Online Case Based Learning (CBL) as a Tool for Formative Assessment in Anatomy – Neurobiology Course

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ABSTRACT
Introduction: Introducing formative assessment in the neurobiology course is essential as it enables the student to assess their learning and help them get the necessary feedback to improve on their understanding of concepts. The administration of formative assessment through case-based learning is more effective in understanding the concepts and clinical relevance in neurobiology. **Materials and Methods:** A prospective interventional study was conducted during the neurobiology course for the first-year preclinical students. Two case-based learning sessions were conducted. In each session the students were divided into small groups and case discussion was done in the online platform Webex. A pretest and posttest were conducted in the college learning management system for each session. The perceptions of the students and the faculty were taken in a feedback questionnaire that had close ended questions (on a five-point Likert scale) and open-ended questions. **Results:** Descriptive analysis showed that the mean of pre-test was higher as compared to the post-test scores in both the sessions. The analysis of the feedback questionnaire of the students indicated that majority of the students agreed that the session helped them in better understanding of the concepts along with understanding of the clinical relevance of the topic. Most of the students felt that the time was not sufficient and that not all members participated equally in the session. The faculty agreed that such sessions help generate interest in the subject. **Conclusion:** Online case-based learning sessions can be used for formative assessments when face to face learning is not possible.

Introduction:
Neurobiology is the study of the structure and function of the nervous system. In most of the colleges it is taught along with gross anatomy whereas in some institutions it is a stand-alone course.
Jozefowicz coined the term 'neurophobia', it is a term used to describe the fear of neural sciences and clinical neurology. This fear can be caused by a number of factors, including the complexity of the subject matter, the difficulty of applying basic science knowledge to clinical

situations, and the fear of the unknown. According to him the main cause for this neurophobia is the lack of integration between basic and clinical sciences. [1]

Studies have indicated that the difficulty of neurology could be due to the students' insufficient knowledge of the subject. [2]

Educational interventions in addition to the regular lectures are essential not only to help the students understand the basic concepts of neurobiology but also to learn the application of the knowledge in clinical settings.

Educational interventions such as case-based teaching (CBT), team-based learning (TBL), and problem-based learning (PBL), have been implemented to improve students' understanding of neuroscience and have shown a positive response in annihilating the fear of the subject. [2]

Another important educational intervention that can help student learning of neurobiology is the introduction of formative assessment (FA). This is because FA acts as an immediate source of feedback that enables the student to track their understanding of the topics in neurobiology. Formative assessments are designed to improve student learning. When designing formative assessments, it is important to focus on three specific drivers: identifying gaps in student learning, informing students about the expected outcomes of summative assessments, and providing feedback that guides student learning. [3]

More use of formative assessment throughout the course can provide a good opportunity for encouraging a spaced mode of learning.

Studies have found that formative assessments administered as case-based discussions are an excellent way to enhance learning. This method of learning is effective in the preclinical years as it helps the student understand the clinical relevance of the topics being taught to them, knowledge of the clinical implications can generate student interest that can facilitate the learning process. [4] Discussing these cases as teams also enables them to inculcate in peer learning which is an added advantage of CBL.

Students taking the neurobiology course have always expressed that they face difficulty in understanding the concepts taught and would require additional help in their learning process. Use of FA to guide student learning though an effective method has been scarcely used in the delivery of the neurobiology course in our institution. The present study was thus planned to facilitate student learning by introducing FA as CBL activity to facilitate student learning in the neurobiology course. Though originally planned to be conducted as a face-to-face session due to the covid pandemic it had to be conducted in an online mode.

The objectives of the study was:

1. To implement online case-based learning (CBL) for formative assessment in Anatomy – Neurobiology course.
2. To assess the perceptions of the undergraduate medical students toward introduction of CBL sessions for formative assessment.
3. To assess the perceptions of the faculty towards introduction of CBL sessions for formative assessment.
4. To assess student learning by administration of pretest and posttest.

Methodology

Study design: A prospective interventional study was conducted in the department of anatomy & neurobiology, on a single cohort of first year preclinical students registered for the neurobiology course during 2020.

Sample size: Convenience sampling was employed, and 133 students were enrolled for the study. 94 students participated in the CBL1 session, and 104 students participated in the CBL2 session.

Inclusion criteria: All the students registered in the course and willing to participate in the session were included.

Exclusion criteria: None

Study procedure

Ethical approval from the Institutional Research and Ethics Committee of the college was obtained to conduct the study.

Prior to the intervention the following steps were undertaken:

1.The faculty were sensitized to the need of conducting the session and the necessary guidelines were designed.

2.Cases for the sessions, pre and post test questions along with the feedback questionnaire for the students and faculty were prepared and face validated by the faculty. Feedback questionnaire had both close ended questions (on a Likert scale) and open-ended questions.

3.Content validity of the feedback questionnaire was done by 5 faculty members of different departments.

4.The students were oriented about the session process, advantage of attending the session (an informed consent was obtained).

Process of the session

Neurobiology is an 8-week course conducted in the summer in month of May to July first week. The online platform Cisco WebEx, which is used by our institution for online teaching was used to conduct the online CBL sessions. There is a facility of breakout room in WebEx meeting where students can be divided into groups.

2 sessions of CBL were conducted.

First session of CBL: The topics on which the cases were prepared were:

-Functional areas of cerebrum

-Tracts of spinal cord

-Blood supply of brain

-Brainstem

Students were divided into groups (each group consisting of 13-14 students), a total of 10 groups were created. There were 5 facilitators so each of them got 2 groups to facilitate. **(Figure-1)**

The facilitators conducted the CBL discussion for both the groups separately in two batches.
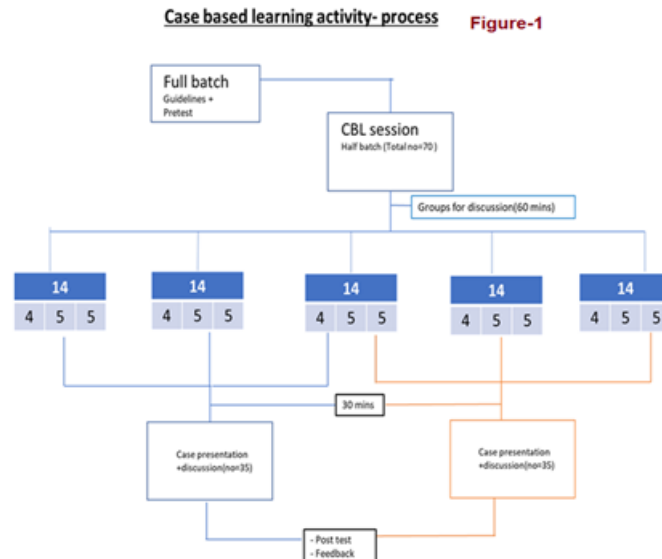
Figure 1

On the day of the session:

1) All the students first attended an online session during which the steps and guidelines to be followed were informed.
2) The students then were given time to solve the pre-test questions individually. The test was uploaded on the college learning management system (LMS).
3) Each facilitator was given the responsibility of conducting the session for 2 groups of Students (each group consisting of 13-14 students). These students join their respective online batches to discuss the cases.
4) In each online session group, the facilitator further divided the students into 3 smaller groups of 4-5 students and assigned them to each breakout rooms. The students were given 1 hour to discuss 4 cases and were regularly visited by the facilitator to guide the students and clear any doubts.
5) After the discussion was completed the students from all the 5 groups were divided again into 2 groups of 35 each and were asked to join a common session where further discussion and wrap up of the cases was initiated by the faculty. The students presented their groups view on the cases and any further doubts were cleared.
6) After 2 days the post test was administered on the LMS, and the feedback was administered after that in the LMS.

Second session of CBL:

The topics on which the cases were prepared were:
- Basal ganglia
- White matter of brain
- Cranial nerve nuclei and their functional components

Steps similar to the first session were followed, the only difference was that the students in the second CBL session were allotted one primary case to discuss, and option was given to discuss the other cases.

Section A-Research paper

This was done as in the feedback the students mentioned that the time was not sufficient to discuss all the 4 cases.

The pertest, posttest and feedback was also administered in the LMS similar to the first session, but the questions asked were different to that of the first session. After completing the 2 sessions the faculty feedback was collected.

Results

Statistical analysis of the data was done using the online free statistical software jamovi (Version 1.6).

Descriptive statistics were used to describe the results for quantitative variable i.e. means & standard deviation. (Table 1)

The comparison of pre and post intervention mean CBL scores were done by the paired sample t test.

The results of the pre-test and post-test scores (shown in Table 1) in CBL sessions shows that the number of students who attended the post-test were less than those who attended the pre-test.

Students who had not participated in the CBL session had also taken the pre-test in both sessions.

The mean value of the post test results was significantly less than the pre-test scores in both the sessions.

Table 1: Descriptive analysis of the pre-test and post test scores

	CBL1 pre-test	CBL1 post-test	CBL2 pre-test	CBL2 post-test
N	111	52	119	92
Mean	6.15	4.90	6.20	2.39
Standard deviation	2.35	3.13	2.44	1.38

Comparison of pre and post intervention mean CBL scores done by the paired sample t test shown in table 2 &3.

Table 2: Comparison of pre and post intervention mean CBL1 session scores

CBL scores	Mean	Standard Deviation
Pre-Intervention	6.66	2.38
Post-Intervention	5.13	3.02

Statistical Results: t-value: 3.49 df:43 p-value:0.001

Interpretation: The difference in mean CBL score was normally distributed as found by the visual inspection of the Q-Q plot. There was one outlier which was kept in the analysis. In our study there is significant decrement in the mean CBL scores after intervention. The difference in mean CBL scores was 1.53 (95% CI: 0.649-2.42)

Table 3: Comparison of pre and post intervention CBL 2 scores.

CBL 2 scores	Mean	Standard Deviation
Pre-Intervention	6.15	2.42

Post-Intervention	3.06	1.71

Statistical Results: t-value: 12.9 df:88 p-value:<.001

Interpretation: The difference in mean CBL 2 scores was normally distributed as found by the visual inspection of the Q-Q plot. There were very few outliers which were kept in the analysis. In our study, there is significant decrement in the mean CBL 2 scores after intervention. The difference in mean CBL 2 scores was 3.08 (95% CI: 2.61-3.56)

Descriptive analysis of the close ended questions administered on Likert's scale of the student and faculty questionnaire was done and expressed as percentage. Open ended questions were analyzed by thematic grouping.

Table 4: CBL session 1 - student feedback (N=94)

Question no	Question	Strongly agree %	Agree %	Uncertain %	Disagree %	Strongly disagree %
1	I enjoyed attending Case based learning (CBL) session	4.3 %	28.7 %	39.4 %	13.8 %	13.8 %
2	CBL sessions helped me learn how to interpret clinical case scenarios	9.6 %	44.7 %	30.9 %	4.3 %	10.6 %
3	Cases were well prepared and helped us to understand the clinical relevance of the topic.	9.6 %	52.1 %	28.7 %	2.1 %	7.4 %
4	The time allocated for the CBL session was sufficient	10.6 %	35.1 %	34.0 %	12.8 %	7.4 %

The student feedback taken after the first CBL session (shown in table 2) showed that, 33% of students expressed that they enjoyed attending the session whereas 39.4% were uncertain.

Majority of the students agreed or strongly agreed that the CBL sessions helped them learn how to interpret clinical case scenarios. They also strongly agreed that the cases were well prepared and helped them understand the clinical relevance of the topic.

Only 46% students agreed or strongly agreed that the time allotted for the session was sufficient.

To the open-ended question on suggestions how to improve the next CBL session, most of the student's response was:

- to increase time for case discussion with the peers,
- to include few topics for the CBL sessions and
- Many were not happy that this session was scheduled very close to the midterm exam.

Table 5: CBL session 2 - student feedback (N=104)

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Question no	Question	Strongly agree %	Agree %	Uncertain %	Disagree %	Strongly disagree %
1	Participating in CBL session helped me in better understanding of the concepts of topics covered in the session.	9.6 %	44.2 %	26.9 %	11.5 %	7.7 %
2	Participating in the session helped me learn how to interpret clinical case scenarios	11.5 %	50.0 %	23.1 %	8.7 %	6.7 %
3	Participating in the session provided an opportunity for self-learning	14.4 %	41.3 %	26.9 %	10.6 %	6.7 %
4	Break out room sessions in Webex were helpful to interact with team members.	7.7 %	29.8 %	30.8 %	15.4 %	0
5	There was equal contribution from all the team members	6.7 %	27.9 %	25.0 %	17.3 %	23.1 %
6	Facilitators(faculty) were supportive in clearing the doubts regarding the topic	12.5 %	60.6 %	17.3 %	5.8 %	3.8 %
7	Cases were well prepared and helped us to understand the clinical relevance of the topic.	13.5 %	55.8 %	24.0 %	1.9 %	4.8 %
8	CBL sessions should be conducted for other courses also	4.8 %	26.9 %	29.8 %	19.2 %	19.2 %

Table 6: Thematic Aggregation of the open-ended responses by students about CBL 2 session

What did you do during the CBL session?	What did you like most about CBL session & why?	How will you further improve your learning after this session?	Mention one most significant concept that you learnt during the session.

-Discussion -Solve questions and analyse the cases -Participate	-We were able to connect our study to the cases -team discussion as it helped correcting our mistakes -challenge of being able to diagnose cases -practice what we learned -not graded - breakout rooms **-** pre & post-tests since it introduced to new questions and overall tested knowledge	-Try to relate topics with each other and with actual cases. - study in form of" why this happen? which structures and functions may get affected? etc" analysing more. - revise the lectures that I couldn't answer their questions. - spend more time reviewing the material before hand - Do group study - Focus on cases because they are useful in understanding the concept	- Understood how Parkinson's disease happen and its management -involvement of cranial nerve examination in diagnosis - Got to know many difficult terms and their meanings - Direct and indirect light reflex - Sensory and motor aphasia + cranial nerves - relation between the cerebral cortex and the disease of brain - conjugate eye movements -Internuclear ophthalmoplegia

The feedback of the second CBL session (shown in table 3) showed that majority of the students agreed that participating in CBL session helped them in

- Better understanding of the concepts of topics covered in the session.
- Helped them learn how to interpret clinical case scenarios
- Provided an opportunity for self-learning

They also agreed that facilitators(faculty) were supportive in clearing the doubts regarding the topic. And that the cases were well prepared and helped them to understand the clinical relevance of the topic.

Only 37% of students felt that break out room sessions in Webex were helpful to interact with team members. And 34% reported that there was equal contribution from all the team members in solving the case.

When asked if CBL sessions should be conducted for other courses also 0nly 31.7% agreed or strongly agreed whereas 38.4% students either disagreed or strongly disagreed.

Table 7: CBL session - faculty feedback

Question	Strongly agree %	Agree %	Uncertain in %	Disagree %	Strongly disagree %
1. Students enjoyed the CBL session.	33.3 %	66.7 %	-	-	-
2. CBL session stimulates students' interest to learn	66.7 %	33.3 %	-	-	-
3. Students felt confident to apply theoretical knowledge to solve clinical cases	16.7 %	66.7 %	16.7 %	-	-
4. Students actively participated in group discussion.	33.3 %	66.7 %	-	-	-
5. Role of teacher as facilitator is important in this method	50 %	50 %	-	-	-
6. More topics can be covered using this method	50 %	50 %	-	-	-
7. It is a time-consuming activity.	16.7 %	50 %	-	33.3 %	-

Table 8: Thematic Aggregation of the open-ended responses by faculty about CBL 2 session

1. How was your experience in conducting the session?	-Good -Happy to see students actively participate in the session
2. What are the difficulties you faced while conducting the session?	-Being online some students did not participate and more did not open their camera. -More faculties and time lots required
3. What is your opinion about conducting CBL sessions?	-Should be done regularly in the course
4. What are your suggestions for improving the CBL sessions?	Should be done face to face, more time and faculty needed

The feedback from the faculty indicated that the CBL session was effective and that it stimulated students' interest in learning. The major obstacle was that it was online due to which most of the students did not actively participate in the session.

Discussion

Study of neurobiology has always been a challenge to the undergraduate students. Students taking up the neurobiology course in our institution usually fail to comprehend the most of the

concepts taught including the applied aspects clinical application. of the topics taught. This may be because most of the teaching is delivered as didactic lectures, giving no scope for the students as well as the faculty to track the learning that is taking place. No other attempt, other than testing them through summative assessments is used to assess students learning.

An intervention that can track students learning and further help them improve their performance during the course by giving the needed feedback would benefit both the student and the faculty.

The role of formative assessments in student learning is a well-accepted fact. Formative assessments help students identify their learning gaps, understand the expectations of summative assessments, and receive feedback to guide their learning.

Due to the emergence of COVID pandemic many curricular changes had to be made to adapt to the online mode of teaching. Along with teaching even the assessments had to be conducted in an online mode.

Formative assessments have known to been conducted both in an offline and online mode.

Online formative assessments in various formats as one best answers (OBA), Objective structured practical examination (OSPE) and short answer question (SAQ), quizzes have been conducted. [5,6]

Various other methods like problem-based learning (PBL), case-based learning (CBL) and team-based learning have also been used to administer formative assessment. [7,8]

CBL helps the student prepare for clinical practice and links theory to practice, through the application of knowledge to cases, using inquiry- based learning. It is an effective tool to link the basic science knowledge to clinical management. [9]

The use of case-based teaching is an effective tool to create interest in the study of neurobiology, as students discuss a clinical case related to the topic taught, they use higher-order thinking skills to evaluate their own understanding of the concept. This active learning process encourages interest in the subject and helps students become self-directed learners. [10]

In lieu of this advantage and the ongoing pandemic an attempt was made to conduct formative assessment session in the form of online case-based learning during the neurobiology course.

After the first CBL session only 40% of students agreed that they enjoyed the session whereas the rest half were divided in being uncertain or disagreed that they enjoyed attending the session.

One of the main reason the students expressed in the open-ended question was that this session was very close to the midterm exam and the cases given for discussion were too long and they felt more time was needed to solve the cases.

But majority agreed that solving the cases helped them understand the clinical relevance of the topic and learn how to interpret clinical case scenarios.

Based on the feedback received on the first CBL session The second CBL session was well place in the schedule so that it does not overlap with any other exam, the cases were also modified so that the discussion could be completed in the time allotted.

The number of students who attended the second session were slightly more than those who attended in the first session, this may indicate that the students were interested in participating in the session.

The feedback from the second session indicated that more percentage of students felt that participating in the session helped them understand the clinical relevance of the topic and learn

how to interpret clinical case scenarios. Majority of the students agreed that the cases were well prepared.

The major issue was that most of the students were not happy it being conducted online as proper discussions could not happen in the breakout rooms and not all members in the group participated in the discussions.

There was no study found in the literature on online mode of CBL conducted as a formative tool.

Shaifaly et al, introduced CBL as a teaching learning method in teaching neuroanatomy, where after teaching 5 tracts of neuroanatomy the students were divided into groups and were given a case to discuss. After the session the students in the feedback reported that CBL was an effective learning tool and helped in better understanding of tracts. [11]

In a study, 200 students were exposed to case-based learning (CBL) and didactic lectures for Topic I in the first month. Then, the students were switched to the other method for Topic II. The students' knowledge was assessed before and after each session with multiple-choice question (MCQ) tests. Knowledge retention was assessed with another MCQ test conducted four weeks after the post-session test. The average difference between the scores on the pre-session and post-session tests in the CBL group was significantly higher for both Topic I and II than in the didactic lecture group. [12]

In the present study, the students participated voluntarily in the formative tests having no contribution to the final transcript. The number of students who attended the post-test were comparatively less than those who attended the pre-test. Even the results of the post test scores were less than the pre-test scores.

This may be because of the online mode of administration and being formative depended on the student's interest to take time to read and attempt the test. One of the possible reasons for lack of motivation of the students to accept the feedback and improve the performance was the absence of weight to the scores of the formative test.

On analysis of the time taken by the students to complete the test it was found that most of the students opened the exam for only 2-5 mins, which showed the disinterest on part of the students in attempting the test.

One of the factors for this may be the lack of enough internet access that may have not prompted them to spend time to answer the test.

Most of the students get access to the questions either by taking pictures of the question without attempting them or can even get the images of the questions from their peers.

Another reason could be that the students did not review the topics after the session was conducted.

The lack of reliability of the online exams have always been a matter of concern.

NK Mitra et al reported a similar situation where the online quiz as formative assessment did not show any improvement in student performance as compared to paper-based FA. It is usually the brighter highly motivated students that accessed online test to improve their learning. [13]

The scores of the test though were not satisfactory the fact that CBL helped majority of the students in understanding the concepts and developing interest in the subject cannot be ignored. The response of the student to the open-ended questions shows that the student participated in discussions and learned how to solve the questions. At the end of the session, they learned some new concepts that was difficult for them to understand prior to the session.

They felt that participating in the session helped them how to connect their learning to the clinical situations, which can be of vital importance in generating interest.

Some students also like that it was not graded, and were appreciative of the pre-test and posttest as it helped them have knowledge of the subject.

The feedback given by the faculty was also indicated that most of the students participated actively though the main barrier they felt was the online mode of administration of the session. Various other studies done using CBL as mode of teaching also indicated similar views. [14–16].

Limitations of the study:

Our study included students who volunteered for the sessions and absence of a control group this may limit the generalizability of the results.

Conclusion

Case based learning helps the students understand the clinical relevance of the topics in neurobiology. Being administered in a formative mode can help the students assess their understanding and the student can further improve their learning.

The greatest disadvantage of conducting an CBL session especially as a formative assessment in an online is that depends on the student's interest to attend and participate in the sessions. The barrier of poor student participation in an online environment can further discourage student attendance.

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