

Use of Student-generated Multiple Choice Questions to Enhance Team-based Learning of Anatomy at the University of Rwanda

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Research article

Keywords: Anatomy, teaching, MCQs, TBL, University of Rwanda

Posted Date: March 12th, 2020

DOI: <https://doi.org/10.21203/rs.2.15234/v2>

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Version of Record: A version of this preprint was published at Advances in Medical Education and Practice on November 1st, 2020. See the published version at <https://doi.org/10.2147/AMEPS274298>.

Abstract

Background: Teaching of human anatomy has undergone significant changes in last 3 decades. At the University of Rwanda, anatomy is being taught using team-based learning. While student generated multiple choice questions (MCQs) stimulate deeper thinking of a given topic, their impact on anatomy learning is not known. This study aimed to improve anatomy teaching and student satisfaction by combining both models.

Methods: It was a comparative interventional study where two similar chapters of anatomy were selected and one taught using team based learning (TBL) while the other one, in addition to TBL, student were encouraged to set MCQs while studying. Pre- and post-test scores were analysed using SPSS 23 and student t-test was used to compare the mean score obtained.

Results: 31 medical students were recruited. Pre-test mean scores in both chapters were 25.10 and 25.19 over 50 for chapter 1 and chapter 2 respectively. Although the students' post-test scores improved after teaching for each chapter, it was much more for chapter 2 than chapter one with mean score of 39.97 and 32.45 over 50 respectively ($P < 0.05$). Despite such improvement, setting MCQs was not easy in almost a half of students.

Conclusion: This study has found that student generated MCQs can be used as a simple and cost effective tool to enhance TBL learning of anatomy.

Background

Human anatomy is the science of human structures and their relations. It is subdivided into gross anatomy which deals with structures and position of organs, histology which occupies with microscopic appearance of cells and tissues and embryology which studies the fetal development [1]. Human anatomy is one of the cornerstones of medical curricula and fundamental for safe clinical practice especially in surgery [2, 3, and 4].

With time constraints and increasing number of medical students per class in addition to limited number of cadavers for dissection, anatomy teaching has undergone significant changes in last 3 decades [1, 5, and 6]. Traditional teaching methodologies of anatomy were basically cadaver dissections, inspection of prosections or plastination and didactic teachings [1]. With increasing use of technology in academia, these have shifted to the use of models in teaching, computer based learning and teaching based on radiological images [1, 2].

While instructors of human anatomy have been overloaded by large anatomy study materials with time constraints; other teaching methodologies such as team- based learning (TBL) were tried where students are encouraged to be active and take self-responsibilities of learning [7]. These teaching styles give opportunity to student to interact with others and to apply conceptual knowledge through working in small groups [7, 8]. TBL also overcome the shortage of anatomy lecturers in some universities [9].

All above teaching changes intended to increase knowledge of anatomy. However no single method found to be better and multimodal approach is favored [2, 5].

Several other methodologies have been tried in medicine to cope with curricula and student satisfaction, one of them is student generated MCQs. It is thought that if student is encouraged to make his own MCQs while studying, it stimulates deeper understanding of the topic; and it was found that the knowledge required to set a good MCQ is usually greater than that required to answer one [10].

At the University of Rwanda, didactic methods were initially used to teach anatomy, but with increasing number of medical students, this has shifted to power point presentations and then since 2013, TBL has been introduced at the University as the teaching methodology for only anatomy. There are no prior studies done at the University to address the impact of such changes though they are satisfactory for both lecturers and students. As the room for improvement is still wide for other interventions aimed to improve anatomy science delivery at the University, student-generated MCQs could be one of the simplest interventions if applied correctly.

Methods

This study aimed to improve anatomy learning and knowledge retention at the University of Rwanda by determining the impact of student generated MCQs on team based anatomy learning.

A comparative interventional study was conducted by comparing TBL and TBL enhanced by student generated MCQs (TBL+) as teaching methodologies for anatomy course at the University of Rwanda.

The study recruited 31 final year medical students who were rotating in surgical department at the University teaching hospital of Kigali (CHUK) from January 2019 till February 2019. During their clinical rotation, 2 chapters of surgically oriented anatomy were chosen among other teachings and were included in this study. These chapters were selected based on that they have similar length and level of complexity in the standard anatomy textbooks. Both chapters were taught by the same lecturer but not at the same time and the scores obtained after teaching assessment were not part of students continuous assessment; chapter one started and after its completion, chapter two followed.

During the first chapter (innervation of the upper limb); students used the current teaching methodology of the anatomy learning at the University of Rwanda which is " team-based learning"

Description of chapter 1 teaching:

- The chapter teaching lasted one week
- On the first day, the lecturer gave introduction of the chapter and study materials to the students (textbooks, CDs)
- A pre-test was given to the student to measure their baseline knowledge to the chapter.
- The group was formed by 5-6 students chosen randomly
- Students were instructed to take a minimum of 2 hrs/day to discuss the topic in respective groups
- After 5 days, lecturer gave individual and team readiness assurance tests using MCQs and guided students for clinical problem solving.

- The post test assessment test was done on day 7 using the same MCQs as in pre-test.

The second chapter (innervations of the lower limb) was taught using the new teaching methodology (TBL+) where students were instructed to set their own MCQs while studying.

Chapter 2 teaching description:

- The chapter also lasted one week. Similarly to the first chapter, the same environment was provided for learning
- Lecturer started by giving the introduction of the chapter and study materials to the students (textbooks, CDs).
- Students also were taught about how to set high quality MCQs and introduced on the bloom's taxonomy of categorizing questions into different levels of complexity and specificity.
- A pre-test also was done to measure the baseline knowledge of students to the chapter with use of MCQs
- Students remained in their respective groups of 5-6 students
- A minimum of 2 hrs/day was the requirement for each group to discuss the topic
- During this chapter they were encouraged to set at least 5 MCQs/group and to discuss them while studying
- After 4days, the lecturer collected student generated MCQs to appreciate their quality and to find out if they meet the study objectives. All well set MCQs were given back to students on Day 5 to discuss them deeply before the post-test assessment which was done on day 7 using the same MCQs as in pre-test. At the same day (5th day) students were also assessed for individual and team readiness using pre set MCQs by lecturer and guided them for clinical problem solving.

Post study survey:

To understand student's perceptions on the new teaching methodology, an anonymous survey questionnaire was developed and given to the students after the study. This questionnaire based on 5 points Likert scale was initially tested in 4 pilot students (about 12% of respondents) to address if there is any confusion from the items and whether the respondents understand the questions in the same way as the questionnaire developer.

Data collection and analysis

The study included the following variables: student demographics, pre and post test scores for the innervations of the upper limb and pre and post test scores for the innervations of the lower limb. SPSS software version 23 was used for data analysis. Mean and standard deviation were basic statistical tests calculated for individual student score and were also used to report demographic data. Student paired t-test was employed to determine and to compare mean scores obtained after the 2 chapters assessments. Post-study evaluation consisted of SurveyMonkey online questionnaire of prepared and tested questions based on a Likert scale ranging from 1-5 points.

This study was approved by the Institutional review board (IRB) of the College of medicine and health sciences of the University of Rwanda with record number: 334/CMHS IRB/2018.

Results

The study recruited 31 medical students. Their age ranged from 23-30 years with mean age of 25 years (SD: 1.599). Male were 22 (71%) while female were 9(29%). Though they were all final year medical students, some were on level 5 (15 students) while 16 were on level 6 of training.

The pretest minimum score for the upper limb was 17/50 and the maximum was 30/50 with mean score of 25.10 ±3.18 STD dev. On the other hand the minimal pretest score for the lower limb was 16/50 and maximum of 32/50 with mean score of 25.19±3.73 Std dev and there was no statistical difference between the mean score obtained (P:0.885). Figure 1 indicates how individual scores for both the upper and lower limb chapters fluctuate around the 50th percentile which shows that students baseline knowlage on both chapters was almost similar before learning.

Independent sample t-test was used to determine difference in mean score between level 5 and level 6 students' pre-test-scores for both chapters. Though the students were at different level of training, there baseline scores were not statistically different (table1).

Table 1. Pre-test Scores variation depending on the level of training of students.

Pre-test scores	Level of training	Number (%)	Mean score/50	Std. Deviation	P value	Mean difference	95% CI of the difference	
							lower	Upper
Chapter 1	Level 5	15(48.38)	24.40	2.613	0.245	-1.350	-3.677	0.977
	Level 6	16(51.62)	25.75	3.606				
Chapter 2	Level 5	15(48.38)	25.13	3.441	0.933	-0.117	-2.910	2.676
	Level 6	16(51.62)	25.25	4.107				

Post-test scores for both chapters were compared with pre-test scores using student t-test. Overall there was an increase in student scores after the tests for both chapters (table 2). However, Students scored better in post-test of chapter two than chapter one with mean difference of 7.515 (P<0.05) (figure 2).

Table 2: Paired t-test for chapter one and chapter two comparing the mean pre-test and post-test scores

				Paired Differences				t	P value	
				Mean diff.	Std. Deviation	Std. Error Mean	95% CI of the difference			
pter scores	Mean	N	Std. Deviation				Lower	Upper		
est (Chapter	25.10	31	3.187	-7.355	4.378	0.786	-8.961	-5.749	-9.353	0.000
-test (Chapter	32.45	31	4.675							
est (Chapter	25.19	31	3.736	-14.77	5.714	1.026	-16.87	-12.67	-14.39	0.000
-test (Chapter	39.97	31	5.050							

Quality of MCQs generated by students during chapter 2:

During the second chapter students have set 35 MCQs. They were corrected and analysed by lecturer to appreciate their quality by assessing mainly:

- Whether the set MCQs cover the study objectives
- If they were written in clear and understandable language
- The way proposed answer and distractors were constructed

Of 35 MCQs, 6 (18%) were found to be poor quality questions based on above criteria and the remaining 29 were further assessed for their complexity based on different domains of Bloom's taxonomy. Among good MCQs, 62.5% were demonstrating adequate medical knowledge by recalling the anatomical concepts while only the remaining 37.5% of questions were demonstrating higher level of thinking (table 3).

Table 3: Categorization of student generated MCQs in different domains of Bloom's taxonomy

Bloom's categorization of MCQs generated by students	% of questions
Knowledge (questions that are only based on recognition or recall of memorized information)	62.5
Comprehension/ Application/ Analysis/Synthesis/Evaluation (questions that demonstrate a higher level thinking and which make important goals of education)	37.5

Post study survey results

All 31 students did the post study survey which was prepared based on 5 points likert scale. The developed questionnaire was having 8 questions which were tested in pilot study with 4 students randomly selected from the study participants. These pilot students could clearly catch the meaning of 5 among 8 questions of the survey. The other 2 questions were either difficult or meaningless for them to answer and therefore were removed from survey questions. The remaining question of the survey was asking their levels of difficulty to set a MCQ; of 31 students, it was not easy to set a MCQ in 14(45%) students while it was neither easy nor difficult in 5(16%) students. However, it was very easy to set a MCQ in only 12(39%) of students.

The rest of survey questions and results are presented in the figure 3 where almost 70% of students have found self generated MCQs very helpful in their learning during the second chapter.

Discussion

This interventional study was the first one conducted at the University of Rwanda testing the impact of student generated MCQs on the current anatomy teaching methodology (team based learning).

This study recruited medical students in their final year of training. They had prior exposure to the anatomy course in their first year of medical school. The best students who were potential candidate for the study should have been the first year medical students without prior knowledge of the anatomy. However, we have selected 2 anatomy topics which are more surgically oriented than gross anatomy and to which they did not deeply learnt during the first year of medical school. Unlike other studies done on the impact of MCQs on learning, this is the only study which evaluated the impact of student generated MCQs on TBL of anatomy course.

The other studies done on the impact of MCQs on student learning have not mentioned the prior knowledge of students on exposed study materials [11, 12]. In the same instance , the fact that the medical students recruited were not on the same level of training (level 6 and level 5) did not resulted into selection bias as all were having almost similar baseline anatomy knowledge with mean score difference of 1.35 (P: 0.245) and 0.117 (P:0.933) for the first and the second chapter respectively.

Students' scores on 2 different topics are usually expected to increase based on various factors such as complexity difference between the topics, length, environment and available time for studying. These confounders were controlled by selecting 2 almost similar topics in the standard anatomical textbooks and pre-tests for both chapters were undertaken before the start of teaching which showed almost the same level of baseline knowledge [figure1] with student pretest mean score of 25.10/50 and 25.19/50 for chapter one and chapter two respectively. However, the fact that the learning should have improved over time after

the first chapter was difficult to control and the decision to start the experiment with the chapter of the upper limb innervation than starting on the lower limb was not based on any other criteria, but also found to be a confounder.

In addition to TBL, students were requested to set MCQs while studying chapter 2. Their mean scores improved from 25.19 to 39.93 for pre-test and post-test respectively ($P < 0.05$). Comparing with chapter one, there was a great improvement in student mean score at the end of the chapter assessments from 32.45 to 39.93 for control and intervention arms respectively. The analysis with independent t-test showed that the difference in scores was statistically significant ($P < 0.05$). These results are comparable to what was found by Abdolhussein et al in their study which was testing the effect of MCQs generation on midwifery students' learning of immunological course where there was a significant increase in post-test score in group which used the MCQs as learning tool than the control group [12]. Unlike this study where the students did not have prior knowledge in immunology course, our students had prior knowledge on anatomy in their first year of medical school which can make interpretation difficult.

Improvement in student scores after chapter two should be reviewed into different angles. The fact that chapter 2 was taught after completion of chapter one should have led to improved learning skills of students overtime and therefore improved post test scores. Crossover design should have been suitable for this study or if possible to randomize students in 2 categories where one group can use either method. The improved student score should have also resulted in chapters which are different; though the students demonstrated same baseline medical knowledge based on pre-test score, both chapters were not identical and probably students were having less difficulties to study chapter 2 than chapter one.

During the second chapter, students were asked to set MCQs while studying. The quality of MCQs set were analysed using Bloom's taxonomy and classified according to its cognitive domain for questions which test knowledge, comprehension, application, analysis, synthesis and evaluation [13].

For good questions set, 62.5% were testing the knowledge as students were only recalling the memorized anatomical concepts. However, only 37.5% were categorized into the higher cognitive domain. The findings are almost similar to what was found by Palmer et al who evaluated the impact and quality of student constructed MCQs on learning clinical surgery at the University of Adelaide where students were able to produce only 25% of MCQs which test the higher cognitive skills while many questions were testing the knowledge and comprehension [10]. Though students were unfamiliar with the task of setting MCQ, they did not have sufficient time to develop skills necessary for setting MCQs.

Several other studies have highlighted the benefits of MCQs in learning in general which include active learning and development of higher thinking skills in problem solving [10, 11]. Like our study, the adjunctive effect of student generated MCQs on current TBL of anatomy course have been positive based on student performance scores and appreciation after the study, but as this was the first study done on anatomy teaching, randomized studies are needed.

Setting a MCQ is an exercise that requires adequate knowledge of the subject and higher thinking skills. However, all studies which proved the benefits of student constructed MCQs as a stimulus of learning did

not evaluate the time required to accomplish this task. As the anatomy constitute a large module in the preclinical years of medical school, students may get overloaded by the fact that generating a MCQ is an extra work to the preexisting huge anatomy study materials, therefore this need to be addressed with further studies.

Unlike our findings, the study by Grainger et al recognized all benefits of students generated MCQs on improvement of learning, but students perceived negatively the task of setting questions mainly because of inadequate question writing skills and extra work requiring high cognitive load for them to generate high quality MCQ [14].

This study has the following limitations:

First of all, the chapters used in teachings are very small in the standard anatomical textbooks and usually the way TBL is being done at the University of Rwanda, students get assessment after studying a big component of the course such as anatomy of the head, neck, trunk or upper limb. Therefore, students can easily memorize the chapters used in this study which can potentially impact post-test scores. Secondly, the fact that the scores obtained were not having an impact on student continuous assessment could have led to some student not to make effort while studying and finally, the student perceptions on the new learning methodology were based on 5 points Likert scale which does not allow students to express all their thinking.

Conclusions

The results of this study prove much improvement on student performance with using student generated questions as a stimulus of learning and therefore a simple and cost effective tool to enhance TBL learning of anatomy at the University of Rwanda. However, students need to get familiarized on the principles of how to set good and formative MCQs.

List Of Abbreviations

CD: compact disc

CHUK: centre hospitalier universitaire de Kigali

CMHS/IRB: college of medicine and health sciences/ institutional review board

MCQS: multiple choice questions

SD: standard deviation

SPSS: statistical package for the social sciences

TBL: team based learning

TBL+: team based learning plus student generated multiple choice questions

Declarations

Ethical approval and consent to participate

This study was approved by the Institutional review board of the College of medicine and health sciences of the University of Rwanda with record number: 334/CMHS IRB/2018. A written consent for participation was given by each participant prior to the study.

Consent for publication

N/A

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request

Competing interests

The following authors have no financial disclosures (I.S, J.C.B, J.G and F.N)

Funding

This study did not receive any fund

Author's contribution

I.S: principal investigator. He conducted protocol drafting, data collection, data analysis and manuscript drafting

ID.K, I.N: participated in study protocol implementation

J.C.B and J.G: provided guidance as well as all necessary documents required for study protocol drafting

F.N: senior author and faculty supervisor.

All authors have read and approved the manuscript.

Acknowledgements

N/A

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Figures

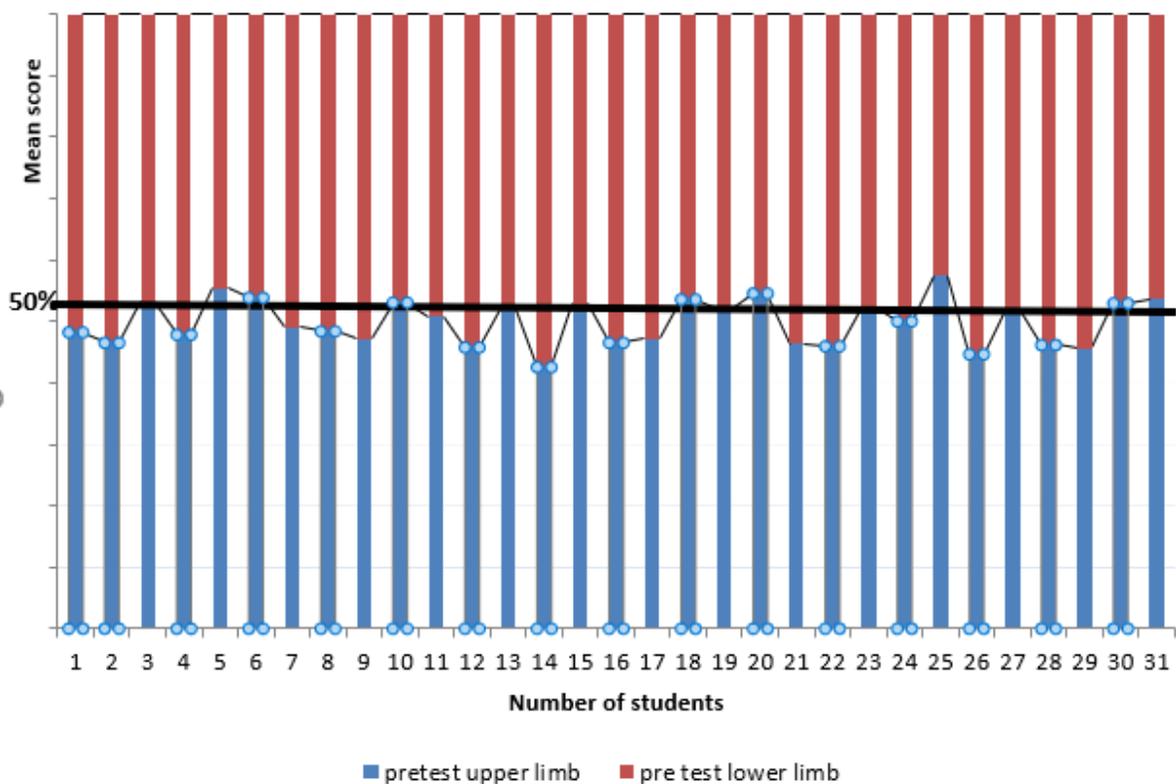


Figure 1

Student pre-test scores for upper and lower limb nerve supply

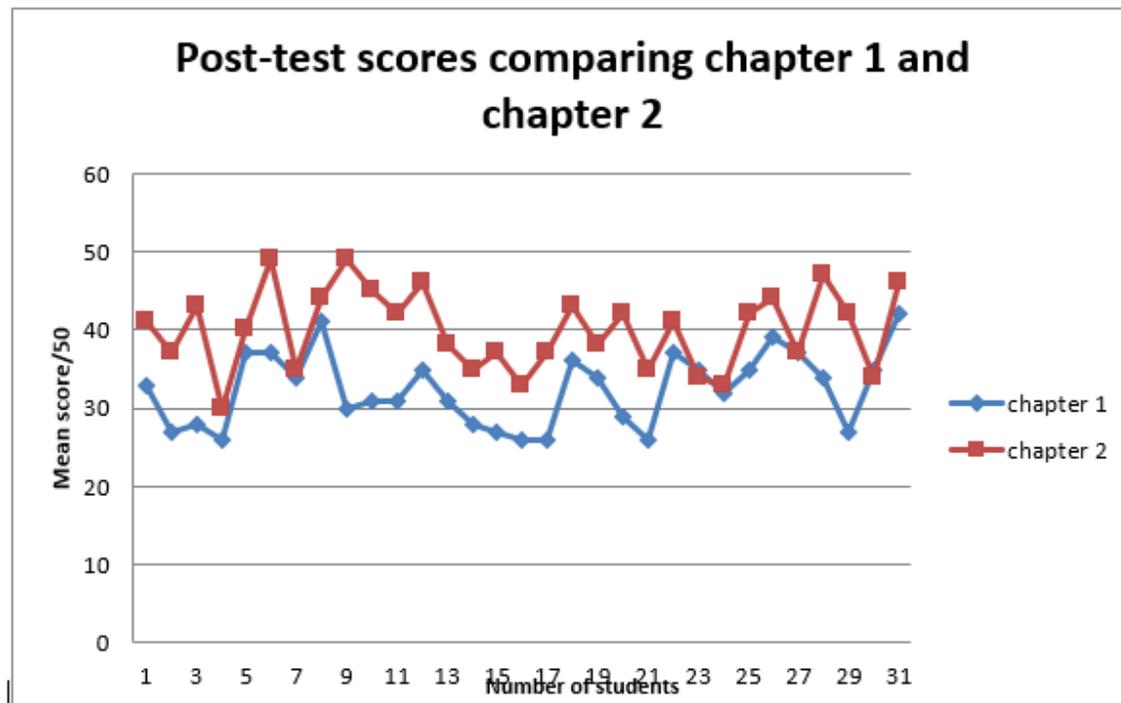


Figure 2

post-test scores for chapter 1 and chapter 2

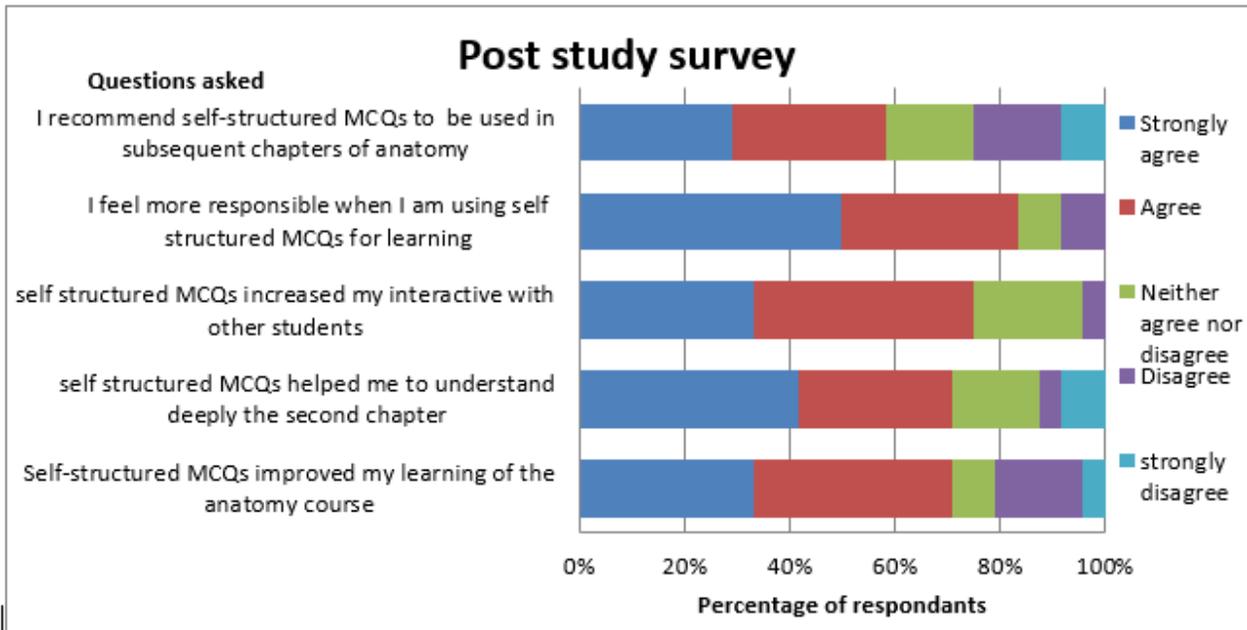


Figure 3

student perceptions on new teaching methodology