Heart and Guts for Medicine: Pre-university students' perceptions and attitudes about the anatomy and physiology outreach

Ranganath Vallabhajosyula, Vivek Perumal, Ramya Chandrasekaran, Sreenivasulu Reddy Mogali

Submitted to: JMIR Formative Research
on: September 07, 2023

Table of Contents

Heart and Guts for Medicine: Pre-university students' perceptions and attitudes about the anatomy and physiology outreach

Ranganath Vallabhajosyula[1*] PhD; Vivek Perumal[1] PhD; Ramya Chandrasekaran[1*] PhD; Sreenivasulu Reddy Mogali[1*] PhD

[1]Lee Kong Chian School of Medicine, Nanyang Technological University Singapore SG
[*]these authors contributed equally

Corresponding Author:
Sreenivasulu Reddy Mogali PhD
Lee Kong Chian School of Medicine, Nanyang Technological University
11, Mandalay Road
Singapore
SG

Abstract

Background: Outreach activities serve as vital components in the realm of education, particularly in the context of healthcare profession. The purpose of these outreaches is to motivate and inspire prospective students to embark their journey into health professions education and foster their pursuit of careers in healthcare. The empirical support for this hypothesis is relatively scarce within the existing research.

Objective: The primary objective of this study is to gather evidence on the attitudes and perceptions of pre-university students on outreach activities in health professional education via an integrated anatomy and physiology outreach. The aim is to gain the insights of the student learning experiences including their interaction with the learning tools, engagement in activities, and interaction with facilitators and how these experiences influence student motivation to pursue a career in health care.

Methods: A tailored workshop mimicking medical teaching was taught over two days at the Lee Kong Chian School of Medicine in Singapore utilizing the multimodal practical and team-based learning pedagogy. Ninety pre-university students from 21 pre-university institutions in Singapore participated; their experiences were evaluated using a four-point Likert scale and open-ended survey questions. Free text comments were analysed using inductive thematic analysis.

Results: Most students felt that the course materials were adequate (Mean ± SD = 3.56 ± 0.56) and met the learning objectives (3.72 ± 0.52) and instructors were clear (3.72 ± 0.52) and effective (3.70 ± 0.53). They liked the organization of the outreach session (3.64 ± 0.48) and held high motivation to study medicine or allied/biomedical sciences (3.69 ± 0.53). Practical and team-based learning were regarded as exceedingly satisfactory (3.63 ± 0.53 and 3.58 ± 0.53, respectively); all the respondents would recommend this course to peers. Thematic analysis revealed gaining a new perspective, unique learning settings, motivation and aspirations, sense of satisfaction and interaction with facilitators.

Conclusions: The structured outreaches provide students with unique opportunities to experience medical school preclinical learning environment, which has positive impact on building their knowledge, understanding of human structure and function, and increase students' motivation to pursue future health profession careers. Clinical Trial: NA

(JMIR Preprints 07/09/2023:52533)
DOI: https://doi.org/10.2196/preprints.52533

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Title: Heart and Guts for Medicine: Pre-university students' perceptions and attitudes about the anatomy and physiology outreach

Ranganath Vallabhajosyula[1] 0000-0002-8617-3804

Vivek Perumal[2] 0000-0002-9610-5813

Ramya Chandrasekaran[3] 0000-0002-3468-2092

Sreenivasulu Reddy Mogali[4] 0000-0002-0981-5607

[1,2]Senior Lecturer, Anatomy, Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore

[3]Assistant Manager, Course Evaluation, Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore

[4]Associate Professor, Head of Anatomy, Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore

Corresponding address:

Sreenivasulu Reddy Mogali
Associate Professor, Head of Anatomy
Lee Kong Chian School of Medicine
Nanyang Technological University Singapore
11, Mandalay Road
Singapore 308232
Email: sreenivasulu.reddy@ntu.edu.sg

Abstract

Introduction: Outreach activities are aimed to motivate and spark interest among prospective students in the study of science and health professions; however, research studies supporting this hypothesis is limited.

Objective: To gather evidence on the attitudes and perceptions of pre-university students on such activities, an integrated anatomy and physiology outreach was organized to examine students' learning experiences (of learning tools, activities, and facilitators) and motivation to pursue a career in health care.

Material and methods: A two-day course on cardiorespiratory and gastrointestinal systems was presented at the Lee Kong Chian School of Medicine in Singapore using its key pedagogies, i.e., multimodal practical and team-based learning. Ninety pre-university students from 21 pre-university institutions in Singapore participated; their experiences were evaluated using a four-point Likert scale and open-ended survey questions. Free text comments were analyzed using inductive thematic analysis.

Results: Most students felt that the course materials were adequate (97.72%; Mean ± SD = 3.56 ± 0.56) and met the learning objectives (98.86%;3.72 ± 0.52) and instructors were clear (96.59%, 3.72 ± 0.52) and effective (98.86%; 3.70 ± 0.53). They liked the organization of the outreach session (97.72%; 3.64 ± 0.48) and held high motivation to study medicine or allied/biomedical sciences (98.85%;3.69 ± 0.53). Practical and team-based learning were regarded as exceedingly satisfactory (97.5%; 3.63 ± 0.53 and 97.53%; 3.58 ± 0.53, respectively); all the respondents would recommend this course to peers. Thematic analysis revealed gaining a new perspective, unique learning settings, motivation and aspirations, sense of satisfaction and interaction with facilitators.

Conclusion: The structured outreaches provide students with unique opportunities to experience a medical school preclinical learning environment, deepen their understanding of human structure and function, increase their motivation and interest in science, and may lay foundations for potential

health profession education.

Key words: anatomy, physiology, educational outreach, pre-university outreach, team-based learning, anatomy workshop, medical education

Introduction

The majority of pre-university students position education at the forefront of their aspirations for a successful future [1]. They explore opportunities that multiply their individual interests in Science, Technology, Engineering and Mathematics (STEM) education, in the form of outreach programs from universities which provide a wide range of engaging activities to involve and inspire the next generation. Such initiatives introduce students to the higher education, bridge the gap between classroom knowledge and real-world experience, and ultimately build their confidence in pursuing STEM education [2].

Typically, outreach activities in STEM education are developed and executed by experts to provide a unique learning experience for the younger generations outside the classroom [3]. The nature of outreach programs ranges from introductory to developmental to consolidation (Medical Schools Council, Woburn House, London) based on student learning experiences [4-6]. Commonly employed activities of outreach are roadshows, guest lectures, campus tours, workshops, demonstrations, and summer schools [4-11]. These events give an opportunity for widening participation in raising goals and encouraging under-represented students (from lower socio-economic and lower income groups) to enter higher education [12,13]. The most valuable outcomes from the events are not only the opportunities for education, engagement, or the development of interest but also inspiration from the senior students and faculty of the participating institutions [14]. This is vital in supporting young people in their decision-making and suitability for a future career, for example in medicine [15].

Existing studies have shown that undergraduate Anatomy and Physiology (A&P) students who were exposed to anatomy observational outreach through multi-modal teaching techniques showed enhanced knowledge and interest in STEM and Allied Health degrees [8,9]. There is also evidence that even shorter and flexible programs increased student understanding of anatomy and extra academic discussions like body donation [16]. These studies [4-11,16] demonstrate the significance

of the outreach program in fostering students' engagement and motivate them towards a career driven program. However, in current literature, a detailed outreach program that is integrated with pedagogical practices is limited [9]. We propose that when anatomy and physiology outreach combine with student-centered pedagogy, it would deepen students' understanding of the human body and ignite students' interest and motivation to make an informed decision for a future career objective.

Theoretical framework of the study

The main objective of the outreach activity presented here is to provide a unique learning opportunity for the pre-university students. This will involve acquainting them with the pre-clinical learning environment of medical school and fostering their enthusiasm for pursuing a career in medicine, healthcare, and/or biomedical sciences. The self-determination theory [17] provides the theoretical framework for understanding the motivation in this context.

Engaging learning materials and student-peer-faculty collaboration contribute to a stimulating learning environment in which students can apply prior knowledge in real-world contexts and discover personal relevance [17,18]. Learning satisfaction is the fulfilment that learners experience when their needs and requirements are met through learning activities [19]. This satisfaction is influenced by factors such as course content, teaching modalities, learning convenience, and interactions with peers and instructors [20]. The self-directed learning approach cultivated both external and internal motivation within the individuals by influencing rewards or grades, and innate satisfaction and personal interests, respectively [17], which in turn has been shown to improve student attitude towards STEM courses and career choices [21]. By addressing these fundamental requirements and developing a structured and engaging learning activity, an outreach program can increase interest in the topic and recognizing its applicability to future professions [21].

Context of the study

While there are studies in the literature that used outreach programs in medical schools to spark interest among pre-primary to high school students [8,10], there is sparse information in the Asian context on the effectiveness of structured outreach programs that mimic actual pre-clinical integrated anatomy and physiology learning experiences for pre-university students. One identified Asian study by Simok et al. 2022 [22], described an outreach program in conjunction with world anatomy day. It was essentially an engagement session for the visitors including students, faculty and staff across various departments and universities. The event comprised of ~~activities such as puzzles~~ games, quizzes, and other fun related activities related to anatomy. Another study [23] reported the program that offered a tour of the various departments; these activities could have been informative on organizations' facilities, infrastructure, programs offered than providing structured learning opportunities for the prospective university students to explore organizations' pedagogy and educational resources.

To stand out of the typical outreach program that are basically designed as open days and awareness events, Lee Kong Chian School of Medicine (LKCMedicine) conducted a two-day outreach program (workshop) to the pre-university students in Singapore; the event was titled "Heart for Medicine and Guts for Medicine". LKCMedicine is the youngest medical school in Singapore, offering a five-year Bachelor of Medicine and Bachelor of Surgery (MBBS) degree. The school adopted a system-based integrated curriculum in the pre-clinical (first two) years, delivered via team-based learning (TBL) pedagogy with appropriate anatomy and science laboratories. The major focus of the event was to introduce the pre-university students to the actual medical school learning environment (pedagogy, educational tools, and infrastructure), guided by medical students and faculty.

We understand that a successful learning environment should have five essential features, namely the context, selection, location, objective and, teaching method that shapes the perceptions and prospectus of participants, as well as nurture their motivation and learning [24,25]. Our outreach program meets these criteria- being conducted in an educational context by carefully selecting pre-

university students, utilizing a location where medical students routinely study, employing an objective and teaching method aligned with the medical curriculum (team-based learning and hands-on practical), and the program's goal.

In addition to the main objective of the outreach activity i.e., providing a unique learning experience, this study was also aimed to obtain the perceptions of the participants over the two-day structured outreach program through a survey questionnaire. This study analyzed and reported the students' learning experiences and the utility of a two-day outreach program based on the survey data and the open-text comments of the participants.

MATERIALS AND METHODS

Workshop theme and process: Given that potential medical graduates need a whole 'heart' (dedication) for medicine and 'guts' (courage) to practice medicine, an event theme based on the anatomy of the cardiorespiratory (CR) and gastrointestinal system (GI) was chosen. The activities in the program were similar to the learning environment for anatomy practical and TBL-based anatomy and physiology instruction in LKCMedicine. The learning outcomes of the session are presented in supplementary data 1.

Participant's recruitment: The outreach invitation (a two-days anatomy and physiology workshop) was extended to all public polytechnic and junior colleges in Singapore. To ensure fair representation from each school, a limit of five students per institution was applied. The nomination of students was left to the discretion of each school. However, certain criteria such as academic achievement, scientific interest, and collaboration or leadership qualities were specified. It was strongly recommended that one of the five pupils from each institution receive financial assistance for their studies; this was consistent with the percentage of LKCMedicine medical students receiving financial support.

Outline of educational outreach session

Teaching topics: Cardiorespiratory (CR) and Gastrointestinal (GI) systems were chosen for this session to align with the theme of outreach. The main rationale to choose these topics is that both CR and GI systems are usually considered easier than some other body systems for example the nervous system [26]. Other reason for this consideration was that these systems are usually taught in high schools at least at an introductory level. Also, that the structures comprising these systems are usually large and distinguished enough for easy visualization and demonstration. On the contrary, musculoskeletal system has complex details to visualize and remember the similar looking structures like tendons, vessels, and nerves etc.). This rationale is further supported by evidence in the literature on perceived difficulty of organ systems [26]. These factors were carefully considered by the authors

while developing the themes for the outreach program.

Duration and facilitators of outreach session: The basic anatomy and physiology of the CR and GI were covered over the course of two days (6 hours per day). The teaching and learning were managed by a multi-disciplinary team of content experts (anatomy, radiology, surgery, and physiology). In addition, LKCMedicine MBBS students also assisted in facilitating the practical and TBL activities.

Learning materials: The course consisted of hands-on anatomy practicals and Team-Based Learning (TBL) sessions. The practical was done in the morning, and the TBL was delivered in the afternoon on the same day. To support practical teaching and learning, plastinated human bodies and organs, Anatomage (3D virtual dissections), plastic models, and imaging were used. In addition, a practical hand-out highlighting the learning objectives and structures that need to be identified in the specimens was provided. For the TBL sessions, PowerPoint (PPT) slides were prepared for the students and given two weeks prior to the outreach program so that they could prepare for the session. The TBL questions such as individual and team assurance tests (IRA/TRA) and application exercises (AE) were made by content experts. All these activities were in accordance with the routine teaching style followed at LKCMedicine.

Teaching and learning activities: Day 1 of the outreach program was focused on CR anatomy and physiology, and day 2 on GI. To maintain student diversity, they were sorted into five-member teams based on their school, level of study, and sex; no more than two students from the same school were placed in any team The same team was used for both days' sessions. A brief icebreaker session was conducted at the beginning so that the team members could get to know each other better.

During the practical (AM session, duration about 3 hours), students were divided into three groups and were assigned to one of the three learning stations (2 gross anatomy and one imaging station). In the practical sessions, the students are asked to identify the organs and their associated bones, blood vessels, nerve and their topographic arrangement and key anatomical relationships using the

multimodal practical resources and discuss the features within the teams as well as with the facilitators. These practical sessions align with the learning outcomes (supplementary data) such as identify the bones and muscles of the thoracic wall and summarize the structure and function of the stomach, small and large intestine including their location, vascular supply, lymphatic drainage, and nerve supply. They spent about one hour at each station before moving on to the next. Each station was managed by a member of the faculty. At the gross anatomy stations, students were encouraged to handle the models and specimens to identify key anatomical structures and appreciate their functions and relationships. At the imaging station, they learned about different imaging modalities and their applications. By watching the real-time cardiac ultrasound, they also learned about the heart's structure and how it works.

Following the practical, a TBL (PM session, duration 3 hours) was administered to assess the content and application of the acquired knowledge. Students engaged in individual and team activities (IRA, TRA, and application exercise). As part of the TBL process, they actively engaged in the group discussion to share their solutions and rationales. The in-house learning management system was used to administer the TBL activities. These TBL sessions align with the learning outcomes for example, describe the concept of referred pain and describe the position and functional anatomy of the liver and pancreas (supplementary data). At the end of the practical and TBL, a debrief was given to provide a summary and take-home message.

A similar teaching and learning plan were followed on day 2 for the GI system. However, unlike on day 1, no ultrasound teaching was conducted for the GI system, instead, plain and contrast radiographs were used.

Survey: At the end of day 2, participants responded to a 4-point Likert scale questionnaire (1-strongly disagree; 4-strongly agree) that collected data about learning resources, learning activities, motivation, and learning experiences. A four-point scale was chosen, as it would be easily comprehended by younger respondents [27]. Additionally, three open ended questions such as

aspects of the workshop that was important for student learning, aspect of the workshop that should be changed and any other additional comments were also asked to get the free-text responses from students on use of outreach session. The questionnaire was distributed via Qualtrics (Qualtrics LLC., Provo, UT, USA) at the end of the program.

Ethical considerations: Institutional Review Board (IRB-2019-09-011) approval was obtained to use the survey data to evaluate the effectiveness of the outreach program retrospectively. The study involved human subjects (participants of the outreach); however, the study is with less than minimal risk. The participant information was anonymized for the data analysis. There was no compensation given to the participants for their involvement in the study.

DATA ANALYSIS

Mixed methods were employed to analyze the Likert scale and open-ended responses. The Likert scale scores were reported using the descriptive statistics (Mean, percentages, and standard deviation). The Cronbach's alpha was used to assess the survey internal consistency. The data was computed and analyzed Statistical Package for Social Sciences (SPSS), version 26 (IBM Corp., Armonk, NY).

Thematic Analysis:

An inductive thematic analysis was conducted on the free-text comments [28]. First, textual data was stratified according to the answers to the open-ended questions. The two authors then (SRM and RV) looked through the text to acquaint themselves with the data before coding. Two researchers then independently analyzed the data to provide initial coding for participant responses. The codes were then compared, and discrepancies were addressed until a resolution was achieved. After consensus, final themes were described.

RESULTS

Participant demographics

There were 92 initial registrations from 21 different pre-university academic institutions. Two participants had withdrawn, so the final registration number was 90. All the 90 participants (16 teams of 5 each) attended the day 1 activity, but the day 2 activity had 89 participants. The participant information is summarized in Table 1.-

Qualification Group	Number of participants
Poly Yr 2	9
Poly Yr 3	1
International School Year 12	4
IB-1	7
IB-2	17
JC1	19
JC2	35
Total	**92**

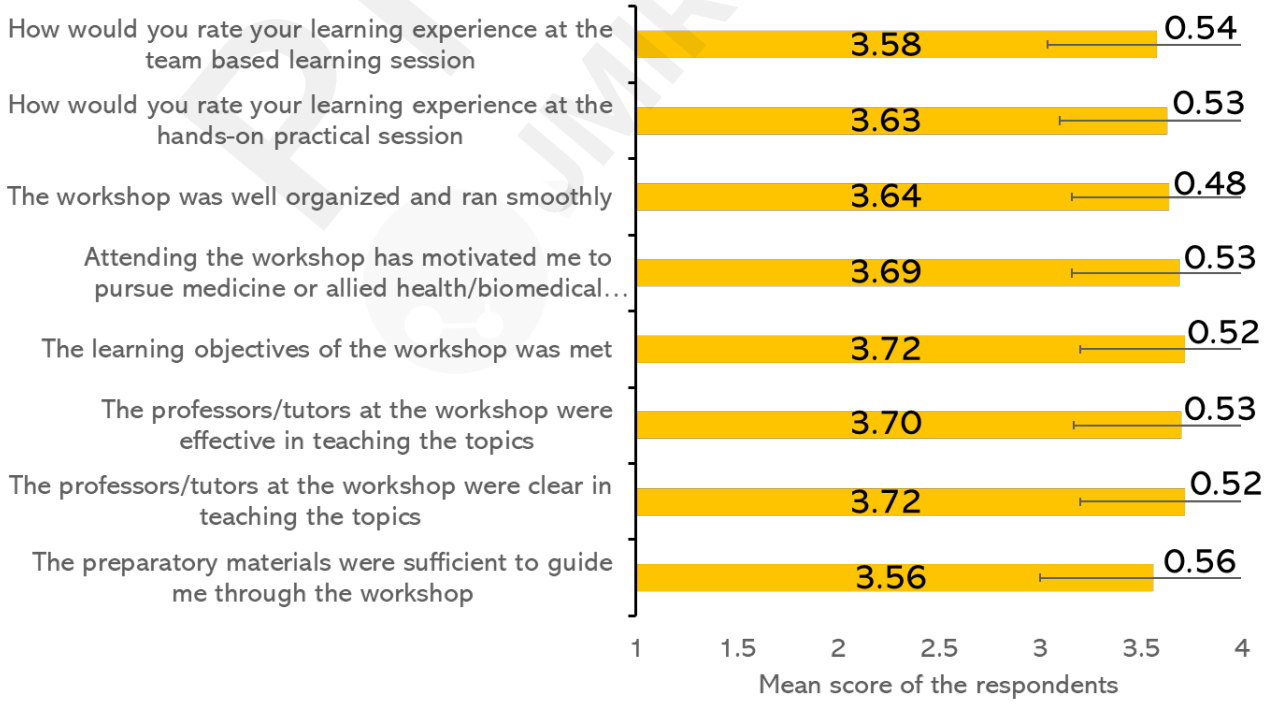
Table 1: Demographic information of the participants that were registered for the two-day outreach (workshop).

Ministry of Education (MOE) Schools are the most represented in Singapore with primary and secondary education. The medium of instruction is English. The primary education is compulsory where primary 1 to primary 4 form the foundation stage, primary 5 and primary 6 forms the orientation stage. At the end of primary school, the students sit for the Primary School Leaving Examination (PSLE) and their results will determine the stream in which they enter the secondary education. The secondary education is a 4-year course, leading to Singapore-Cambridge General Certificate of Education (GCE) “O” level exam. Following this exam, the students must go through Joint Admission Exercise (JAE), which allow the students to apply admission for courses offered by either the Junior colleges (JC), polytechnics (Poly) or Institute of Technical Education (ITE) based on their performance.

Likert-scale survey responses

There were 88 participants who took the survey and only 81 participants completed it. The mean (±SD) scores observed were summarized in Figure 1. Most students agreed that the preparatory materials were adequate to guide them through the teaching and learning sessions (97.72%; Mean ± SD, 3.56/4 ± 0.56), and that the learning objectives of the course were achieved (98.86%; 3.72 ± 0.52). Regarding faculty, Likert scale assessments revealed that teaching was both clear (96.59%; 3.72 ± 0.52) and effective (98.86%; 3.70 ± 0.53). They also provided a positive assessment of the outreach session's organization (97.72%; 3.64 ± 0.48) and motivation to study medicine or allied/biomedical disciplines (98.85%; 3.69 ± 0.53). Most students also rated their hands-on practical and team-based learning experiences positively (97.5%; 3.63 ± 0.53 and 97.53%; 3.58 ± 0.54, respectively). All participants agreed that they would suggest the course to their peers and juniors. The Cronbach's alpha value is 0.79 indicate good internal consistency of the survey items.

Figure 1: Mean ratings of the 4-point Likert scale results on the eight survey items (n=81). The error bar denotes standard deviation.



Themes derived from qualitative data.

Five themes were discovered from the qualitative comments (presented in italics) as follows.

Gaining perspective: Nearly all the respondents indicated that hands-on experience with real specimens was most important and extremely useful in visualizing the various organs and systems and how they are connected in real life in a three-dimensional fashion. They believed that this experience was enlightening and provided them with the opportunity to get a better picture of human structure and function.

"The explaining of anatomy and physiology using plasticinated cadavers or models were extremely helpful in helping me to understand and visualize the processes".

"The hands-on practical was very important for me. I could never have dreamt of feeling a heart or a lung before joining medical university".

Unique learning settings: Most students thought that TBL activities were crucial for their learning and that they could work together, share knowledge, discuss problems, consolidate, and clinically apply anatomy and physiology topics. They thought that the whole experience of working together to learn was more novel, enjoyable, insightful, and captivating than typical lectures.

"Team based learning was a great experience as I have never done anything like that before and it was really helpful and aided me in communicating well with new peers from other institutions".

"……Being able to speak with one another on the cases also enabled us to learn more efficiently as it was more engaging and is a change of pace from the usual lectures".

Aspirations and motivations: According to the students, the outreach program increased their interest and attitude towards medicine and motivated them to seek a career in the profession. In addition, they said that this session was beneficial for exposing them to the life of medical school and clarifying prospective medical students' concerns about applying to medical school and studying medicine. They valued the interaction with medical students and faculty.

"Very informative and helpful and definitely motivated me to join medicine…"

"I think the workshop exposes me to the life of medical school and the first part of MBBS syllabus which will help me to make informed decision in the future."

A sense of satisfaction: Students had the impression that the two-day outreach program had a positive impact on their overall learning experience and attitudes towards medical sciences. They remarked that the learning environment was quite different from the typical junior college class, and they would love to come back to learn different systems. They also suggested carrying on with the session and adding more days to the training program.

"It was an eye-opening experience, and I am glad that LKC medicine has opened up opportunities for us students to experience this firsthand".

"I would have liked if the workshop were longer (i.e more days for other organs and systems) because I really enjoyed the two days and would have really liked to learn more".

Interaction with facilitators: They felt that they were able to increase their understanding of anatomy and physiology because of the interaction they had with faculty and medical students, as well as the systematic approach, clarity, and precision of the explanations they received.

"The tutors were clear and concise when explaining the various concepts to us".

"…the teachers and medical students were a great help in answering our questions".

In addition to the above themes, students suggested improvements including more days of workshop, providing voice-over PowerPoint, more interaction with current students, more hands-on with plastinated cadavers, better time management of the teaching session.

Overall, the students' learning motivation and experience were positively impacted by the outreach program, as shown by both the Likert and thematic analyses.

Discussion

The findings from this study strongly supported the idea of a structured-outreach program offering opportunities for pre-university students to experience the unique pre-clinical anatomy and physiology learning in a medical school. The students' enhanced interest, motivation, and attitudes toward pursuing medical and/or allied health courses, have been supported by the study's findings.

The learning environment has a key role in fostering student motivation and learning [24,25]. Extensive comments were made on the hands-on and visual representation of the anatomical structures and their relationships in real human bodies. These results are comparable to those of prior research that used cadaveric materials in outreach programs [10]. The ability to touch, manipulate, and visualize specimens demonstrates the significance of visual-spatial learning in anatomy because cadavers are typically reserved for use by health science students, those who participated in this study had the opportunity to see and touch plastinated human bodies and organs for the first time. Various imaging modalities, virtual dissection, and plastic models were also employed to augment the plastinated materials during the faculty demonstration. This multimodal activity may have stimulated the anatomy practical session and seemed to improve their understanding of human body structure [10].

Medical students employ a variety of learning approaches, the commonest being the VARK model (Visual, Auditory, Read, and Kinesthetic) [29]. At LKCMedicine, teaching method has always been multimodal to cater the students of diverse needs. For example, the TBL material comprise of PowerPoints and video lectures (read/auditory/visual of VARK). In the practical class, the plastinated specimens used in teaching are available both in physical form and a virtual 3D application, accompanied by a demonstration by the facilitators (kinesthetic/visual/auditory of VARK). This implies that individuals with diverse learning styles are afforded the chance to engage with and incorporate various forms of available resources in order to maximize their educational experience. This approach is well supported by evidence [30-33], so the same experience was

provided to the participants of the outreach program.

The outreach activities appear to be extremely effective when they focus on topics that are rarely emphasized in detail in a conventional classroom [34] or clinical applications of biological science principles [6]. This is consistent with the current study that found students enjoyed the novel method of learning anatomy and physiology of CR and GI in an integrated and clinically oriented manner through a team-based and hands-on participation. This approach differs from their regular classroom dynamics in that it requires students to communicate with new peers and collaborate to share and develop information. The TBL also involved clinical case vignettes related to common cardiac and gut clinical conditions which required the application of anatomy and physiology concepts. This would have provided them with different ways to think about the concept integration and actively discuss the rationale behind their answers within and other teams rather than just memorizing the facts. Several studies have supported the positive benefits and perception of the TBL for student learning in higher education [35,36]. In addition, they valued the interaction with faculty and medical students to clarify their questions and improve their understanding. The participants were actively engaged, and they saw the program as essential for boosting their confidence and assisting them in achieving their long-term medical career objectives. Based on these data, it indicates that the student-centric emphasis, clinical application opportunities, and sharing with facilitators contributed to the effectiveness of outreach session.

Medicine is often regarded as a prestigious and rewarding profession, but junior college students often struggle to connect their coursework to future professions. Like prior research [1,6,7,9,11], the current study demonstrated that an anatomy and physiology workshop improved participants' desire to pursue medicine and other health-related courses. Nonetheless, this outreach session differs from previous research, which was observational or flexible in design rather than a realistic model of MBBS classrooms. As in regular class, participants were expected to study pre-reading materials, expose to multi-modal teaching methods during the anatomy practical, team activities of TBL, and

have multi-disciplinary faculty teach to promote integration of anatomy and physiology with their clinical application. This allows prospective candidates to get first-hand knowledge of medical school expectations, pedagogical appropriateness, professors and current medical students, life as a medical student, and the general learning environment. For instance, the flip-class and team-based learning methods may be preferred by some but not by others owing to differences in teaching and learning styles and preferences [37]. Thus, the outreach activities could emulate the formal undergraduate classes to make informed decisions on selection of institution and what to pursue for their career.

The current outreach program differs from previous anatomy or A&P programs in terms of its content, length, and delivery style [9,38]. The uniqueness of this outreach is replicating the exact learning environment that a first year medical student would go through in a medical school on a typical day. The transparency made in this outreach program allows the students to experience the teaching tools and methods, discuss with faculty, both academic and clinical, who they would potentially interact with if they joined the medical school as part of the TBL and practicals.

This outreach was longer than earlier anatomy or A&P initiatives, but participants in this research advised extending it further. They also recommended adding other body systems to future rounds and were excited to return to the workshop in the future and recommend it to their peers. Despite a two-day program, this implies that participants are highly engaged in the learning process and can conceptualize the basic anatomy and physiology of the CR and GI in a short amount of time. In addition, they offered comments and made various suggestions to improve and optimize the course (more engagement with medical students, voice-over power points, more hands-on practicals, time management). This may be another indication of how engaged they are and how important they see the program.

Implications:

Most educational institutions do conduct outreach programs to engage general community to provide a sense of their facilities, research, admission processes, available courses, and others. However, this is the first time we have designed and evaluated a unique program bringing in prospective students, providing them a life-like experience at the medical school and stimulating their decision making in choosing a career in science and health professions. Although this study has explored the novel outreach program in Asian context, the design of the program has got global applications. We suggest other schools to adapt some of the aspects discussed in the study and modify approach towards their outreach goals.

Limitations of the study

As the outreach was structured to closely emulate the LKCMedicine's MBBS pre-clinical integrated anatomy and physiology session, the study does come up with limitations. While the structured session provided better direction to the teaching and team discussions, we did not quantitatively measure the learning outcome using pre- and post-knowledge tests. This is mainly because the session was intended to give them experience of medical school learning environments and exposure to the anatomy and physiology teaching and learning. Other limitations included participants representing different years of A-levels (equivalent to senior secondary school) and Polytechnique course, limited number of students from each school; student ability may vary considering their academic, leadership, teamwork, and socioeconomic status.

Conclusions

The “Heart and Guts for Medicine” outreach was highly acclaimed by pre-university students that the program provided them with a near authentic experience as a medical student in the medical school. This study confirms students’ increased interest in anatomy and physiology attributed to the hands-on learning and collaborative learning, and an increase in students' motivation and attitudes towards pursuing medical and/ or allied health courses. These findings might be useful for other educational institutions to plan and organise the outreach programs as described in this report. It is suggested that the current standard approach to outreach programs be modified to transform the 'open day' concept into a comprehensive learning experience. This modification would allow pre-university students to immerse themselves in the experiences of a medical student.

Author Contributions:

All authors contributed to the study conception and design. The first round of data collection, analysis was performed by Ranganath Vallabhajosyula (RV) and Ramya Chandrasekaran). The first manuscript drafting was performed by RV with feedback and suggestions provided by Sreenivasulu Reddy Mogali (SRM) and second drafting was done and reviewed by RV and Vivek Perumal. All authors read, provided feedback, and approved the final manuscript.

Acknowledgements

The authors would like to acknowledge Ms. Ruth Choe and team (education management office) Mr Lim Meng Shun Darren and team (science and anatomy laboratory), for their support to organise the workshop.

Data availability

All data generated or analyzed during this study are included in this published article [and its supplementary information files.

Funding statement: Not applicable

Conflicts of Interest

The authors declare no conflict of interest.

References:

1. Holzer BM, Ramuz O, Minder CE, Zimmerli L. Motivation and personality factors of Generation Z high school students aspiring to study human medicine. BMC Med Educ 2022 ;22(1):31. doi: 10.1186/s12909-021-03099-4

2. Vulperhorst JP, Wessels KR, Bakker A, Akkerman SF. How do STEM-interested students pursue multiple interests in their higher educational choice? Int J Sci Educ 2018 ;40(8):828–846. doi: 10.1080/09500693.2018.1452306

3. Vennix J, den Brok P, Taconis R. Perceptions of STEM-based outreach learning activities in secondary education. Learn Environ Res 2017 ;20(1):21–46. doi: 10.1007/s10984-016-9217-6

4. Burns ER. Anatomy of a successful K-12 educational outreach program in the health sciences: Eleven years experience at one medical sciences campus. Anat Rec 2002 ;269(4):181–193. doi: 10.1002/ar.10136

5. Zhang G, Fenderson BA, Veloski JJ, Livesey M, Wojdon-Smith T. Medical School Anatomy and Pathology Workshops for High School Students Enhance Learning and Provide Inspiration for Careers in Medicine. Acad Pathol 2016; 3:2374289516685323. doi: 10.1177/2374289516685323

6. Meyer ER, Williams S, Conway M, Notebaert A. Kids in the Gross Anatomy Lab: How an Outreach Program in Anatomy Educates High School and Undergraduate Students about Health Care. HAPS Educ 2018 ;22(3):262–267. doi: 10.21692/haps.2018.031

7. Taylor AM, Diggle P, Wessels Q. What do the public know about anatomy? Anatomy education to the public and the implications. Anat Sci Educ 2018 ;11(2):117–123. doi: 10.1002/ase.1746

8. Clarke MA, Sharma NM, Schiller AM. An outreach program with hands-on, physiology-based exercises generates questions about STEM career expectations. Adv Physiol Educ

2019 ;43(2):175–179. doi: 10.1152/advan.00013.2019

9. Mathis M, Gonzalez-Sola M, Rosario M. Anatomy Observational Outreach: A Multimodal Activity to Enhance Anatomical Education in Undergraduate Students. J Stud Res 2020 ;9(1). doi: 10.47611/jsr.v9i1.869

10. Ortug G, Midi A, Elbizim DS, Karaot H, Yılık E, Uluışık IE. Introducing Children to Anatomy: "Getting to Know Our Bodies: The First Step Toward Becoming a Scientist." Anat Sci Educ 2021 ;14(2):232–240. doi: 10.1002/ase.2019

11. Adams J, Nelson H, Strong E, Wisco J, Klappa S. Mentors' Experience in Teaching Basic Science Concepts in the Community Outreach Program, Anatomy Academy: A Phenomenological Study. HAPS Educ 2020 ;24(2):27–35. doi: 10.21692/haps.2020.017

12. Figueroa O. The significance of recruiting underrepresented minorities in medicine: an examination of the need for effective approaches used in admissions by higher education institutions. Med Educ Online 2014 ;19(1):24891. doi: 10.3402/meo.v19.24891

13. Gall AJ, Vollbrecht PJ, Tobias T. Developing outreach events that impact underrepresented students: Are we doing it right? Eur J Neurosci 2020 ;52(6):3499–3506. doi: 10.1111/ejn.14719

14. Zandvliet DB. PLACES and SPACES: Case studies in the evaluation of post-secondary, place-based learning environments. Stud Educ Eval 2014 ;41:18–28. doi: 10.1016/j.stueduc.2013.09.011

15. Burgess AP, Horton MS, Moores E. Optimising the impact of a multi-intervention outreach programme on progression to higher education: recommendations for future practice and research. Heliyon 2021 ;7(7): e07518. doi: 10.1016/j.heliyon.2021.e07518

16. Ruth AA, Nesbitt A, Johnson LE. Flexible, short-duration outreach sessions in the human

anatomy laboratory provide authentic, humanistic experiences. Anat Sci Educ 2023;16(2):280–290. doi: 10.1002/ase.2209

17. Ryan RM, Deci EL. Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. Am Psychol 2000; 55(1):68-78. https://doi.org/10.1037/0003-066X.55.1.68 .

18. Priniski SJ, Hecht CA, Harackiewicz JM. Making Learning Personally Meaningful: A New Framework for Relevance Research. J Exp Educ 2018; 86(1):11–29. doi: 10.1080/00220973.2017.1380589

19. Sanchez-Franco MJ. The moderating effects of involvement on the relationships between satisfaction, trust, and commitment in e-banking. J Interact Mark 2009;23(3):247–258. https://doi.org/10.1016/j.intmar.2009.04.007

20. Wu YC, Hsieh LF, Lu JJ. What's the relationship between learning satisfaction and continuing learning intention? Procedia-Soc Behav Sci 2015; 191:2849–2854. https://doi.org/10.1016/j.sbspro.2015.04.148

21. Eagleton S. An exploration of the factors that contribute to learning satisfaction of first-year anatomy and physiology students. Adv Physiol Educ American Physiological Society Bethesda, MD; 2015;39(3):158–166. DOI: 10.1152/advan.00040.2014

22. Simok AA, Hadie SNH, Mohd Ismail ZI, Ansari MA, Kasim F, Mohd Yusof NA, Shamsuddin SA, Mohd Amin MSI, Mukhtar SF. Anatomy outreach through the world anatomy day celebration in Universiti Sains Malaysia. Educ. Med. J 2022;14(4):113-120. https://doi.org/10.21315/eimj2022.14.4.10

23. Redway TH, Hanna P, Loomis B, Quinn MM. Anatomy outreach days: one approach to large

scale anatomy outreach events. HAPS Educ 2023;27(2):18-35. https://doi.org/10.21692/haps.2023.014

24. Vennix J, den Brok P, Taconis R. Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM? Int J Sci Educ 2018 ;40(11):1263–1283. doi: 10.1080/09500693.2018.1473659

25. Cents-Boonstra M, Lichtwarck-Aschoff A, Denessen E, Aelterman N, Haerens L. Fostering student engagement with motivating teaching: an observation study of teacher and student behaviours. Res Pap Educ 2021 ;36(6):754–779. doi: 10.1080/02671522.2020.1767184

26. Lieu RM, Gutierrez A, Shaffer JF. Student Perceived Difficulties in Learning Organ Systems in an Undergraduate Human Anatomy Course. HAPS Educ ERIC; 2018;22(1):84–92. doi: 10.21692/haps.2018.011

27. Nemoto T, Beglar D. Developing Likert-Scale Questionnaires. JALT2013 Conference Proceedings 2014;1-8.

28. Gibbs GR. Thematic coding and categorizing. Anal Qual Data 2007; 703:38–56. http://dx.doi.org/10.4135/9781849208574

29. Fleming ND. 2012b. Facts, fallacies and myths: VARK and learning preferences. 1st Ed. Christchurch, New Zealand: VARK Learn Limited. 3 p.

30. Hernandez JE, Vasan N, Huff S, Melovitz-Vasan C. Learning styles/preferences among medical students: kinesthetic learners' multimodal approach to learning anatomy. Med. Sci. Edu. 2020; 30:1633-1638. https://doi.org/10.1007/s40670-020-01049-1

31. Padmalatha K, Kumar JP, Shamanewadi AN. Do learning styles influence learning outcomes in anatomy in first year medical students. J Family Med Prim Care 2022; 11: 2971-2976.

32. Martinez EG and Tuesca R. Learning styles and gross anatomy assessment outcomes at a Colombian school of Medicine. Educ Med. 2019; 20:79–83. https://doi.org/10.1016/j.edumed.2017.12.012

33. Lujan HL and DiCarlo SE. First year medical students prefer multiple learning styles. Adv Phyiol Educ 2006; 30:13-16. doi:10.1152/advan.00045.2005

34. Saravanapandian V, Sparck EM, Cheng KY, Yu F, Yaeger C, Hu T, Suthana N, Romero-Calderón R, Ghiani CA, Evans CJ. Quantitative assessments reveal improved neuroscience engagement and learning through outreach. J Neurosci Res 2019;97(9):1153–1162. DOI: 10.1002/jnr.24429

35. Sibley J, Parmelee DX. Knowledge is no longer enough: Enhancing professional education with team-based learning. New Dir Teach Learn 2008 ;116:41–53. doi: 10.1002/tl.332

36. Gast I, Schildkamp K, van der Veen JT. Team-Based Professional Development Interventions in Higher Education: A Systematic Review. Rev Educ Res 2017 ;87(4):736–767. doi: 10.3102/0034654317704306

37. Fernández-Rodríguez CA, Arenas-Fenollar MC, Lacruz-Pérez I, Tárraga-Mínguez R. Teaching Methods in Medical Education: An Analysis of the Assessments and Preferences of Students. Sustainability. 2023; 15(11):9044. https://doi.org/10.3390/su15119044

38. Bavis RW, Seveyka J, Shigeoka CA. Another strategy for teaching histology to A&P students: classification versus memorization. Am Biol Teach JSTOR; 2000;365–369. DOI:10.1662/0002-7685(2000)062

Abbreviations:

1. STEM – Science, Technology, Engineering and Management
2. LKCMedicine – Lee Kong Chian School of Medicine
3. A – level – Advanced level (certificate of education advanced level)
4. Poly Yr 2 = polytechnic year 2
5. Poly Yr 1 = polytechnic year 1
6. International school year 12 = Class XII - CBSE curriculum
7. IB = International Baccalaureate
8. JC1 = Junior College year 1
9. JC2 = Junior College year 2

TABLES AND FIGURES LEGENDS

Table 1. Demographic information of the participants that were registered for the two-day outreach (workshop)

Figure 1. Mean ratings of the Likert scale results on the eight survey items (n=81). The error bar denotes standard deviation.