

Concept Map in Medical Education

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Abstract

Objective: To assess and compare the proficiency of concept mapping skills among resident doctors of varying experience levels (1st, 2nd, 3rd, and 4th-year residents) before any instruction. This shift aims to produce more effective doctors who can comprehensively grasp diseases. Pakistani medical colleges have adopted these teaching reforms to enhance students' cognitive skills, encouraging them to apply knowledge to clinical scenarios for better decision-making.

Method: The study was conducted among 21 resident doctors in a pediatric unit of a public hospital, spanning from January 1st to August 31st, 2022. All participants, comprising 1st-year residents (5), 2nd-year residents (7), 3rd-year residents (5), and 4th-year residents (4), provided informed consent. Initially, participants underwent a concept mapping training session and created a concept map of diarrhoea as a baseline assessment. Subsequently, they completed a 3-session diarrhoea course. After this instruction, they were tasked with creating a post-instruction concept map of diarrhoea.

Results: the study highlights the positive impact of education on concept mapping skills, particularly among 3rd and 4th-year residents, underscoring the potential for enhancing medical education strategies.

Conclusion: In conclusion, this study conducted among resident doctors in a pediatric unit investigated the impact of concept mapping training and a diarrhoea education program on their concept mapping skills. The findings revealed significant differences between 1st-year residents and their more experienced counterparts, with 3rd and 4th-year residents demonstrating more complex concept maps.

MeSH Keywords: Medical Education, Clinical Competence, Cognitive Skills, Problem-Based Learning.

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1. Introduction

In the recent past medical education has taken tremendous strides and turns. The main focus has been to make students self-directed learners and understand the concepts of the subject rather than rote memorization of the books.¹ In medical science it will help the students to become good doctors and understand the disease from different dimensions and prove to be more beneficial for the patients.² In Pakistan prominent medical colleges have assumed new instructing methodologies and changed the strategy of their teaching so that their students should become self-directed learners widen their cognitive skills and correlate their knowledge with the clinical problems so that their decisions should be effective and fruitful.

The constructivist theory of learning elaborates the idea which highlights that purposeful learning is effective when applied to knowledge in the predefined purposeful framework.³ It elaborates critical thinking and problem-solving skills at the grassroots level. An effective tool to assess the calibre of students with, limited purposeful background is available which

creates problems in drafting and implementing accusative measures.

The research gap in this study centres on the efficacy and validity of concept mapping as an assessment tool within medical education. Despite its potential benefits, there is limited empirical evidence supporting the effectiveness of concept mapping in evaluating learners' understanding and critical thinking skills in medical contexts. Concerns persist regarding the reliability and validity of concept mapping as a form of assessment, particularly in comparison to traditional evaluation methods. Additionally, there is a notable gap in research exploring the specific impact of concept mapping on the learning outcomes and critical thinking abilities of medical residents. Furthermore, the correlation between concept mapping scores and performance on traditional assessments, such as standard written exams, remains inadequately explored within medical education literature. Closing these gaps in knowledge is essential for informing the development and implementation of effective educational strategies in medical training programs.



The rationale for the present study stems from the evolving landscape of medical education, which increasingly emphasizes the importance of self-directed learning and conceptual understanding. As medical practice becomes more complex, future healthcare professionals need to possess not only factual knowledge but also the ability to critically analyze information and apply it effectively in clinical settings. Concept mapping offers a promising approach to assessing learners' comprehension and problem-solving skills by visually representing the relationships between concepts.

The research problem in this study focuses on the effectiveness and validity of concept mapping as an assessment tool in medical education. Specifically, it addresses questions regarding whether concept mapping enhances learners' understanding and critical thinking skills, the reliability and validity of concept mapping as an assessment method, and the impact of concept mapping on the learning outcomes of medical residents. The present study has tried to assess concept mapping.⁴ The technique of concept mapping was developed in the 1970s by Joseph Novak which requires to creation of a 2-dimensional diagram by the students. In this diagram, their concept is highlighted by evaluation of the relationship between and among subject matter. This assessment is different from traditional assessment in the way that how student organizes their knowledge or conclude a problem. This technique of assessment has not been used quite frequently because of issues of its reliability and validity.

2. Materials & Methods

This study is conducted among the resident doctors of the pediatric unit of a public hospital. The study will be conducted from 1st January to 31st August 2022. A total of 21 resident doctors participated in the study after obtaining informed consent. The breakdown of the participants is residents of 1st year: 5, residents of 2nd year: 7, residents of 3rd year: 5 and residents of 4th year: 4.

The study employed a prospective, observational design to assess the effectiveness of concept mapping as an educational intervention in a paediatric unit of a public hospital. The study included resident doctors from various levels of training: 1st year (n=5), 2nd year (n=7), 3rd year (n=5), and 4th year (n=4). A total of 21 resident

doctors participated in the study after providing informed consent. Convenience sampling was utilized to recruit participants from the pediatric unit of a public hospital. This approach was chosen due to the accessibility and availability of resident doctors within the study setting. The sample size of 21 resident doctors was determined based on the feasibility of recruitment within the study period and the desire to capture a diverse representation of residents from different training levels. While this sample size may not be statistically powered to detect small effects, it was deemed sufficient for the exploratory nature of the study and the intended analyses. All participants underwent a training session on concept mapping. Following the training, participants created a pre-instruction concept map on the topic of diarrhoea. Subsequently, participants attended a 3-session diarrhoea education program. After completing the program, participants created a post-instruction concept map on the same topic.

Participants were instructed to create concept maps consisting of four components: concepts, concept links, hierarchies, and cross-links. The pre-instruction and post-instruction concept maps were evaluated for the presence and quality of these components. The concept represents the sequence of events in a regular pattern, shown on a map enclosed in a circle; related concepts are connected with the help of lines or arrows creating a concept map. A concept link is when one concept is linked to another concept with the help of an arrow along with a statement. A hierarchy of concept maps is developed with the help of arrows, which indicate the direction of general concepts mentioned at the top followed by concepts, which need to be highlighted more below. The domain of knowledge in the hierarchy is highlighted by linking the related concepts. When different domain of knowledge is related to each other, it is done through cross-linking. Concept maps were scored by three independent consultants, who were blinded to each other's ratings. Consultants underwent a 45-minute training session before scoring. Scoring criteria included the presence of concept links, hierarchies, and cross-links, with scores assigned based on the depth of thinking required for each component. Scoring of a concept map is done by consultants who are fellows of the speciality or have acquired a postgraduate qualification.⁵ Scoring is done by 03 consultants who are not aware of each other and it is done independently. Each consultant was given a training of 45 minutes just before rating. Scoring was based on concept links,

hierarchy and cross-links. The depth of thinking required to develop a category was based on scoring. A valid and reliable concept was awarded a 02 score, individual hierarchy was awarded a 05 score, and a valid cross-link was provided with a 10 score. Statistical analysis was performed using STATA software. Spearman rank correlation was used to correlate scores between raters and sub-scores. The Wilcoxon signed rank test was employed to compare pre-instruction and post-instruction concept map scores. Differences in scores between different levels of residents were analyzed using the 2-sample Wilcoxon rank sum test. The correlation between concept map scores and

performance on standard written exams was assessed using the 2-sample Wilcoxon rank sum test.

3. Results

Results were cumulated from 21 participants who went through all phases of the study, which included training in concept maps, diarrhoea education programs, and pre-instruction and post-instruction concept maps. Scores of concept maps using training as base Figure I shows a comparison of 1st-year residents showing low scores to high-scoring concept maps of 3rd and 4th-year residents.

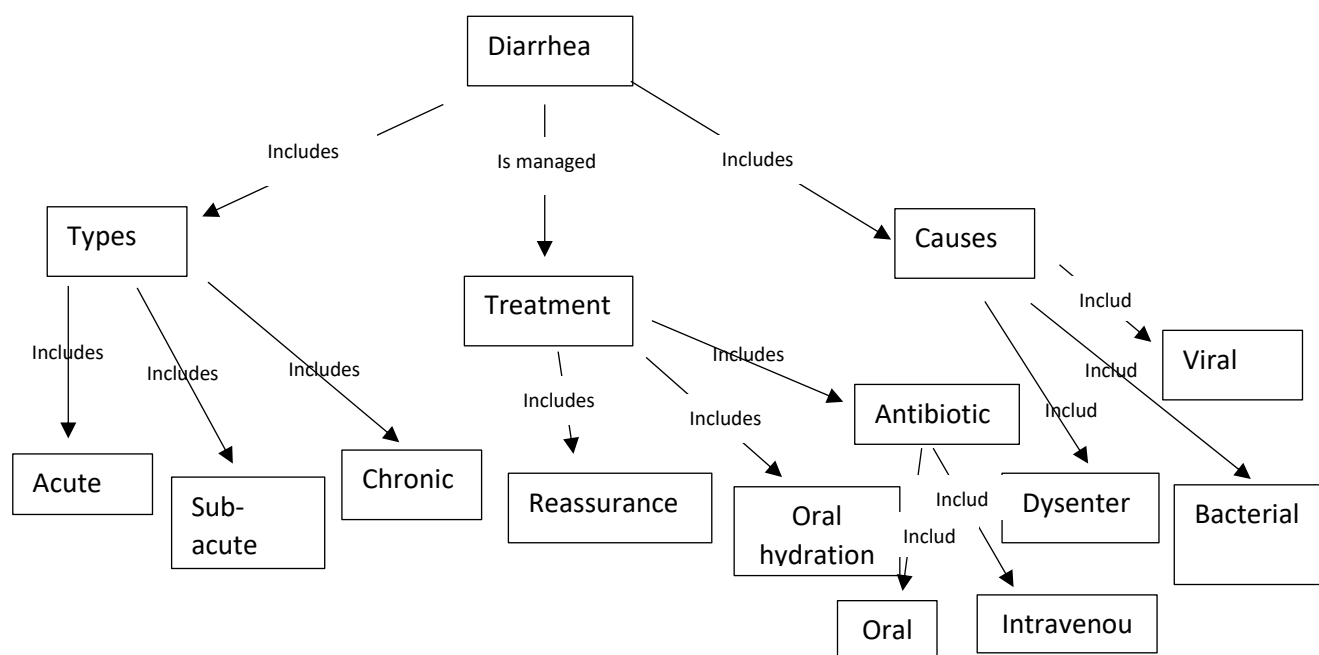


Figure-1 Typical 1st-year resident concept map with low-scoring

A 1st-year concept map is quite simple and linear whereas 3rd and 4th-year concept map is more complex than 1st-year resident map, which is elaborated by cross-links. Table-1 Highlights the mean of the total standard and sub-scores of participants by their training. Pre-instruction map shows that 3rd and 4th-year residents have high total and cross-link scores in comparison with 1st-year residents i.e. ($p=0.3$) and ($p=0.1$). Training did not show any improvement between the concept map, cross-links and hierarchy figure. Post-instruction Map was not significant although there was marked improvement in the total and sub scores of 3rd and 4th year residents. An important observation in the total and

sub-score of the pre-instruction map was not significant after instruction ($p=0.15$ and 0.14 respectively).

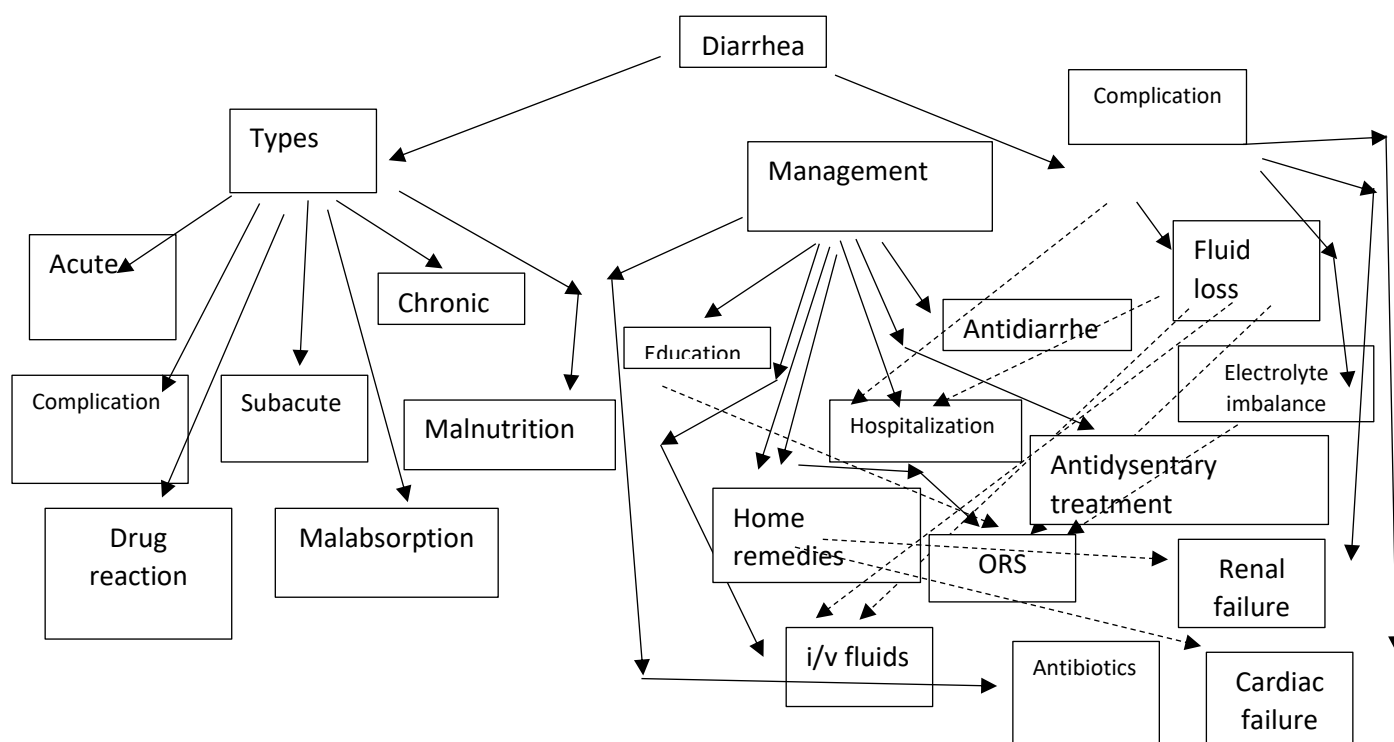
Impact of education on concept map scores

Education has a positive impact on total score which showed gross improvement ($p=0.4$). Scores of cross-links and sub-links also showed improvement ($p=0.03$ and 0.01). A non-significant decrease in the hierarchy was observed.

Table 2 concludes the mean standard score and sub-score of all the participants before and after the instruction of the diarrhoea course.

Table-1 Comparative data of concept map between 3rd and 4th year to 1st-year resident, total score and sub-score

Component	3 rd and 4 th year resident	1st-year resident	P value
Pre-instruction map			
Total	469(114)	368(100)	0.03
Crosslink	159(85)	70(45)	0.01
Concept link	179(79)	169(56)	0.85
Hierarchy	66(24)	65(26)	0.79
Post-instruction map			
Total	559(200)	449(180)	0.15
Crosslink	210(130)	129(109)	0.14
Concept link	229(77)	209(77)	0.20
Hierarchy	60(19)	59(23)	0.55

**Figure-2** High-scoring concept map

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Table-2 concludes the mean standard score and sub-score of all the participants before and after the instruction of the diarrhoea course.

Table-2 Impact of Educational intervention on concept map and sub-scores

Component	Map before instruction	Map after instruction	P value
Total	430(120)	517(199)	0.04
Crosslink	125(86)	180(131)	0.03
Concept link	180(74)	225(84)	0.01
Hierarchy	66(21)	60(24)	0.45

After educational input total score increased ($p=0.4$), and concept link and cross-link also showed significant improvement ($p=0.01$ and 0.03), there was a decrease in the hierarchy score however, it was not significant.

The relationship between interrater was not strong, rather it can be rated as moderate before instruction ($r=0.49-0.70$) and after instruction, it was quite strong ($r=0.72-0.90$). the correlation of interrater for sub score was almost a replica of the total score.

4. Discussion

It is observed that educational intervention shows a significant improvement score of concept map of participants which leads to the view that conceptual framework is expected to change, a systemic review and meta-analysis conducted in 2017 by Yue M, Zhang M, Zhang C, Jin C supports our finding.⁶ The best demonstration of this concept is exhibited by comparison between pre-instruction and post-instruction concept maps. This shows that new concepts are incorporated into the post-instruction map, thus causing a change in concepts and cross-linking, a study conducted in Korea in 2018 is in favour of our study.⁷ A gross increase in total concept, cross-link and sub score and hierarchy is observed on qualitative ground, a study conducted in 2018 by Haymovitz E, Houseal-Allport P, Lee RS, and Svistova J in assessing concept map, supports our finding.⁸ Although the sample size was less than the desired size even training and expertise increased significantly the score of the participants than without training and education in the subject. This resulted in a complex map by participants after

educational programming, a study conducted on nurses in Iran by Sadeghi R, Hashemi M, and Khanjani N in 2018 supports the present study.⁹

It was exhibited that senior residents were more organized in their knowledge and reasonably developing their links of concepts and cross-links which were grossly deficient in junior residents, in a systemic review in 2017 done by Schuelke S, Barnason S also supports our study.¹⁰ It was also observed that once junior residents went through education programs much improvement was observed and new concepts and cross-links were developed by the same residents after a six-day educational intervention by Broekema S, Luttik MLA, Steggerda GE, Paans W, Roodbol PF in 2018 also supports our finding.¹¹

This study shows that the ITE scores of senior residents were much better than junior residents, and junior residents showed much improvement after educational intervention, in a study conducted by Park K-S, Yoo J-I, Kim H-Y, Jang S, Park Y, Ha Y-C in 2017 on education and exercise impact shows improved results such as in the present study.¹² However, the scores of ITE did not match with the scores of CMAS. Residents who scored high on CMA were different from residents with higher ITE scores, in other words, different residents scored high on CMA and ITE, rather than the same residents scoring high on CMA and ITE. This weak correlation suggests that knowledge measured by CMA is different than knowledge measured by MCQ examination.

Reliability is an integral part of any assessment. It was observed in this study that the reliability of the interrater was reasonably good and much improved in post-instruction maps. The learning outcome is that for any future assessment training of rater is very important a study conducted by Escalera A, Hayes B, Prodanović M in 2018 and another study conducted in 2020 by Chow R, Bruera E, Temel JS, Krishnan M, Im J, Lock M which was a system meta-analysis is in favour of our study.^{13,14} A vast majority of literature has highlighted that concept maps could be used as an effective educational tool and the same can be applied in health care settings also a study conducted on biochemistry on using concept mapping as an assessment tool in 2020 by Sivaraman SK and another study conducted by Sieben JM, Heeneman S, Verheggen MM, Driessen EW in a mixed method study in 2021 supports present study.^{15,16} Due to the limited literature available, the validity of concept map as an assessment tool is quite weak which could be related to several issues a study conducted on the internal

validity of concept mapping in 2017 by Péladeau N, Dagenais C, Ridde V and another study conducted by Orsi R in 2017 also support the present study.^{17,18}

Measuring competency by different tools such as MCQs, OSCE, and OSPE could not be compared to concept map assessment because this assessment tool highlights how a learner thinks about a problem which is not assessed by any other tool of assessment a study conducted on higher order thinking by Widana IW, Parwata I, Parmithi NN, Jayantika I, Sukendra IK, Sumandya IW in 2017 supports the current study.¹⁹

A closely related study to concept mapping is pathfinder network in understanding pulmonary physiology was assessed, a study conducted in 2020 by Stevenson JL, Yeagley NC, Bish JP supports our study.²⁰

CMA has a greater potential to assess the thinking ability, organization and application of knowledge of the student than the traditional system of assessment such as objective method, and short essay questions, which have limited access to such objectives a study conducted in 2018 by Moon B, Johnston C, Moon S, editors are favour of the present study.²¹ Finally, CMA provides us with a guide line why some students perform quite well in objective exams and show poor performance in clinical exams.

5. Conclusion

In conclusion, this study conducted among resident doctors in a pediatric unit investigated the impact of concept mapping training and a diarrhoea education program on their concept mapping skills. The findings revealed significant differences between 1st-year residents and their more experienced counterparts, with 3rd and 4th-year residents demonstrating more complex concept maps.

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M.M - Conception of study

M.M - Experimentation/Study Conduction

M.M, R.N.K - Analysis/Interpretation/Discussion

S.B.A, A.S - Manuscript Writing

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N.H - Facilitation and Material analysis

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