

Piloting Case-Based Instruction in Immunology Course for Enhancing of Cognitive Learning

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I. INTRODUCTION

Abstract

Context

Immunology as a course occupies corner stone in the domain of Biotechnology due to its relevance and applications. The significance of the course lies in its critical applications like vaccines, diagnosis and organ transplantation. Learning immunology at undergraduate level is often a challenging task for students since it involves integration of diverse concepts and coherent thinking. In this context, the present study of employing case-studies was undertaken for undergraduate students of Biotechnology engineering studying the course of immunology.

Purpose or Goal

The key objectives of the pedagogical intervention were to enhance the understanding of the fundamental immunological concepts and to induce cognitive thinking amongst the students leading to attain higher levels of cognitive dimensions of Bloom's taxonomy. At a broader level, the exercise aims to aid the increase the retention and comprehensive understanding of the concepts.

Methods

Selected clinical-case studies from "Case Studies in Immunology- A Clinical Companion" by Geha and Notrangelo was used as instrument for the intervention. 'Cooperative learning model was practiced for the activity and rubrics-based assessment was practised .

Outcomes

The exercise of case-based instruction was found to be instrumental in enhancing the cognitive learning of the course amongst the students. Also the depth of the case-studies gave them an immersive experience and enabled them to think critically and analyze the cases to arrive at appropriate solutions for the questions posed at the end of the case-study.

Conclusion

The activity was instrumental in achieving key elements of cognitive and knowledge dimensions of the cognitive process of learning. Further iterations of the exercise would be helpful in more effective implementation from the faculty perspective.

Keywords— Case-based learning; Cooperative learning; Immunology. Key-terms-based assessment

A About Immunology and its associated challenges

Immunology is the study of body's defense system and its functions. It deals with physiological functioning of the immune system in states of both health and disease as well as malfunctions of the immune system in immunological disorders like allergies, hypersensitivities, immune deficiency, transplant rejection and autoimmune disorders. Though immunology is a fascinating subject, yet arguably it is considered to be a challenging course both from teaching and learning perspectives. It involves complex interactions between innate and adaptive systems which are distinct yet interrelated.

The learning challenges of immunology for students involves comprehending the complex terminologies and think coherently about a physiological system that is so anatomically disseminated. Immunology requires students to learn the meaning of new words, and rapidly apply them to build a knowledge base and answer complex questions. Despite the course being practically relevant, it needs serious and conscious efforts from students end to internalize the concepts. Teaching immunology is challenging since it requires students to integrate knowledge derived from pre-requisite courses like Microbiology, Cell biology, biochemistry, anatomy and genetics.

B Case-Based Learning in Immunology

Conventional didactic lectures wherein students are passive learners are known to have a very minimal impact on students learning and acquisition of knowledge. They often fail to stimulate students' cognitive skills of higher order like analytical, reasoning skills and their problem-solving ability. In this context, the present study of Case-Based-Learning (CBL) was practised for Immunology course of IV semester undergraduate students of Biotechnology with an objective to enhance the learning effectiveness of immunological concepts. Case-based learning is a student-centred active learning method that facilitates the students' learning. The pedagogical intervention evokes students' interest, promote their learning, and engage them in active discussion in solving a clinical

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problem related to immunology. The CBL enables the students to apply the concepts learnt from theory to real-life scenarios reflected in the clinical case-studies using inquiry-based learning methods. This enriches their cognitive skills of higher order like critical and analytical thinking, (Tayem, 2013; Zhang et al, 2013). In the first place, the case studies in CBL though are comprehensive in nature, yet are loosely structured and hence require the students to recollect and comprehend the concepts from pre-requisite courses and articulate the concepts learnt. CBL brings in a sense of life-long learning amongst the students (McEnerney, 1999).

CBL is known to engage the students in solving complicated questions and enable to attain higher order cognitive skills by thinking cognitively about means of approaching the feasible solutions. (Stranford et al, 2020). In context of Bloom's taxonomy, generally "remember" and "understand" are regarded as lower order cognitive skills that need only a minimum level of understanding, the third level "Apply" is considered as transitional whereas the application of knowledge and critical thinking are higher-order cognitive skills (HOCS) that require deep conceptual understanding (Zoller, 1993). Students often have difficulty performing at these higher levels (Zoller, 1993; Bransford et al., 2000; Bailin, 2002).

Case-Based Learning (CBL) has gained recognition in medical education for fostering active engagement and critical thinking (Thistlethwaite et al., 2012; Parmelee et al., 2012). In the realm of immunology, CBL proves beneficial, demonstrating enhanced understanding and retention of intricate concepts among students (Radcliffe, Lester, & Perera, 2019).

Research suggests that CBL contributes to cognitive learning enhancement, particularly in medical and health science education contexts (Thistlethwaite et al., 2012; McLean et al., 2016). Comparative studies highlight the superiority of CBL over traditional lecture-based instruction in immunology, showing better long-term retention and application of knowledge (Thistlethwaite et al., 2012; Parmelee et al., 2012). Moreover, CBL positively influences student engagement and motivation, creating a more favorable learning experience (Graffam, 2007). Case-Based Instruction effectively integrates basic science principles with clinical applications in immunology courses, providing students with a comprehensive understanding of the subject (Radcliffe et al., 2019; Graffam, 2007).

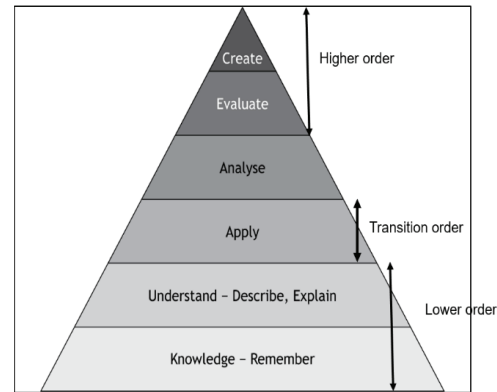


Fig.1. Levels of Bloom's taxonomy and order of learning

C Objectives of the study

The key objectives of the present study involving CBL are:

1. to incite the the students to understand the context, problem and analyse the facts of the case-scenario involved.
2. to enable the critical thinking skills in ambiguous case-scenarios, decision making, propose the possible solutions and chose the best feasible one and
3. to encourage co-operative learning amongst the team members.

II. METHODOLOGY

A Group Dynamics and target students

Engineering undergraduate students of IV semester Biotechnology were chosen for the CBL of Immunology course. Student groups (n=12) each comprising four members were formed for the CBL exercise. The groups were heterogeneous in terms of gender, merit and location. The exercise was a group activity and each group was assigned with a case-study for the purpose.

B Pedagogical instrument and reference material

Case-based instruction also referred to as case-based learning (CBL) was the pedagogical tool employed for the activity. "Case Studies in Immunology- A Clinical Companion" (VI Edition) authored by Raif Geha and Luigi Notarangelo regarded as the gold standard for clinical cases in Immunology was used as the reference study material for the activity. The rationale behind using the reference material was the clinical cases were complex and diagnostic in nature, mimic the real-world scenario, underscore the practical applications of Immunology and encompassed the test questions which were critical in nature.

C Cooperative learning- Write and Share activity

Cooperative learning wherein students work in groups towards a common course assignment was practiced with Write and Share activity. As part of Write and Share activity, the assigned topic was classified into different parts and each student of the

group was to study the assigned part in-depth and write the concept in their own words. All the members of the group were to meet, narrate their assigned part of the topic and discuss the topic in detail. The underlying objective was to bring-in individual responsibility, in-depth understanding, enhance attainment levels of students, develop positive relationships, create a learning community that values diversity and team coherence.

A template sheet for Write and Share activity consisting of topic and sub-topic and the concept chosen by the students amongst the group members was provided for bringing in the clarity and uniformity in presentation of the activity.

D Focused Group Discussion (FGD) with faculty

The learning of the student groups was facilitated by scheduling periodical focused group discussion with the members wherein the case-study topic assigned was discussed at length. The students could clear the doubts and find means of approaching the questions for possible solutions. This complimented their efforts of self-study of the topic and ingrained the conceptual understanding.

E Choice of case studies

Twelve case studies were hand-picked from the reference book and assigned to the student groups keeping in view the level of difficulty, understanding of the undergraduate students, course content and diversity of the case-scenarios. Accordingly the following is the list of case studies

TABLE I
LIST OF IMMUNOLOGY TOPICS OF CASE STUDIES

Sl. No.	Topic of Case Study	Concepts covered
1	Allergic Asthama	Regulation of Immune-response and Immune tolerance
2	Drug-Induced Serum Sickness	
3	Hyper IgE Syndrome	
4	Deficiency of the C8 Complement Component.	Immunological disorders
5	Acquired Immunodeficiency Syndrome	
6	Multiple Sclerosis	
7	Rheumatoid Arthritis	
8	Adenosine Deaminase Deficiency	
9	Hemolytic Disease of the Newborn	
10	MHC Class I Deficiency	
11	MHC Class II Deficiency	Transplantation immunology
12	Graft versus Host Disease	

E Assessment

A two-level assessment was performed to evaluate the understanding of the case-studies by the students. The first review was oral on one-to-one basis with student members of

the group. The key objective of the review was to assess the broad understanding and basic tenets of the topic assigned. This assumed significance in the light of the case studies being complex and the questions were analytical in nature which demanded a thorough knowledge of the basic concepts. All the students were expected to have a sound know-how of the concept with a threshold to attempt the test questions.

The second review was through a written report submitted as a group activity by the students. The report comprised responses to the questions which were critical and evaluative in nature. The students were expected to propose possible solutions with one best alternative. Given the descriptive nature of the report it needed a detailed study into the case study with reading between the lines and comprehending the information with an objective of attempting the questions which were critical in nature.

An aid in the form of key-word based assessment was practiced which proved to be an efficient solution for evaluating electronically (Mahmud et al, 2020). This was coupled with the descriptive evaluation of the written reports to assess the comprehensive understanding. The assessment was rubrics-based and inputs from different external experts working in the area of immunology was taken for the assessment.

F Insights into a Model Case Study

A model case study entitled “ Allergic Asthama was assigned to a students’ group. The case study dealt with a case Frank Morgan-a 14-year boy with chronic asthma and rhinitis. Allergic Asthama is a Type-I hypersensitive chronic allergic disease caused by adaptive immune response to an inhaled antigen.

The following are sample questions posed as part of the CBL activity.

1. Explain the failure of Frank's asthma to improve despite the frequent use of bronchodilators, and his response to steroid therapy.

Keyword answers: Sensitized mast-cell, Degranulation, histamine, cytokines,

2. Eosinophilia is often detected in the blood and in the nasal and bronchial secretions of patients with allergic rhinitis and asthma. What is the basis for this finding?

Keyword answers: allergic rhinitis, Montoux test, IgE. Leishmans stain.

3. Frank developed wheezing on several occasions after taking the nonsteroidal anti-inflammatory drugs (NSAIDs) aspirin and ibuprofen (Motrin). Explain the basis for these symptoms.

Keyword answers: asthma exacerbation, cyclooxygenase inhibition, Polypoid hypertrophy.

Essentially the questions seek answers in the light of diagnosis, immune-response of the patient and rationale for the therapy administered by the physician.

III RESULTS AND DISCUSSION

A Graduate attributes and Course Outcomes

The CBL activity was instrumental in addressing some of the course outcomes outlined in the course. Also few graduate attributes expected of an undergraduate Biotechnology graduate could be addressed which would have been difficult to meet by routine methods of delivery and assessment. The following Table 2 summarises the competencies, performance indicators and course outcomes attained as a result of CBL implementation.

TABLE II
GRADUATE ATTRIBUTES AND COURSE OUTCOMES

Competency	Performance Indicators	Course Outcomes addressed
1.2 - Demonstrate the competence in basic sciences	1.2.1 - Apply laws of basic science to an engineering problem	1. Analyze the mechanism of Cell-mediated Immunity, Major Histocompatibility Complex and Phagocytosis (L4)
1.4 - Demonstrate competence in domain knowledge of Biotechnology	1.4.1 - Apply knowledge of molecular biotechnology to solve conceptual engineering problems	2. Apply the principles of Complement system, cytokines, immune tolerance and hypersensitivity reactions in immune responses (L4) 3. Apply the concepts of autoimmunity & immunodeficiency and their associated disorders (L4)

A total of twenty marks were apportioned for the CBL activity with ten marks each for review 1 and 2. Among the total of fifty students, 15% 65% and 20% students scored in the range of 10-13, 14-16 and 17-20 marks. Majority of the students fairing average (14-16 marks out of 20) can be attributed to the facilitation of learning by cooperative learning. Given the criticality of the questions based on the complex case scenario this would have been difficult otherwise. Nevertheless the activity gave a rigor of learning experience for the students.

B Key experiences from the CBL activity

The students expressed that their depth of understanding enhanced due to reading and re-reading of the concepts. The write and share activity of cooperative learning not only honed the technical writing skills but also made them responsible learners amongst the group members. They appreciated the practical relevance of the immunology course in day-to-day life. The inclusion of external experts as stake-holders for evaluation brought in new thought processes and objectiveness

to the activity. The course instructor in the process of facilitation had an overall knowledge of the all the concepts dealt.

From the faculty's perspective, studies indicate a positive attitude towards CBL in immunology courses, with many instructors recognizing the value of real-world cases in enhancing student learning (McLean et al., 2016). However, challenges exist, including the need for effective case selection, time constraints, and potential resistance from traditionalists (Parmelee et al., 2012; McLean et al., 2016).

In assessing CBL in immunology, diverse strategies such as case-based exams, group discussions, and reflective essays are proposed, showcasing a range of evaluation methods (Thistlethwaite et al., 2012). Moving forward, further research is crucial to explore optimal strategies for implementing CBL in immunology courses, considering variations in student backgrounds, institutional contexts, and the evolving landscape of medical education (Radcliffe et al., 2019).

III. CONCLUSION

The study on Case-Based Learning (CBL) in Immunology for fourth-semester Biotechnology engineering undergraduates demonstrated several key achievements. The primary objectives of the study were successfully met, including the stimulation of students' understanding of case scenarios, fostering critical thinking skills in decision-making, and promoting cooperative learning within diverse teams. The selection of "Case Studies in Immunology- A Clinical Companion" as the reference material proved effective in presenting complex, diagnostic, and real-world scenarios, aligning well with the pedagogical tool of CBL.

The implementation of cooperative learning through the Write and Share activity facilitated individual responsibility, in-depth comprehension, and positive relationships among group members. Focused Group Discussions (FGD) with faculty members further enriched students' conceptual understanding, providing a platform for clearing doubts and refining problem-solving approaches. The choice of twelve diverse case studies ensured a comprehensive coverage of difficulty levels, aligning with the undergraduate students' understanding and course content.

The assessment methodology, involving both oral reviews and written reports, provided a robust evaluation of students' comprehension. The results indicated that the CBL activity effectively addressed course outcomes and graduate attributes, contributing to a meaningful learning experience.

In summary, the study demonstrated that CBL in Immunology, when integrated with cooperative learning strategies, diverse case studies, and robust assessment methods, can effectively enhance students' critical thinking, problem-solving skills, and

overall understanding of complex subject matter. The positive feedback from students and the alignment with course outcomes underscore the value of CBL as a pedagogical approach in higher education.

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