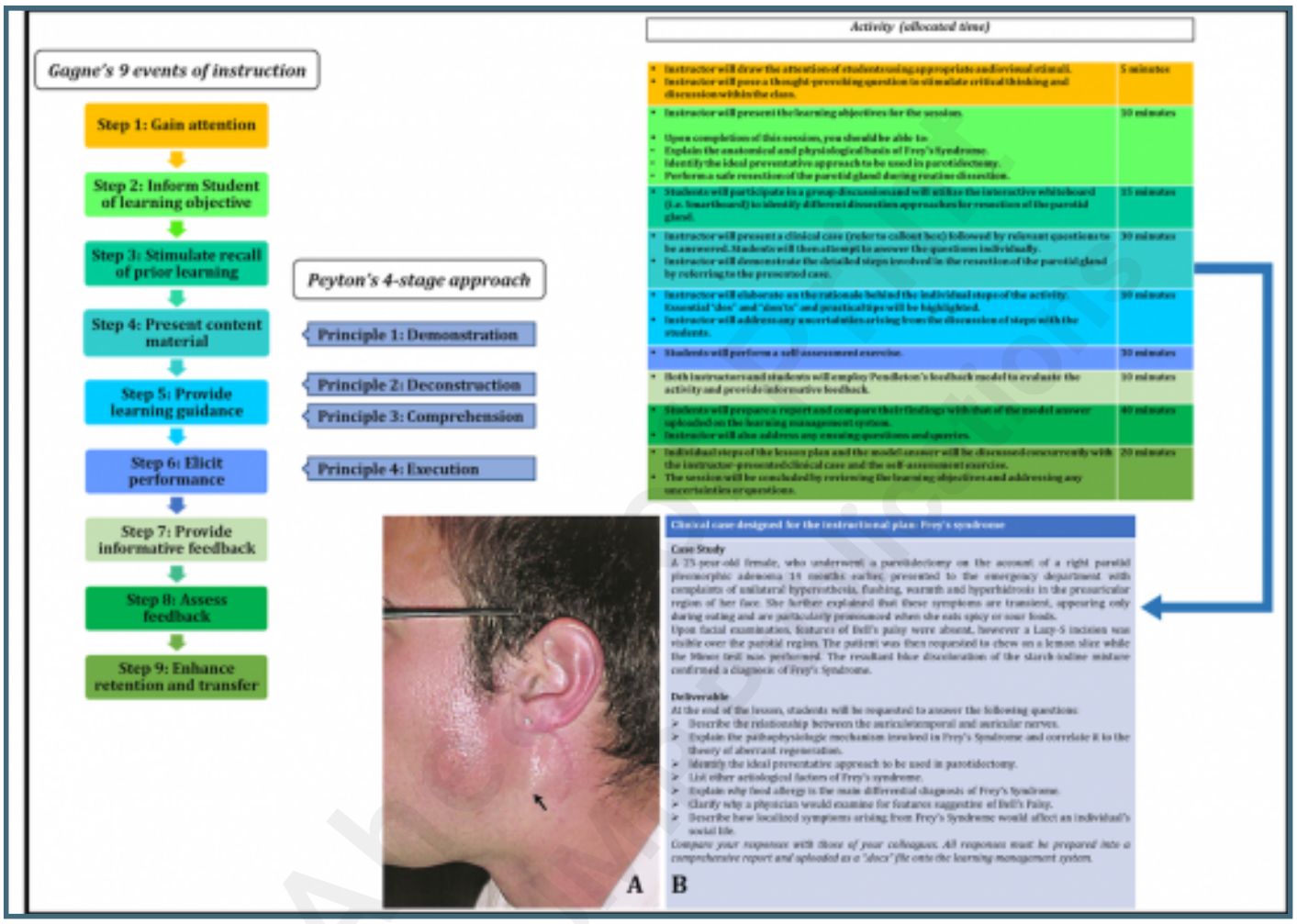
The SMA Interactome. The dissemination of the teaching framework using SMA, during the unprecedented times of COVID-19 is shown in this figure. The interactome consists of two aspects, one which is instructor centric whereas the other is learner centric. Individual steps of the teaching framework attesting to the two aspects in shown. Step: 6 is common to both the aspects (indicated by *). The crosstalk between the two aspects is facilitated by SMA (YouTube and WhatsApp at MBRU, and also through discussion sessions on the learning management system at the university).



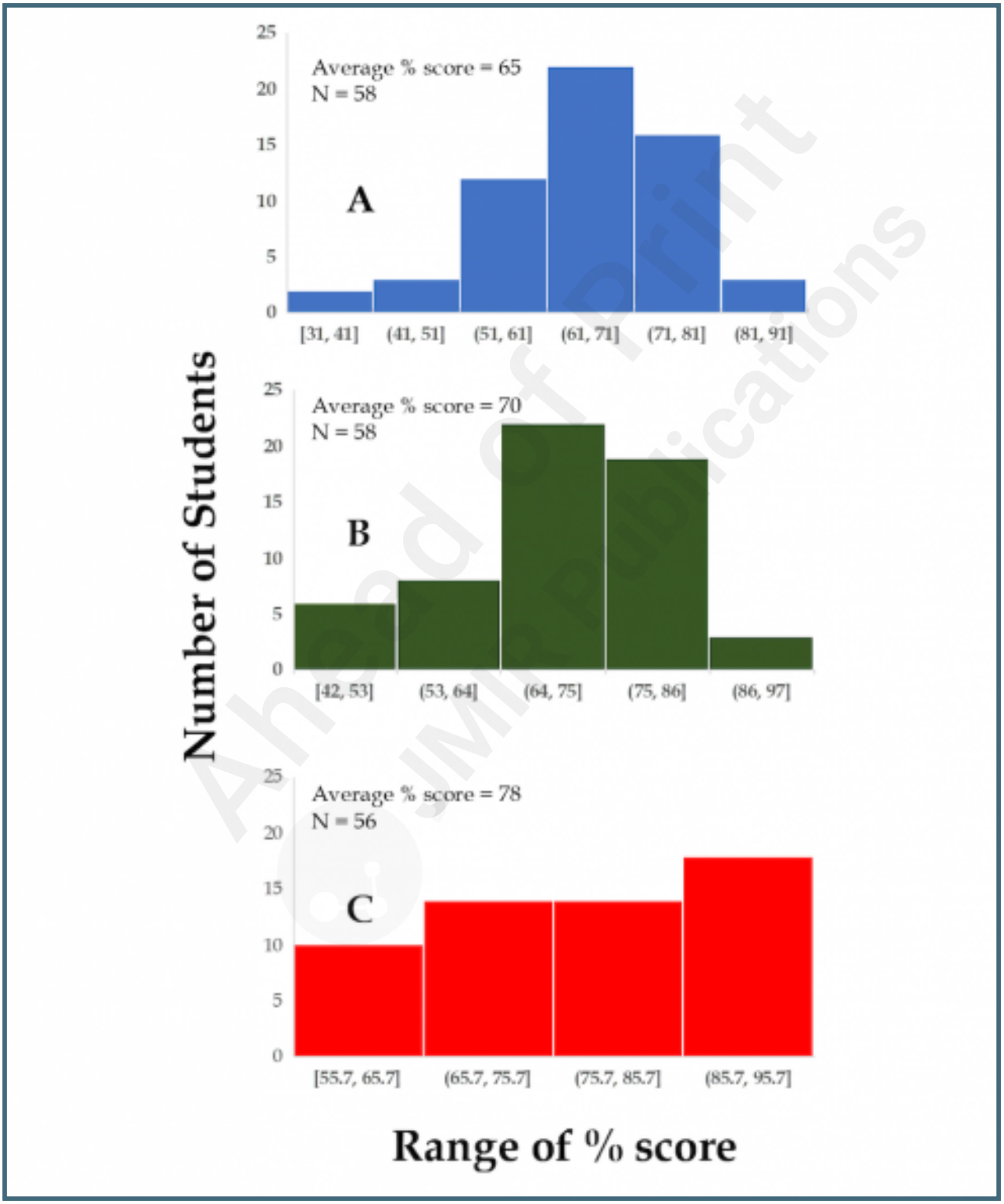
Bourdieu's Theory of Practice. The figure elaborates on three intimately related concepts: field, capital, habitus. The text box in blue elaborates how Bourdieu's Theory of Practice when applied to the current context demonstrates the benefit of the teaching framework being adopted by a medical school. The concept of the figure was derived from Brosnan C. Making sense of differences between medical schools through Bourdieu's concept of "field." Med Educ. 2010;44:645–652.



Design of the pedagogical framework. The instructional design strategies of Gagne and Peyton were blended to design the framework. The blended steps are also indicated. On the extreme right, the dissemination of the teaching framework with the sequential steps is shown with the allocated time for each step. The clinical case associated with Frey's syndrome and associated deliverables are shown in the table below. Medical image of Frey's syndrome was adopted from the New England Journal of Medicine with permission (permission attached in S1 File.).



Performance of students in the summative assessment of the H&N course across three cohorts. A. Cohort where the course was delivered on-site using traditional didactic pedagogy; B. Cohort where the course was delivered on-site using the blended pedagogical framework with incorporation of dissection sessions; C. Cohort where the course was delivered using the blended pedagogical framework, with integration of the SMA interactome during the COVID-19 mandated lockdown period. (Note: The performance of the students was better when pedagogical framework was implemented in the delivery of anatomy education).



Multimedia Appendixes

PowerPoint presentation used for the delivery of the instructional plan.
URL: https://asset.jmir.pub/assets/1945129c6c806b880d7af57f63b32c7d.pdf

Frey's Syndrome figure permissions.
URL: https://asset.jmir.pub/assets/5e5cc6920108ad3b231041d596793ed7.pdf