

## Effectiveness of concept mapping as a learning tool in physiology: a quasi-experimental study among second-year medical students

Rekha Prabhu<sup>1</sup>, Girish Prabhu<sup>2</sup>

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Corresponding Author: Rekha Prabhu

Email: rekha.prabhu@manipal.edu.my

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<sup>1</sup> Department of Physiology, Manipal University College Malaysia (MUCM),

<sup>2</sup> Department of Biochemistry, Manipal University College Malaysia (MUCM)

### ABSTRACT

**Background:** Concept maps can display network of relationships between concepts and by integrating aspects of pathophysiology, concept maps encourage a multidisciplinary approach to learning. **Objectives:** The objectives of the study were to compare the effectiveness of construction of concept maps on long essay question scores among medical students and to investigate students' perceptions on concept mapping as a learning tool. **Methodology:** The quasi-experimental study was conducted among second-year medical students (n=27), undergoing urinary system module at a medical college in Malaysia. Students were randomly divided into groups and were asked to create a concept map on "factors affecting glomerular filtration rate" topic. At the end of the module in the summative assessment, one long essay question (LEQ) on the topic covered through face-to-face lecture and other LEQ on the topic covered through face-to-face lecture with concept mapping were assessed. Students' perceptions on the effectiveness of concept map as a learning tool was collected. Statistical analysis used were mean, paired sample t-test and student t-test. **Results:** LEQ1 showed significantly higher scores ( $p < 0.001$ ) than LEQ2. Many of the students agreed that concept mapping improves critical thinking skills, helps to visualize concepts, helps to understand concepts and construction of concept map was an appropriate learning strategy. **Conclusion:** The concept-mapping construction on a topic resulted in a higher LEQ score compared to the LEQ score on topics without concept mapping. The construction of concept map was perceived favourably by the students.

#### Keywords:

Face to face lectures, concept mapping, glomerular filtration rate, medical students.

### INTRODUCTION

Glomerular filtration is the first step in the urine formation and glomerular filtration rate (GFR) is the best indicator of kidney disease. An understanding of renal anatomy, physiology and pathology is necessary for the effective management of glomerular disease which is a prevalent cause of chronic kidney disease (Miao J et al. 2023). Factors affecting GFR is generally perceived by the undergraduate medical students as a topic or a concept difficult to visualize, understand and retain.

In a didactic teaching session, the teacher often uses images, animations, and computer simulations to teach various factors that affect glomerular filtration. This usually leads to rote learning and not into meaningful learning by the learners. To facilitate meaningful learning among learners creating a concept map would help in clearer understanding of concepts.

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Concept mapping, initially proposed by Novak, is an innovative approach that helps the learner to organize knowledge (Novak DJ et al. 2008). They have been used in many disciplines and at all levels of education to provide a very useful and extremely appealing way of illustrating concepts (Novak JD et al. 1998). Concept maps include concepts, which are usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts (Novak DJ et al. 2008).

Concept maps have been found to be a useful education tool in the health sciences. A concept map is a diagram that depicts a set of concept meanings within a framework of propositions (Joseph Novak D et al. 2008). Concept maps have been employed as a learning tool in a variety of educational settings, and they allow students to explore their knowledge structures while also encouraging critical thinking and comprehension. By linking and chunking new concepts with what they already know, the student thinks and learns with concepts. Learning with concept maps entails making a conscious effort to link, differentiate, and relate concepts to one another in a hierarchical manner (Mrudula Chandrupatla et al. 2020). To construct a concept map, people recall concepts related to a primary concept, consider the attributes and relationships of these terms and arrange them (Jonassen, D. H. et al 1997, Wandersee, J. H. et al. 1990). Using concept mapping as formative assessment provides learners an environment where they can build their knowledge, visualize it, make decisions, and receive feedback.

Previous studies have shown that the scientific reasoning ability and learning style differs between male and female students. While female students learn through collaboration in small groups, male students prefer learning activities associated with competitions in hierarchical organizations. Studies have suggested that males feel more comfortable in T-L session with didactic lecture (Spelke, E. S. 2006).

The objectives of the study were

1. To compare the effectiveness of construction of concept map on long essay question scores among medical students
2. To understand second-year medical students' perception about concept mapping as a teaching-learning tool

## **METHODOLOGY**

### **STUDY PARTICIPANTS**

Twenty-seven second year medical students (14 male (M), 13 female (F)) participated in this study. One male student withdrew from the study and one female student who did not attend the end of module assessment was excluded from the study.

### **ETHICAL APPROVAL**

This study was approved by the TUHC institutional research ethics committee with approval number HEC 2021/045. Students who participated provided informed consent to ensure their voluntary participation.

### **STUDY DESIGN**

This quasi-experimental study was conducted among second year medical students at a private medical school in Malaysia. Year 2 of the Bachelor of Medicine and Bachelor of Surgery (MBBS) program follows an integrated modular curriculum and four-week urinary system module is taught in the last semester of MBBS year 2. Topic 1 and topic 2 in the module were taught by using the traditional methods in the form of didactic lectures using PowerPoint (ppt) presentations. Topic 1 was on 'glomerular filtration' and topic 2 was on 'tubular reabsorption'. Topic 1 was complemented with concept mapping by students.

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## STUDY INTERVENTION

After the didactic lecture on glomerular filtration, an introductory session on the purpose of concept mapping and its relevance was explained.

Students were randomly divided into four groups, and each group were given an assignment to create a concept map on the topic “factors affecting GFR”. They were asked to complete the concept map by hand on a chart paper. Each group was given 10 days of time to construct the map and after completion of the map one student from each group was asked to present the concept maps to clarify misconceptions if any. The physiology faculty provided general comments about their map.

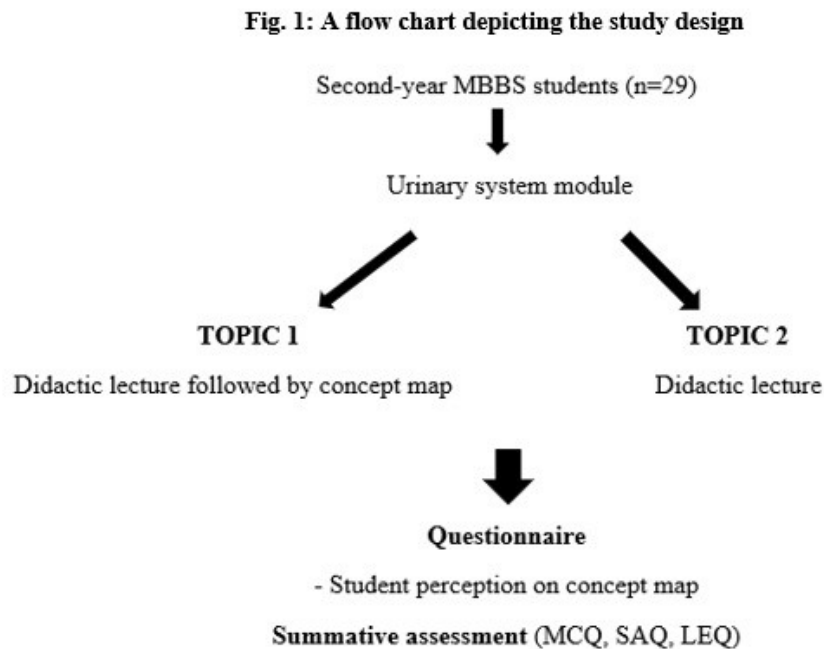
All students attended didactic lectures on both the topics covered in the module and completed the concept map on the topic after the lecture as a group activity.

## EVALUATION

At the end of the module, a summative assessment was conducted which included 30 multiple choice questions (MCQ) 8 short answer questions (SAQ) and 2 long essay questions (LEQ). The study compared student performance on LEQs in Physiology: LEQ 1: On topic 1 and LEQ 2: On topic 2.

## STUDENT’S PERCEPTIONS OF THE CONCEPT MAP AS A LEARNING TOOL

The perception of medical students towards the concept map as a learning tool was determined by asking students to respond to a pre-validated questionnaire. Items were answered by participants using a 5-point Likert scale (where 5=strongly agree, 4=agree, 3=uncertain, 2=disagree, and 1=strongly disagree). The reliability of this was tested by doing an appropriate statistical test.



## DATA ANALYSIS

LEQ scores of students are also represented as means  $\pm$  SE. The LEQ1 and LEQ 2 scores were compared using paired t test. Student t-test was used for determining the gender-wise distribution of SEQ scores. P-value of  $< 0.05$  was taken as significant. The response of the students for the questionnaire was converted into a percentage of agreement.

## RESULTS

### MEAN SCORES OF LONG ESSAY QUESTION (LEQ)

The mean scores of LEQ 1 were  $7.11 \pm 2.08$  and of LEQ 2 were  $5.68 \pm 2.71$ . The statistical significance of the scores obtained are as shown in table 1. The result was analysed using paired t-test.

**Table I:** Comparison of mean long essay question (LEQ) scores

	Mean	Standard deviation	P-value
LEQ 1	7.11	5.68	< 0.0001
LEQ 2	2.08	2.71	

### GENDER-WISE DISTRIBUTION OF LONG ESSAY QUESTION (LEQ) SCORES

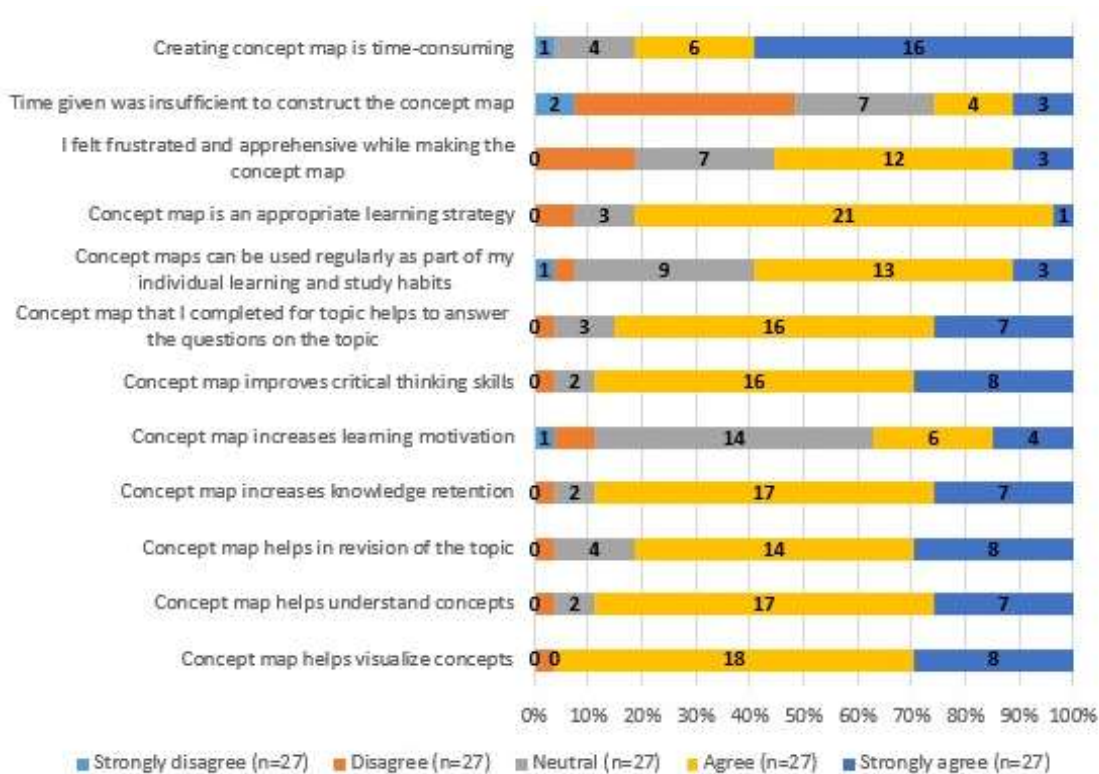
There was no statistically significant difference in the LEQ scores between male and female medical students but the mean LEQ1 and LEQ 2 scores was higher among female compared to male medical students as shown in table 2. The result was analysed using student t-test.

**Table II:** Gender-wise distribution of long essay question (LEQ) scores

Gender	LEQ 1			LEQ 2		
	Mean	SD	P-value	Mean	SD	P-value
Female (n=13)	7.35	2.45	0.64778386	6.65	2.54	0.10
Male (n=14)	6.96	1.81		4.96	2.68	

### STUDENTS' PERCEPTION ABOUT CONCEPT MAP AS A LEARNING TOOL

Figure 1 evaluates the medical student's perception about concept map. This showed that 18 students (n=27) agreed that concept map helps to visualize concepts, and 17 students agreed that concept map helps to understand concepts. 17 students found concept map increases knowledge retention and 16 students felt concept map improves critical thinking skills. Even though majority of students (n=16) found construction of concept map was an appropriate learning strategy but most agreed that creating it was time-consuming.



**Figure 2:** Students perceptions about concept maps as a learning tools

## DISCUSSION

The main research question in this manuscript was to explore the effectiveness of concept mapping on assessment scores. In this study, learning the various factors affecting GFR with concept maps provides students to understand the mechanism.

Through this study, it was seen that the mean score was significantly higher for LEQ 1 as shown in table 1 and the question was based on the topic covered through face-to-face lecture and concept mapping. This finding supports the role of concept mapping as an active learning strategy. This was consistent with earlier studies done among medical students wherein the students receiving concept mapping training performed significantly better than the traditional students in the problem-based exam but not in the multiple-choice exams (Gonzalez HL et al. 2008). In a study conducted in a medical school in India concept mapping with concurrent use of clinical scenarios improved the learning environment of the students and resulted in better test scores in biochemistry among first-year undergraduate students (Krishna M et al. 2013). In studies conducted among eighty medical interns (Sargolzaie et al. 2019) and among 150 MBBS students (Bala et al. 2016) there was a significant increase in student's post-test score after concept map.

The mean scores of LEQ1 and LEQ2 were higher among females when compared to males but it was not statistically significant. Some of the earlier studies had reported better performance by female students for clinical subjects (Haist SA et al. 2003, McDonough CM et al. 2000). Learning methodologies that emphasise group activities and hands-on learning are preferred by females (Mann, J. 1994). The mean LEQ scores higher among female students may have been ascribed to this relational learning preference. In a recent study, gender difference was observed for a pre-clinical subject like physiology with better performance by female students as compared to male students. The study reported significantly high scores in structured long and short answer question (LSQ) as well as in total

theory by the female students of both middle and low achiever groups as compared to male students, but the performance of high achievers did not show any such gender difference (Meenakshi Sinha et al. 2017). In a study conducted by Das et al. after a team-based training session on “Organ function tests: underlying biochemistry and their clinical applications”, the first professional MBBS female students showed a better performance academic performance than male students (Das et al. 2019).

In addition to analysing the data from the students' test scores, the perception of the students towards concept mapping as a learning tool from the questionnaire was analysed as shown in Figure 1. Most of the students agreed that concept maps help to visualize and understand concepts. In a study conducted among medical students undergoing their first module at their medical school, students commented that using the concept maps has refined their understanding of topics and had significantly helped them achieve higher scores on traditional MCQ examinations (CAPT Barbara E.C et al. 2015). The results of this study are in tandem with another study that showed similar percentage of Phase I MBBS students accepting deeper understanding of the topic with concept maps (Agarwal P et al. 2023). Seventeen students perceived that concept maps can increase their knowledge retention on the topic.

In a study conducted by Jain et al. 87.49% of the MBBS second professional students perceived that the concept map learning tool on the topic “management of arrhythmias” enhanced their understanding by helping them retain the knowledge for longer periods of time (Jain A et al. 2020). This is attributed to the fact that concept maps use graphical organization and representation of information in an integrated and concise manner (Jean Pak et al. 2018). Majority of the students however felt frustrated and apprehensive while constructing the concept map. Construction of a concept map was a new addition in the student learning during the four-week module. This might have led to frustration and apprehension among the medical students. In a study conducted by Agarwal P et al. a few students of Phase I of MBBS struggled with the technique of concept map as they needed more practice in construction of concept maps (Agarwal P et al. 2023).

Majority of the students agreed that the time given to construct the concept map was sufficient. This was because students had to work in groups and ten days of time was sufficient to construct a concept map on the topic given. In an earlier study, students were given 75 minutes, and they used the entire time, to work on the group concept maps (CAPT Barbara E.C et al. 2015). Majority of the students agreed that concept mapping improves critical thinking skills. This was consistent with a study done earlier in which approximately 40% of students felt that the concept map enhanced their critical thinking skills (Jean Pak et al. 2018). In our study, majority of the students agreed that concept maps motivated them to learn. This was like a study conducted by Sannathimmappa MB et al. third-year undergraduate (MD3) medical students agreed that concept maps motivated them to learn different topics of Immunology (Sannathimmappa MB et al. 2022).

## LIMITATIONS

The study was limited to a single topic (glomerular filtration) that may not completely capture the long-term effects of concept maps on overall academic performance among medical students. The complexity of the topics involved in the study were not controlled. The sample size was small which may limit the statistical findings. The study is limited to the response to the one-time intervention of concept mapping. The study was conducted in a single medical school and is not representative of other medical schools.

## CONCLUSION

Students performed better in the long essay question on concept-mapped topic than on long essay question about non-concept-mapped topic. Students found that concept maps helped them visualise and understand the concepts, increased their knowledge retention on the topic. The results of this study

conclude that concept mapping can be used in teaching “factors affecting glomerular filtration rate” and other topics in physiology.

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