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Navigating the Case-based Learning Multimodal Learning Environment: A Qualitative Study Across the First-year Medical Students

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ABSTRACT

Case-based learning (CBL) is a popular instructional method aiming to bridge theory and clinical practice. This study aims to explore how the CBL mixed modality curriculum influence students' learning styles and support-learning strategies. We employed an explanatory sequential mixed method with an initial 44-itemed Felder-Silverman's Index of Learning Style (ILS) questionnaire distributed to the first-year medical students (n = 142) using convenience sampling to describe preferred learning styles. The qualitative phase utilised three focus group discussions (FGDs) to explore the multimodal learning style exhibited by students in depth. Most students preferred a combination of learning styles reflective, sensing, visual and sequential (i.e., the RSVISeq style, 24.64%) from the ILS analysis. The frequency of learning preference from processing to understanding were well balanced: sequential-global domain (66.2%), sensing–intuitive (59.86%), active–reflective (57%) and visual-verbal (51.41%). The qualitative data reported three major themes, namely, Theme 1: CBL mixed modalities navigates learner's learning style, Theme 2: Learners active learning strategies from the CBL modalities supports learning and Theme 3: CBL modalities facilitating theory into clinical knowledge. Many quantitative and qualitative studies have reported the multimodal learning style of the first-year medical students. Medical students utilise multimodal learning styles to attain clinical knowledge when learning with CBL mixed modalities. Educators' awareness of the multimodal learning style is crucial in delivering the CBL mixed modalities effectively, considering strategic pedagogical support for students to engage and learn CBL in bridging theoretical knowledge and clinical practice.

Keywords: *Case-based learning, Learning style, Medical students, Multimodal learning style*

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INTRODUCTION

One of the main tenet in medical education includes developing clinical problem-solving skills in the early stage of the medical training (1). Such higher-order thinking skills would require specific pedagogical strategy. Case-based learning (CBL) is an inquiry-based learning method, which is strongly flavoured with active learning

strategies to bridge theory and clinical practice. One of the definitions provided for CBL is "The goal of CBL is to prepare students for clinical practice, through the use of authentic clinical cases" (2). CBL is well-known for establishing a deep-learning approach (3–4), which is characterised by making meaning of the materials, connections and recognising patterns that allows holistic learning (4). Learning is viewed as an intricate and active process, and learners may use various learning styles to internalise information based on situations (5). Engaging with CBL is reported to require a "different strategy and mind set" to attain the learning outcome (6, p. 46).

LEARNERS IN A CBL ENVIRONMENT

According to Al-Khayat (7), to attain clinical knowledge and expertise, more than one learning style is needed. Lujan and DiCarlo (8) stressed a multisensory approach to teaching biomedical sciences effectively to meet learners' needs. Although facilitation of CBL is the responsibility of the instructors, CBL learners should be seekers, processors, constructors, managers and users of knowledge to enable clinical knowledge construction. Thistlethwaite (2) claimed that evidence of how CBL enables students to learn in a more effective way was scarce. Educators' understanding of the different learning styles will enable instructions to be tailored to the students' learning needs and enhance the learning environment (9) for effective clinical knowledge construction. The aim of CBL is to achieve critical thinking and clinical reasoning. Hence, innovative multimodal teaching methods have been recommended to allow stimulating learning environment to attain higher-level learning processes (10). Most first-year medical students were multimodal learners, and interestingly, Baykan and Naçar (11) stated that multimodal learners used active learning strategies as compared to unimodal learners in aiding clinical reasoning and problem-solving skills. In addition, multimodal learners have been reported to apply active learning strategies and achieve higher grades (10), indicating its superiority over unimodal learners. Among undergraduate of first-year medical students, 86.8% reported being multimodal learners, suggesting multiple modalities in the delivery to captivate and motivate students (12).

CBL BY MIXED MODALITIES

In McLean's (6) worldwide review, 19% of CBL delivery modes were reported as mixed modalities and was the third most preferred delivery model in CBL. Mixed modality application in a CBL pathology curriculum (13) recorded a high mean score of 4.46 for satisfaction level. Penney (1989) in Fogelberg et al. (14) described modality as a "sense system used by which the learner receives the material i.e., auditory versus visual" (p. 310). Hence, the term mixed modality in CBL refers to a CBL case presentation utilising more than two modalities (7). To clarify further, it can be said "For example, if an article described assigned reading, lectures, small group discussion, a live case-based session, and patient interactions, then that article would be described as mixed modalities" (7, p. 40). Amin and the team (13) strongly suggested CBL cases include audiovisual, role-play to enhance participation and to incorporate laboratory skills to reinvent real-time clinical settings to allow future clinical practice. The preference to process new information by specific sensory modality is a characteristic of the learning style (8) and is important for CBL educators to understand. Metacognition, critical thinking and clinical reasoning are the main objective of CBL (3, 14–16) and to achieve this, CBL pedagogy strongly flavoured with active and interactive learning strategies and have been reported to influence on student learning style (5).

This is evident from a study on the first-year pharmacy students over problem-based learning materials, which suited certain learning styles over others (17).

Li et al. (5) stressed the need for multiple teaching strategies to meet the demand of the learners' needs. Although CBL benefits are well established in medical education, several practical challenges have been highlighted (18). Moreover, medical students using CBL curricula have been reported to have higher stress over factors such as confidence levels in clinical decision-making, poor clarity over the CBL structure and objectives, and class workload (19). Like most medical schools, the medical school in the present study rolled out its revised preclinical CBL curriculum in 2017. The concept of mixed modalities utilised in the current study is similar to the multiple pedagogies used to create a dynamic and collaborative learning environment by Li et al. (5). Such diverse teaching modalities can be challenging and require students to adapt to different learning methods. More importantly for the first-year medical students experiencing the new learning environment requiring some adjustments (20).

To date, no study has evaluated the active learning strategies of the CBL mixed modalities to support first-year medical students learning styles and how the knowledge integration into clinical practice is facilitated by CBL cases. The findings will better inform our CBL educators and learners to further improve and enhance support for students' preferred learning styles in learning CBL teaching through mixed modalities.

Hence, this study sets out to answer the following research questions:

a. What are the preferred learning styles of the first-year medical students learning in mixed modality CBL curriculum?

b. Does the CBL mixed modalities influence students' learning by their preferred learning style while being in mixed modality CBL curriculum?

c. What are the strategies utilised by first-year medical students to support their learning styles in learning the mixed modality CBL curriculum?

d. Does the CBL modalities facilitate knowledge integration into clinical contexts?

METHODS

Design

This is an explanatory sequential mixed-method study (21) aiming to first identify the learning styles of the current first-year students experiencing CBL mixed modalities first with quantitative methods, followed by qualitative methods to seek in depth insight over the preferred learning style in a unique yet challenging learning environment (22). Phase one utilises a cross-sectional study using Felder-Silverman's Index of Learning Style (ILS) questionnaire followed by a second phase to explore in depth the experiences of students learning with CBL. Phase two pertains to live experience, hence best fits with the phenomenological design to explore the social interaction (23) of the students using focus group discussion (FGD) (24).

Sampling

This study recruited the first-year medical students by convenience sampling (n = 142), who enrolled in 2019–2020. The present study utilised homogenous convenience sampling, rendering a clearer generalisability (25), and our population was sampled across all the first-year medical students who homogenously experienced the CBL curriculum. Considering the downside of convenience sampling, the clear study objectives with a large number of participants in quantitative reporting with validated ILS questionnaire and accepted FGD protocols increases the credibility

of this study (26). Ethics was obtained from institutional research management committee. Following a briefing session, the ILS was distributed to the students at the end of teaching sessions with written consent obtained and anonymity assured. FGD recruitment was performed through emails, with voluntary participation and written consent obtained for those accepting the invitation.

The Preclinical CBL Curriculum

The CBL curriculum for first- and second-year students is designed with teaching and learning strategies designed to be student-centred and learning-outcomes driven, with students receiving information in diverse ways. These CBL mixed modalities are presented in Table 1, and allow students to pace their learning independently and urge them to strive to explore and accommodate a range of learning styles accordingly. Students assume responsibility, with teachers support for 13 cases in Year 1 followed by 12 cases in Year 2 (Figure 1). Each case led to the underlying key concepts and mechanisms. The cases were introduced with core clinical presentations and students were conditioned to experience resource materials in live lecture sessions, seminars and practical sessions or were aided using resources in the medical learning environment (MLE), the university learning management system (LMS). The core modules are Basic Clinical Sciences, Anatomy Practical, Public Health and Social Medicine, Clinical Reasoning, Clinical and Communication Skills, Professional Development Skills and Early Clinical and Community Exposure (ECCE) were addressed by cases with clinical presentations to ensure the learning issues were identified to inform the subsequent teaching/learning process. The cases reflected the range of core clinical presentations and problems progressively exposed through their clinical years.

Table 1: CBL mixed modalities pedagogies

CBL modalities	Cases 1 to 25 across year 1 and year 2 students
Case launch	In the form of large group plenary sessions (involving case presentations with patient interactions) with recording made available.
Small group seminars	Focused on communication skill, basic science, public heath, professionalism and clinical reasoning. Generally, seminars encompass problem-solving tasks, presentations, debating and role-playing along with case roundups that overviews the whole case with opportunities to reflect their accrued knowledge at the end of each case.
Small group clinical teaching	In campus via volunteers and video demonstrations to provide clinical learning resembling authentic case patient scenarios.
Laboratory practical	Aimed to help students to develop observational, manual proficiency, data handling and interpretative skills where clinical skills training are offered in the clinical skills laboratory.
Self-directed resources in MLE	Allows students to access the learning contents either via verbal or visual presentation of information or both. MLE offers the entire story of the case, embedded videos (pertaining to cases/on communication skills/on practical's), recap links, personal capture (P-cap) links and interactive tutorials (tailored to topics like anatomy, physiology, immunology etc.).
Case roundups	Delivered either in the form of seminars (e.g.: team-based learning) or in a large group based on lead. The entire case is overviewed with parallel reflection, discussion and clarifying queries to bridge their knowledge and understanding.

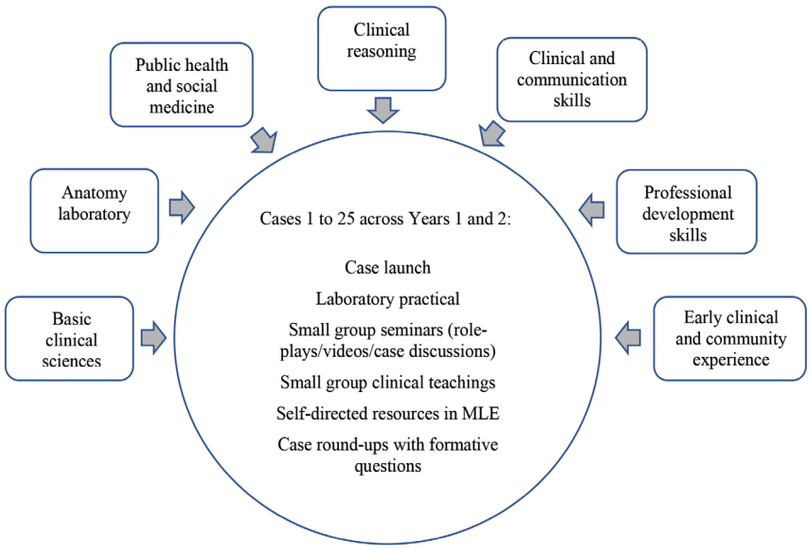

Figure 1: Cases 1 to 25 across years 1 and 2 through five CBL modalities.

The quantitative data was collected using the ILS questionnaire (27) with two opposing styles in each of the four dimensions as shown in Table 2. The 44-item questionnaire comprises 11 items evaluating each of the four dimensions. Each item has a binary response corresponding to directional preference for each learning dimensions. An odd score for each dimension was computed (by substracting higher to lower responses depicted as "a" or "b") as an integer ranging between –11 and +11. Integer were then scaled as mild, moderate and strong preferences within a range of 1–3, 5–7 and 9–11, respectively. Scoring 1 or 3 for a dimension indicates a fair balance followed by a moderate and strong preferences. ILS is a validated and feasible instrument vastly utilised and its reliability and validity is indicated by a Cronbach-alpha value greater than 0.5 (28).

Table 2: Dimensions of ILS with learners' features

Features (Sensing/Visual/Active/Sequential)	Dimension	Features (Intuitive/Verbal/Reflective/Global)
Concrete thinkers, prefer utilising facts, data, and like solving problems in well-established route	Sensing-intuitive (Sen-Int)	Abstract thinkers, grasps concept well and relationship and remain innovative
Receive inputs via sights, pictures, flowcharts and timelines	Visual-verbal (Vis-Ver)	Inclines written or oral discussions or explanations
Absorb best when they participate in a process and prefer to be in groups	Active-reflective (Act-Ref)	Introvert, love thorough thinking and prefer executing tasks alone
Expand understanding in linear stepwise progression and good at analysis	Sequential-global (Seq-Glo)	Likes to view things with a broader sense by making bigger leaps and better in synthesising

Data Collection and Analysis

Descriptive statistics was used to analyse the frequency distribution of study variables. Normality distribution of data was analysed using histograms, Q-Q plots and Kolmogorov-Smirnov/Shapiro-Wilkinson statistical test. All data were analysed using SPSS software version 23.0 and graphs were plotted using Sigma plot software version 10.0.

Online FGD (29) was conducted due to the pandemic via Zoom. Semi-structured interview questions were developed based on specific protocol (30) and used as a guide to gain in-depth data (31).

Verbal consent was obtained prior to FGD audio-recording. Three FGD sessions were conducted, each lasting 60–90 minutes. The qualitative researcher sought to minimise bias and the data was transcribed verbatim and analysed thematically (32) using the qualitative data analysis software Atlas.ti version 7. All three FGD session's reliability of data was enhanced with member checking made to ensure accuracy of data. The confirmability was ensured by sending the interview texts and extracted codes and categories for external verification.

Qualitative data analysis begun with the initial reading of the interview texts to gain general understanding. A second reading helped to identify keywords with initial line-by-line coding made inductively with third reading. This facilitated the subsequent identification of categories to generate themes. We adhered to the concept of "information power" (33, p. 46) for this study as compared to data saturation. This is because, as claimed by Malterud et al. (34), one of the five key dimensions dictating sample size in a qualitative study is the study aims.

Our study aimed to answer the preferred learning style of first-year medical students following the mixed modality CBL curriculum and whether the latter had influenced students in adopting their preferred style. We believed our research question is narrow enough to require fewer participants since it is highly specific participants experience with CBL mixed modalities as proposed by Varpio (33). Moreover, CBL is a well-established theory, which again would require less participants, and the data is sufficient to allow transferability to other similar CBL medical curricula.

RESULTS

Quantitative Findings

In all, 142 medical students (male = 32.4%, female = 67.6%) enrolled in 2019, with a mean age of 19.42 ± 1.61 years (Table 3). Participants were Malaysians (73%), including Chinese (n = 52), Malays (n = 37) and Indians, (n = 16) and international students (27%). The frequency of the learning style preferences adapted by the first-year students are also presented. The learning pattern over four dimensions is summarised and shows the most preferred combination adopted by the students was reflective, sensing, visual and sequential (i.e.: RSVISeq style [24.64%]). The frequency of learning preference from processing to understanding is shown in Figure 2, suggesting learners were well-balanced, with sequential-global domain (66.2%), followed by sensing-intuitive (59.86%), active-reflective (57%) and visual-verbal area (51.41%). Although balanced, shift in preferences were observed more in reflective, sensing, visual and sequential domains. These findings suggest that the study participants utilised multimodal learning style in their studies.

Table 3: Frequency distribution of variables of study population (*n* = 142)

Variables	Number (*n*)	%
Gender		
Female	96	67.60
Male	46	32.40
Nationality		
Malaysian	104	73.24
International	38	26.76
Age		
19 and below	95	66.90
20 and above	47	33.10
Learning style preferences		
RIVi	1	0.70
RViSeq	1	0.70
RSViSeq	35	24.64
RSViG	9	6.33
RSVerG	12	8.45
RSVerSeq	12	8.45
RIViSeq	10	7.04
RIViG	11	7.74
RIVerSeq	2	1.40
RIVerG	3	2.11
ASViSeq	10	7.04
ASViG	10	7.04
ASVerSeq	3	2.11
AIViSeq	8	5.63
AIViG	10	7.04
AIVerSeq	2	1.40
AIVerG	3	2.11

Note: Learning style preferences (A – Active, R – Reflective, S – Sensorial, I – Intuitive, Vi – Visual, Ver – Verbal, Seq – Sequential, G – Global).

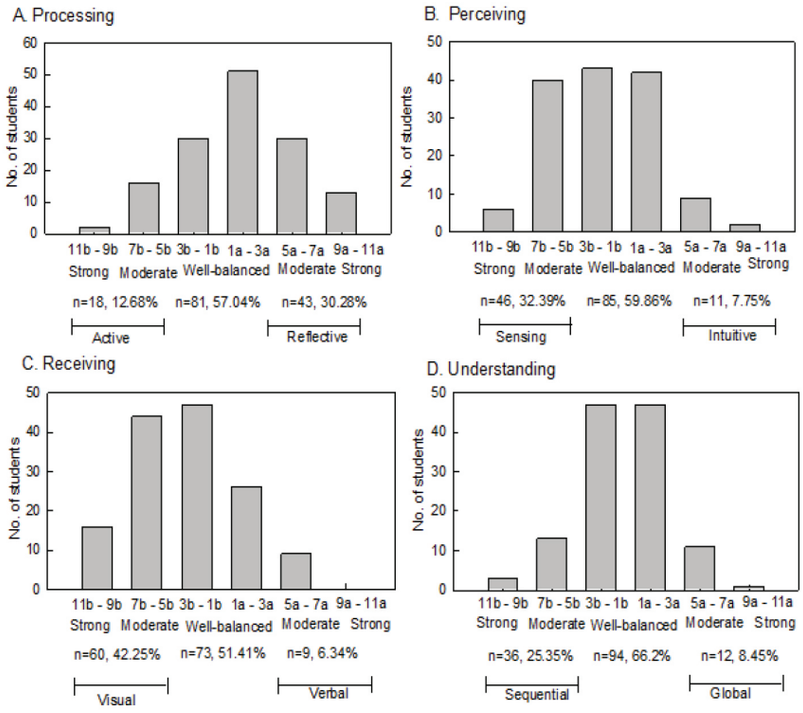

Figure 2: The percentage of "well-balanced students" across four dimensions of learning style.

Qualitative Findings

Twenty-eight participants volunteered and participated in three FGD sessions, with 10, 9 and 9 participants in each session, respectively. Three major themes with five categories emerged from the focus group data obtained from the first- and second-year medical students who experienced learning with CBL curriculum as presented in Table 4.

Table 4: Themes and categories from the FGD

Theme 1: CBL mixed modalities navigates learner's learning style	
Category 1: CBL modalities fostering multiple learning styles	"It definitely did influence my learning style because I never had something like this before, in high school or college and with the CBL, they did try to incorporate different teaching methods to help us to consolidate our knowledge". (FGD 1)
	"It helps in a way, because CBL expose to the need of different style of learning". (FGD 1)
	"I actually enjoy what I am studying now compared to the last time and I think I'm forced to have different learning style compared to last time". (FGD 2)
	"When I got used to CBL, it was like this is how is going to work for me and this is how it is not going to work for me, so mostly it was visual learning, but it was definitely blend of everything". (FGD 3)

(*Continued on next page*)

Table 4: (*Continued*)

Theme 1: CBL mixed modalities navigates learner's learning style	
Category 2: CBL modalities supports individual preferred learning style	"I am a tactile learner, so I feel the clinical skills and role-play, seminars, discussion helps me a lot". (FGD 1)
	"I realise, for CBL, the one case given as a whole, offers a big picture and helps me personally because I like to see the big picture first and then link from one to another slowly". (FGD 1)
	"All those CBL lectures and recording sessions actually helped me learn step by step and then see the big picture as I go along because I felt CBL methods covers various type of learner, so that everyone can learn and do things in their own way and study on their own time". (FGD 2)
	"Each case had different ways to go about, some cases were different than others, like case 13, had more information than other cases and you just had to have some notes but for others, you have to do it in flashcards, and I think it depends on the case you had. For me notes were not working, so I had to expand and try other learning style as well". (FGD 1)
Theme 2: Learners active learning strategies from the CBL modalities supports learning	
Category 1: The active-interactive CBL modalities supporting learning	"In CBL, I think we are all expected to do certain level of self-directed learning (SDL) and I think SDL was well-guided as the lecturers really provided us with the resources that we can relate to, and I think I am very well-supported when comes to SDL". (FGD 1)
	"I like it in Year 1, they had role-plays coming in for actual patients and centred around patients and interviewed and interacted with patients with actually had the condition, and if they don't have the conditions, the lectures will role-play the conditions and I thought that was very nice and interactive and I really liked that and enjoyed it". (FGD 2)
	"I personally benefited from the small group seminars. It was more of a FGD, and you would be able to ask more questions". (FGD 3)
Category 2: CBL instructors' pedagogical skills	"Personally, I enjoyed when they conduct smooth summary and the questions at the end but sometimes, they were not very beneficial as it also depends on the lecturer". (FGD 2)
	"The cardio system or respiratory system tend to appear superficial, but when you get into the depth, and you read a bit more than the information is quite burdening's in such situation if the instruction were clearer in the beginning it would be much easier in the process". (FGD 3)
Category 3: CBL formative questions promoting self-assessment and deep learning	"There were practice questions after each case, and it gave a good overview of what you know and what you don't know and in a way that could motivate you to pursue further on what you know, and they really filled in the gaps, and I enjoyed that". (FGD 2)
	"My experience in Year 1 going through the case and each case has its own extra questions to assess your knowledge before you actually dive into what is actually about, to me, those little pieces of information helped me understand further and more deeper regarding the cases and it did help me to analyse the learning outcome on what the cases were trying to tell me". (FGD 2)

(*Continued on next page*)

Table 4: (*Continued*)

Theme 3: CBL modalities facilitating theory into clinical knowledge	
Category 1: CBL case authenticity aiding knowledge integration	"I think, the CBL clinical skills helps me the most, and I think when come to clinical years, I actually got to see things at first hand from the practical knowledge we gained, and it helped a lot". (FGD 1)
	"I think it helped me to connect each case information together because even though each case offers you different information as the cases are different, at the end of the day, it all linked everything back together, which initially it took a while to get used to but then after a while it make sense". (FGD 2)
	"The CBL, although cases are targeted on one organ system, it is influenced by multiple other factors, in linking up those different cases were something we were taught how to do it so integrating other part was lot easier with all the knowledge and information given were helpful". (FGD 3)

Theme 1: CBL mixed modalities navigates learner's learning style

This theme emerged from two categories (refer to Table 4), namely CBL modalities fostering multiple learning styles and CBL modalities supporting individual preferred learning style. Students across the three focus group sessions shared common learning experiences with CBL, which is the application of multiple learning styles based on learner needs dependent on the mixed modalities of the CBL being exposed. On the same note, students felt their preferred learning was dependent on the type of CBL modalities. Students commented on the various CBL modalities that accommodate different types of learners' style and pace. This was described by some who utilised the sequential learning style initially, which then aided them in utilising the global learning style. Likewise, variations in the CBL case content and volume influenced the selection of learning style from verbal to visual learning style. Figure 3 shows the multisensory teaching modalities implemented in the CBL navigating students' learning styles.

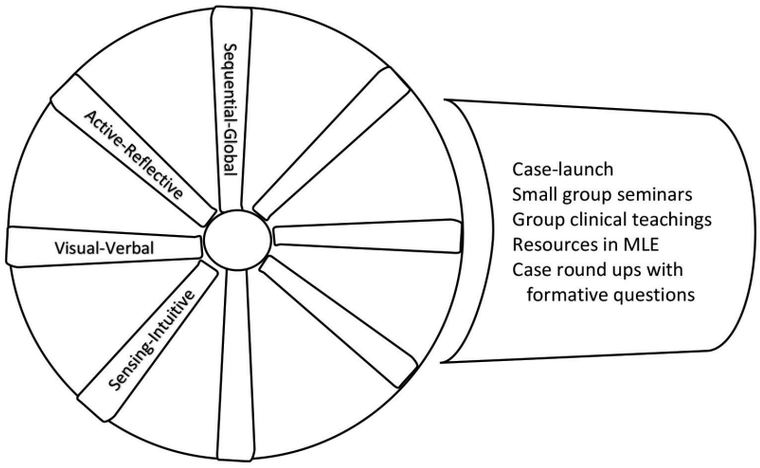

Figure 3: CBL mixed modalities navigating students learning style.

Theme 2: Learners active learning strategies from the CBL modalities supports learning

The second theme characterised by the active learning strategies perceived by the students from the experience with the CBL modalities such as the SDL, active engagement with role-play with interaction facilitated with authentic clinical cases. The resources provided within the CBL seem to have guided students to become self-directed learners effectively. Role-play using volunteers mimicking real clinical conditions was another active learning strategy, which was perceived to have promoted interaction with the simulated patients. Small-group seminar discussions were perceived to be useful because the presence of lecturers guiding and facilitating students was believed to create a non-threatening environment. Hence, it fostered an inquisitive learning environment.

Students also highlighted the instructors in CBL who played a key role in ensuring that the CBL was implemented effectively, and this is highlighted in terms skills in delivering cases and clear instructions from the very beginning. The third category denoting the second theme was the CBL formative practice questions promoting self-assessment and deep learning. The significance of formative CBL practice questions was perceived as facilitating self-assessment and pre-requisite knowledge, motivation and deeper learning of the CBL cases. These elements are viewed to have aided in assessing their learning outcomes and closing the gap in the knowledge learnt as shown in Figure 4.

Figure 4: The active learning strategies promoted by the CBL mixed modalities in supporting multimodal learners.

Theme 3: CBL modalities facilitating theory into clinical knowledge

The third theme emerged from a single category is CBL modalities facilitating theory into clinical knowledge (Figure 5). CBL is believed to aid students' clinical years, suggesting knowledge integration from the CBL case clinical scenarios aided in creating the "insight" for the cases encountered. Furthermore, clinical skills teaching was believed to aid in gaining practical knowledge, which helped integrate the learnt knowledge in clinical years. Another element that facilitated theory integration was the individual CBL cases with its various information, which aided students in recognising pattens and making logical connections. This was further supported by the notion of learning from a single case with many elements connected to other CBL cases, which influenced learning and facilitated knowledge-integrating skills.

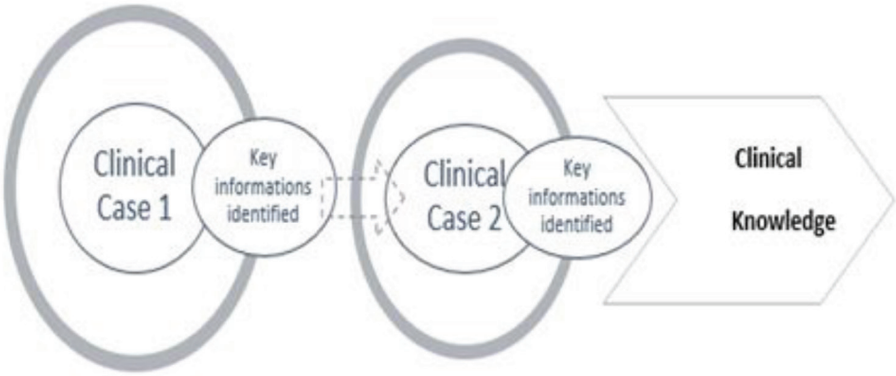

Figure 5: Key information's in CBL cases facilitating theoretical knowledge integration.

DISCUSSION

The current study's sample included 67.60% female and 32.40% male participants, and among these, 73.24% were Malaysian and 26.76% being international students. Mixed reports exist on the significance of gender and learning styles (35–37). The ILS profiled in the current study suggests a multimodal learning styles, with higher preference for RSVISeq (24.64%), suggesting the RSVISeq combination was the most preferred learning style within the CBL mixed modalities environment. Likewise, 8.45% of our students preferred RSVerG and RSVerSeq, followed by 7.04% and 7.74% for RIViSeq and RIViG, respectively.

The ASViSeq, ASViG and AIViG were 7.04%. The least preferred learning styles were RIVi and RViSeq with 0.70%. The current combinations of preferred learning styles, generates an insight for CBL educators to improve and balance the instructions in CBL mixed modalities to support majority of learning style (38). We believe the ILS instrument aided in diagnosing the learning style preference of our students, since learning style preference is influenced by educational experience cases (39) by focusing on teaching styles on content, presentation, participation and perspective in teaching.

We also propose the findings assist educators in developing instructions to equally amplify the least preferred learning styles in this study to increase their capabilities in developing the unexplored areas (38), for example to promote intuitive thinkers to increase their strength in abstract conceptualisation skills, and instructions can be designed accordingly. Our subsequent qualitative data aided to further clarify the quantitative results in depth with three major themes in supporting the second, third and fourth research questions.

Theme 1

The first theme strongly suggests the students navigating their learning style by the various CBL's modalities. Majority of the students in the current study reported applying multimodal learning style to learn the various CBL modalities encountered effectively. The findings from the current study resonates with Karim et al.'s (39) study on 1,004 medical students, with 64.2% of the students employing multimodal learning style, while 35.8% of them to be unimodal learning styles. The current study reports CBL as useful in exploring one's learning needs to adapt to multimodal learning styles. Studies show that awareness of one's learning preferences enhances their learning and there is no one specific learning style

but one or two dominants learning styles always coexist (9). The awareness of one's learning style is reported to assist in using the appropriate learning strategies that allows lifelong and SDL (39). Adopting a multimodal learning style has been claimed to promote pleasant learning environment in the current study, and this is supported by another study reporting the building of interest among medical student experiencing CBL approach in learning anatomy with 86% finding it useful (15).

The multimodal learners are associated with higher grades as compared to unimodal learner (40) and believed to possess the ability to switch to the required model of learning (41). The student-centred approach to learning CBL promotes deep learners (42) and it is recommended that CBL teaching be multisensory, blending all learning styles from active-reflective to sequential-global, to accommodate diverse learning styles (39). Hence, adopting multimodal learning style through CBL offers a range of benefits for learners in terms of experiencing learning in a positive environment.

Current results suggest that tactile learning styles are best for learning clinical skills, role-play and small group seminars and discussions. Tactile learning is the most commonly utilised learning style (43), and 76.3% of medical, dental and diploma students showed unimodal learning styles, with kinaesthetic learners being the majority (44). Tactile learners access information realistically, with experiential learning with practice being the ideal method (39). Moreover, students who experienced CBL cases in the current study reported the cases aiding the global learning style, as cases facilitated global learning style, which then aided in sequential learning style. Inversely, lectures from the case launch with recording reportedly facilitated sequential learning, which later supported the global learning style.

In a cross-sectional study among 366 medical students in Malaysia, 65.3% adopted the sequential or global learning styles in public health medicine (45). Sequential learners are associated with better academic performance compared to global learners (46). Therefore, clinical cases, lectures and recordings in the current CBL fostered both global and sequential learning styles, depending on the types of CBL modalities. The current study also reported preference for note taking (verbal) or flashcards (visual) dependent on the volume of information provided by each case. Perhaps this can be related to ease of retention as reported by the Romanian students claiming preference for visual learning style to aid information retention (47). The students in the current study employed flashcards in aiding visual learning, probably facilitated in retention of information for content-heavy case presentations. In a study measuring pre-and post-test scores among surgical technologist students, comparing mobile learning versus flashcards, mean score for flashcard users increased from 11.85 to 16.25 (48), suggesting its effectiveness.

Theme 2

The present study suggests that multimodal learners utilise active learning strategies from three different perspectives: active-interactive CBL modalities supporting learning, CBL instructors' facilitative skills and CBL formative questions promoting self-assessment and deep learning. Baykan and Naçar (11) also showed that multimodal learners' tendency to utilise active learning strategies to attain higher-order cognitive skills. Several active learning strategies were highlighted in the current study, namely, the active interaction which took place through the role-plays conducted with volunteers with realistic patient conditions was much appreciated and favoured. Clinical case studies in CBL are believed to promote effective learning environment with its active learning perceived as enjoyable

(49). Furthermore, students reported positive socialisation impact of CBL, which enhances communications skill development and cooperation (50). This suggests the significance of active interaction using real clinical case scenarios in delivering CBL effectively.

Next, the present study reported the relevant resources provided via the MLE to facilitate SDL. Medical students perceived SDL sessions to cultivate active learning; hence, promoting better comprehension of a given topic (51) and questions from each case in CBL was perceived as a form of self-assessment in gauging their understanding and guiding further learning their cases.

Theme 3

The fundamental principles underpinning CBL is the integration of theory into clinical practice, and the third theme emerged from a single category, highlighting CBL case authenticity aiding knowledge integration. Students in the present study believed integrating theoretical knowledge into clinical knowledge was aided by two main streams: (a) the clinical case construction with real patient anecdotes with differential diagnosis and realistic presenting symptoms and (b) the information's within each case facilitated linking information from one case to another by connecting key information from each individual case. Students in our study highlighted the ability to apply knowledge on real patient presentations effected by the application of key information from clinical cases in CBL resembling real-time clinical scenarios (2).

Our study's claim on the ability to gain insight and proactive learning is postulated from the promotions of retention of basic science knowledge in the form of clinical context with CBL method as stated by Naveed et al. (16). Such insight can be explained when students operate by identifying the salient features in patient presentations as reported by a nursing study on CBL drawing on a holistic grasp of every aspect of the patient and clinical imagination (52). The nursing students in this study recognised patient signs and symptoms and moved to gather and connect data to master the details of the case with a final attempt to connect knowledge.

The present study also highlights how information from each individual case aiding students in linking information together as claimed. Such sharpening of students' comprehension of central ideas and theoretical concepts and reasons in CBL (53) are facilitated by details in the individual cases, as it aids integration when delivered with a systematic and logical approach in describing the context and activities viewed to be invaluable during the clinical practice year (45).

The current study also highlights the experience of learning with CBL cases, oriented to single organ system with due interconnectedness to other case information, which the students believed to aid learning and help in integrating the information provided. Hence, the claim that cases in CBL enable students to structure their way of thinking and the ability to correlate information together as indicated by Kantar and Massouh (52). The interconnectedness referred to in the current study refers to the vertical integration of preclinical content as the single organ system with the clinical sciences is appreciated and believed to have aided students in bridging theory and clinical knowledge (54).

The practical laboratory teaching which imparts clinical skills is believed to aid students largely during their clinical years, as it enabled them to see the relevance from learnt knowledge. This is similar to a study conducted for a biochemistry module among medical students, with 84% claiming the exposure to the logical application of the knowledge obtained in solving the cases was helpful (49).

Limitations

This study acknowledges the strength and limitations of the current study, and generalisation of the findings is dependent on individual institutional context. The strength of the current study is the fact that it is an explanatory sequential mixed design, which means any quantitative limitation will be counterbalanced by the qualitative findings. However, this study was conducted in a single medical school who adheres to spiral CBL curriculum for its preclinical cohort, and the findings are quite contextual and serve as a guide for medical school implementing CBL.

CONCLUSION

This study shed light on several key characteristics to be considered in implementing mixed CBL modalities across groups of preclinical medical students. Clinical knowledge such as critical thinking and problem-solving skills are higher-order thinking skills, requiring multisensory teaching. To acquire these higher-order thinking skills, one needs to navigate multimodal learning with specific learning styles that best fit the purpose of learning specific cognitive, psychomotor, or affective domain of learning. Second, active learning strategies are key in learning multisensorial CBL mixed modalities, and educators in CBL need to ensure the strategies discussed above are considered in implementing these mixed modalities. Another important consideration is that this study highlights the CBL educators' skill in facilitating active teaching methods, such as role-plays, authentic clinical anecdotes, active small group discussion dialogues and formative CBL questions to foster deep learning and metacognitive abilities. Third, elements that promote knowledge integration in CBL would require cases to be well-constructed in a systematic and logical manner as to resemble real-time clinical cases with active clinical teaching methods to further support the integration process.

ETHICAL APPROVAL

This study was approved by the ethical committee of faculty of medicine of both Newcastle University, UK upon Tyne and NUMed Malaysia [ref no: 6856/2018]. All participant signed a written informed consent form.

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