



MICROBIOLOGY

PATHWAY MCQs AS AN ACTIVE LEARNING STRATEGY FOR STUDENTS IN MICROBIOLOGY: A PRELIMINARY STUDY

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Abstract

Medical curriculum involves many pathways. Understanding and remembering pathways in Microbiology (esp. pathogenesis) is a challenging task for the students. Pathway MCQ (Dugdale AE, 1998) helps in eliminating this confusion. An effort was made to introduce these Pathway MCQs as a teaching, revising and as an evaluation strategy to enable them to remember the pathways more effectively thereby enhancing understanding of concepts. A total of 106 second year medical students of Melaka Manipal Medical College (Manipal Campus) were included in this study. Pathway MCQs (PMQs) on specific topics were prepared by the faculty members. Initially, the students were asked to answer the questions in the form of short answer on few topics prior to administration of PMQs. These short essay answers were evaluated. Later, each student was given a set of Pathway MCQs on the topic administered earlier. Students had to solve the PMQs and write a short answer thereafter. The PMQs and the short answers were evaluated by faculty members who were not involved in the study. A class test was conducted after 4 weeks on topics assigned in the semester including the topics that were administered as PMQs. After evaluation, the marks scored by the students were tabulated and analyzed. A feedback in the form of a questionnaire was collected from students. PMQs were found to be simple and interesting, helped to remember and understand pathways, enhanced active learning, employed as a revising strategy and as a formative evaluation strategy. Statistical analysis suggested that students' overall performance in examinations had been enhanced after administration of PMQs.

Introduction

Medical curriculum involves many pathways which the students have to be adept with. Medical students have always been faced with the challenge of understanding and remembering these pathways. In Microbiology, there are many pathways in the form of pathogenesis of infectious diseases that a medical student needs to understand. The inherent difficulty in remembering these pathways owes to the mere fact that there are many steps with a very slight variation, thereby making them confusing for the students. Pathway MCQs overcomes this drawback as it tests all processes and pathways involving a sequence of events. It also can be used as an effective strategy for revising and also testing deeper approach of understanding the concepts than testing mere factual recall (Dugdale, 1998).

In the present study, our aims were;

1. To introduce and implement Pathway MCQs as a strategy for 2nd year medical students and to analyze the effectiveness of Pathway MCQs as;
 - a. Teaching strategy for faculty
 - b. Learning and revising strategy for students
 - c. An evaluation strategy
2. To assess and co-relate the performance of the students after PMQ administration.

Materials

A total of 106 second year medical students studying in Melaka Manipal Medical College (Manipal Campus) were included in the study. Lists of topics were given to the students two days in advance. Pathway MCQs (PMQs) that were prepared by faculty members on the topics notified were later administered to the students.

PMQs is a modified extended match question (EMQ) that has a stem (phenomenon or event) followed by 7-10 responses (Dugdale, 1998). These responses are both true and false responses which were haphazardly arranged and were linked to the stem. In the pathway MCQ, the responses were linked to each other so that both the content and the order of the responses are relevant. The student should firstly identify all the true and false responses following which all the true responses had to be sequentially arranged based on the phenomenon / event asked in the stem. After completion, a short paragraph (in the form of short essay) was written with a detailed explanation of the process / phenomenon mentioned in the stem (Figure 3).

Methods

The study design consisted of 3 stages. A list of topics in microbiology was selected for the activity and

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these topics were not discussed either as lectures or any other learning activity. In the first stage, the students were given 3 topics on which they were asked to answer the questions in the form of a short essay answer within a stipulated time of 15 minutes. These short answers were evaluated separately by 2 faculty members who were not involved in this PMCQ activity. The average scores of students were tabulated and scores were later scaled down to 10 marks (Pre test).

In the second stage, a set of PMCQs designed by faculty on the same three topics asked previously were administered to the students. The students had to solve the PMCQ and then describe it in the form of short essay answers. These Pathway MCQs were then evaluated separately by 2 faculty members and the marks were tabulated (Post Test). The average scores were then scaled down to 10 marks.

Scoring pattern for PMCQs

- For every right response picked, the student got **+1 mark**
- For every wrong response picked, the student got **-0.5 mark**
- For correct sequencing of events and writing a short essay, the student got **10 marks**

- The total marks awarded after the process were scaled down to **10 marks**

The data from the Pre test and Post test were analyzed.

In the third stage, a class test was conducted 4 weeks after the administration of PMCQs. Questions were prepared incorporating the 3 topics that were administered as PMCQs in addition to other topics. Students were not aware that these 3 topics were included in the class test. The marks obtained were tabulated and analyzed. In addition to this, a feedback in the form of a questionnaire was prepared to generate responses from the students about the challenges faced in remembering pathways, their study pattern and effectiveness of the PMCQs as a strategy to inculcate active learning, for revising and as an evaluation tool. The questionnaire (5 point Lickert's scale i.e. 5=Strongly Agree, 4=Agree, 3=Uncertain, 2=Disagree, 1=Strongly Disagree) with 9 items for pretest and 12 items for post test was used to elicit students responses. The questionnaire had both closed ended and open ended questions (Table I & II). The results obtained were expressed as Mean ± SD.

Sl. No.	Parameters	Agree	Uncertain	Disagree
1	I find it difficult to understand pathogenesis (pathways).	9 (8.5%)	26 (24.5%)	71 (67%)
2	I find it difficult to remember the pathogenesis (pathways).	43 (40.5%)	23 (21.6%)	40 (37.8%)
3	Have difficulty in integration.	29 (27.3%)	40 (37.8%)	38 (35.9%)
4	I tend to miss the sequence of steps in the pathway.	77 (72.7%)	18 (16.9%)	11 (10.4%)
5	I find the pathogenesis (pathways) very confusing.	25 (23.5%)	26 (24.5%)	55 (52%)
6	I practice writing down the pathogenesis while reading.	46 (43.4%)	16 (15%)	44 (41.6%)
7	I just read the pathogenesis without writing.	50 (47.2%)	11 (10.4%)	45 (42.4%)
8	Try to make connections between that subject and related subjects while studying.	56 (52.8%)	25 (23.6%)	25 (23.6%)
9	I prefer to study in a steady, orderly fashion.	84 (79.2%)	14 (13.2%)	8 (7.5%)

Table 1: Distribution of number and percentage of responses prior to administration of PMCQ (Pretest / Controls) N=106

Table 2: Distribution of number and percentage of responses after the administration of PMCQ (Post test/ Cases) N=106

Sl. No.	Parameters	Agree	Uncertain	Disagree
1	Enjoyable and interesting	51 (48.1%)	25 (23.5%)	30 (37.6%)
2	Useful and simple	65 (61.4%)	25 (23.6%)	16 (15%)
3	Fosters deeper approach of understanding of subject	72 (67.9%)	20 (18.8%)	14 (13.3%)
4	Stimulates reasoning	67 (63.2%)	20 (18.8%)	19 (18%)
5	Helps to integrate	70 (66%)	20 (18.8%)	16 (15.2%)
6	Evokes discussion and questioning	54 (51%)	20 (18.8%)	32 (30.2%)
7	Useful for reviewing/revising	76 (71.7%)	18 (17.1%)	12 (16.2)
8	Makes it easy to remember pathways	60 (56.6%)	26 (24.6%)	20 (18.8%)
9	Eliminates confusion regarding various steps	40 (37.6%)	36 (33.8%)	40 (37.6%)
10	PMCQs helps me to remember the sequence of steps in the pathway	63 (59.4%)	21 (19.8%)	22 (20.8%)
11	PMCQs enables for longer retention of the pathways (pathogenesis)	61 (57.5%)	32 (30.2%)	13 (12.3%)
12	Effective tool for evaluation	52 (49%)	33 (31.2%)	21 (19.8%)

Statistical analysis

1. The responses obtained from the questionnaire were expressed as number, percentages and Mean \pm SD, numbers and percentages (Table 1 & 2, Fig 1 & 2).
2. The marks obtained were expressed as Mean \pm SD and means were compared using paired T-test.
3. SPSS 10.0 software and MS Excel were used for statistical analysis.

Results

As shown in Table 1 and Figure 1, students expressed that they found it difficult to remember the pathogenesis / pathways 43 (40.5%), 77 (72.7%) opined that most of them missed the sequence of steps of the pathways. Even though students felt that pathogenesis (pathways) was not very confusing 55 (52%), they found it difficult to integrate the sequence inspite of studying in a steady, orderly fashion 84 (79.2%).

As shown in Table 2 and Figure 2, students felt that PMCQs were useful and simple 65 (61.4%) and fostered deeper approach of understanding of subject 72 (67.9%). With regards to them as a strategy for revising the topics, students strongly expressed that it was very useful for reviewing/revising 76 (71.7%). Students opined that PMCQs made it easy to remember pathways 60 (56.6%) and enabled for longer retention of pathways 61 (57.5%).

With regards to the administration of PMCQs as an evaluation strategy, students expressed a mixed feeling that it was an effective tool for evaluation 52 (49%).

Statistical analysis was performed using paired T-test and means were compared between the Pretest, Post test and after administration of class test. There was statistical significance and correlation between the Pretest and Post test and between Post test and Class test. There was no significant correlation between the pretest and class test (Table 3).

Figure 1: Distribution of students responses for Pretest / Controls (Mean \pm SD)

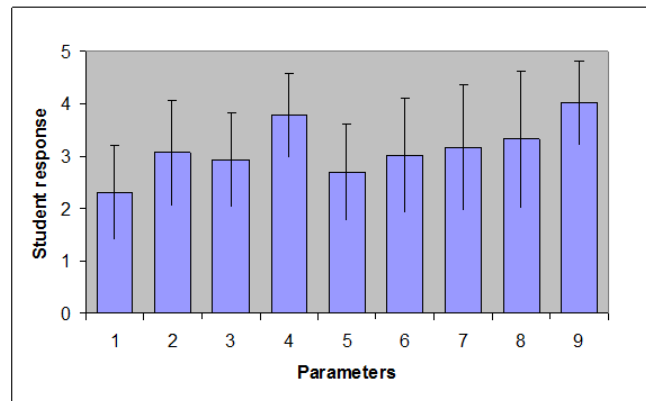


Figure 2: Distribution of students responses for Post test / Cases (Mean \pm SD)

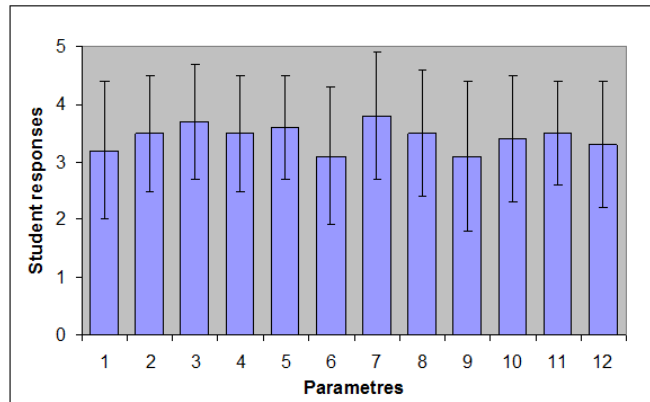


Figure 3: Sample PMCO

Write a short essay

The pathogenesis of poliomyelitis caused by Polio virus is as follows...

- A. Enters RES, further multiplication
- B. Enters blood stream via lymphatics resulting in primary viremia
- C. Direct neural transmission to CNS also occurs
- D. Causes degeneration of Nissl bodies of neurons (chromatolysis)
- E. Results in a meningitic phase that follows a encephalitic phase
- F. Re-enters blood stream resulting secondary viremia
- G. Polio virus enters the humans through mechanical trauma
- H. Crosses the Blood CSF barrier causing meningitis
- I. Ascends the neurons by an active retrograde transfer
- J. Crosses Blood Brain barrier
- K. Lesions are predominantly seen in the posterior horn cells
- L. Multiplication initially in the epithelial cells of the gut and lymphoid tissues
- M. Causes meningo-encephalitis

Correct sequence: L B A F H J D M

Wrong Statements: C E G I K

Parameters	Mean \pm SD	df	P value
Pre test (Controls)	17.85 \pm 5.1	105	0.004 (HS)
Post test (Cases)	19.53 \pm 3.0		
Pre test (Controls)	17.85 \pm 5.1	105	0.944
Class test	17.89 \pm 4.4		
Post test (Cases)	19.53 \pm 3.0	105	0.001 (HS)
Class test	17.89 \pm 4.4		

Table 3: Comparison of Means of Average Scores using Paired T-test;

PS: HS = Highly significant

Discussion

Introduction of Pathway MCQs as an active learning and revising strategy for students was successful. There was mixed response pertaining to it being as an evaluation strategy. Students' cognitive learning, proper deep approach understanding and long lasting memory were enhanced. PMCQs helped students to remember the sequence of steps in the pathway 63 (59.4%) thereby eliminating confusion and enabled for longer retention of the pathways / pathogenesis 61 (57.5%). Students learn better if an atmosphere is created in which they are encouraged to actively involve themselves in meaningful learning activities (group or individual). In addition to this, if students are aware and think retrospectively as to what is the ultimate learning outcome intended, active learning effectively takes place (Bonwell and Eison 1991). The core elements of active learning were student activity and engagement in the learning process either in the form of various activities that were introduced in the classrooms (e.g. PMCQs).

Students had no problem in the understanding of pathways, but found it difficult to sequence and explain it. Students who practiced writing down the pathogenesis while readings were 46 (43.4%) and

students who just read the pathogenesis without writing was 50 (47.2%). This could be one of the reasons for inability to understand and remember pathways. This was because the students merely listened (passive involvement) and did not practice writing the pathways (active involvement). Effective learning occurred when students were actively involved in doing something which was enjoyable, interesting besides mere listening (Ryan and Martens, 1989). Writing down the pathogenesis while reading enhanced longer retention and understanding of the topic and also helped them to analyze. Involving students in writing served to increase their learning skills uniquely as it encompasses powerful learning strategies (Emig, 1983) such as survey, recall, review, rehearse and question (SQ3R method) (Gibbs et al., 1992) Hebeshaw, 1992) and gives them many learning opportunities. Writing the pathways as a process helps them to recollect, refer the books for any forgotten information and also to analyze their understanding skills. Writing the pathways as a product enables them to make corrections, reflect, discuss with peer members and friends and also to enhance collaborative learning. Active involvement is detrimental in the learning process and pathway MCQs were found to be very effective in this regard. The driving force for students'

decision to participate in learning strategies and to incorporate them as a regular strategy is the level of students' motivation and their desire to achieve their goals (Garrison, 1997 and Corno, 1992). In addition to this, if the strategy is simple and easily performed, the ease at which they adapt to this strategy is faster. This enables to monitor the learning process, evaluate the extent of their understanding and their memory and also regulate their cognitive learning strategies (Corno, 1992).

Pathway MCQs as revising strategy for students was effectively implemented for a topic after the lecture (Table II & Fig. 2). Even though there were many methods used by the teacher to facilitate learning, there were other factors affecting student motivation, including student goals and interests, creativity and the willingness to learn (Harlen and Crick, 2003).

It is a known fact that assessment scheme is the pivotal point that tends to drive student-learning (Schotanus, 1999) and the type of assessment employed influences learning and also memory (Feletti and Smith, 1986). There were some inherent difficulties with the application of PMCQs as an evaluation strategy. The 8-10 responses associated with the stem provided hints to the question asked. However, it could be effectively used for formative rather than summative evaluation. An advantage of PMCQs was that faculty could test two skills in a student – the ability to answer MCQ type of question and also assess their organization skills in the form of writing a short essay that is required after solving the PMCQs.

PMCQs had helped the students' overall deeper understanding and remembering the pathways as indicated in our study. There had been a significant correlation between pretest (before administration of PMCQs) and post test (after administration of PMCQs). The same correlation was observed between post test and class test conducted after a gap of four weeks proving the hypothesis that PMCQs enhanced deeper understanding, longer retention (long term memory) and enhanced performance in the examinations.

Conclusion

Students found that PMCQs were simple, enjoyable and interesting and a good means to remember, analyze and understand the pathways (pathogenesis). PMCQs, if framed properly could be effectively used by faculty members as a revising strategy either at the beginning or at the end of class or at the end of the lecture to check if the students have

understood the concepts. PMCQs served as an effective means to review, revise the topics taught in the lecture for the students. PMCQs can be used as an evaluation strategy for formative assessment and not for summative assessment due to its limitations. Administration of PMCQs has tremendously improved the overall performance of students in the examinations thereby enhancing both their understanding skills and thus increased their long term memory.

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Appendix

Legends for Figures:

Figure 1:

X-axis (Parameters):

- 1 : I find it difficult to understand pathogenesis (pathways).
- 2 : I find it difficult to remember the pathogenesis (pathways).
- 3 : Have difficulty in integration.
- 4 : I tend to miss the sequence of steps in the pathway.
- 5 : I find the pathogenesis (pathways) very confusing.
- 6 : I practice writing down the pathogenesis while reading.
- 7 : I just read the pathogenesis without writing.
- 8 : Try to make connections between that subject and related subjects while studying.
- 9 : I prefer to study in a steady, orderly fashion.

Y axis (Students response):

- 1: Strongly Disagree, 2: Disagree, 3: Uncertain, 4: Agree, 5: Strongly Agree

Figure 2:

X-axis (Parameters):

- 1 : Enjoyable and interesting
- 2 : Useful and simple
- 3 : Fosters deeper approach of understanding of subject
- 4 : Stimulates reasoning
- 5 : Helps to integrate
- 6 : Evokes discussion and questioning
- 7 : Useful for reviewing/revising
- 8 : Makes it easy to remember pathways
- 9 : Eliminates confusion regarding various steps
- 10 : PMCOs helps me to remember the sequence of steps in the pathway
- 11 : PMCOs enables for longer retention of the pathways (pathogenesis)
- 12 : Effective tool for evaluation

Y axis (Students response):

- 1: Strongly Disagree, 2: Disagree, 3: Uncertain, 4: Agree, 5: Strongly Agree