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Impact of experiential learning among medical undergraduates: A randomized controlled trial

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Abstract:

BACKGROUND: Experiential learning sessions as a teaching aid have been applied early in the medical undergraduate curriculum to improve the knowledge and inculcate research interest. We compared the ability of 1st-year medical undergraduates to answer the molecular biology questions among those who had attended the experiential learning sessions of molecular biology techniques versus those who did not attend.

SUBJECTS AND METHODS: A randomized controlled trial was carried out with 200 1st-year medical undergraduates, among whom 69 students were selected by simple random sampling for the demonstration of the molecular biology techniques, such as isolation of genomic DNA, polymerase chain reaction, cell culture techniques, western blotting, and high-performance liquid chromatography for 1-week duration. Student's feedback was collected on a five-point Likert sc ale at the end of the session to understand how they agree or disagree with a particular statement. The content validity rate (CVR) and content validity index (CVI) of the questionnaire were determined, and its internal consistency was examined by Cronbach's alpha. The internal assessment marks of these students, valued by faculty who were blinded to their training sessions, were compared with the rest of the 131 students by independent *t*-test to know the outcome of these experiential learning sessions.

RESULTS: On CVR and CVI assessment, all the questions scored more than 0.70 and 0.85, respectively. Cronbach's alpha for the whole questionnaire was 0.85. Student's feedback indicated that these sessions did complement the cognitive skills acquired for these techniques. We also found a statistically significant improvement ($P = 0.006$) in the examination performance between the students who attended versus those who did not attend the experiential learning sessions.

CONCLUSION: Experiential learning, through demonstration and hands-on experience, enhance d the learning of molecular biology techniques among 1st-year medical undergraduates.

Keywords:

Cell culture techniques, medical education, molecular biology, polymerase chain reaction, western blotting

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Introduction

Molecular biology is an integral part of biochemistry, the knowledge of which helps in understanding various complicated biochemical mechanisms in both health and diseased conditions. It is a field of science that deals with the structure, function, and properties of biological molecules and also describes the mechanism of how they contribute to the regulation of biological processes.[1] Over the past few years, molecular biology has witnessed major advances and rapid progress, suggesting its strong impact on all disciplines of life science.[2] Diagnostic molecular biology is one such fast-evolving discipline of laboratory medicine that is widely used in several areas, including immunology, hematology, oncology, and microbiology.[3] These advances have also stimulated the concept of research in young minds allowing revolutionizing discoveries

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not only in the field of molecular biology but also in the other related fields as well. With the help of these sophisticated techniques, we are now able to understand the underlying molecular mechanisms, manipulate the components of the mechanism, and observe the effects.[4] Hence, it becomes the need of the hour to expose the young 1st-year medical undergraduate students to these techniques early in their medical training to master the basic principles, thereby enriching their knowledge and capability to analyze and interpret the results of the molecular biology assays.

In the past few decades, education has focused on emphasizing skill development during undergraduate medical training.[5] This has made way for several innovations in the teaching–learning methodologies, with experiential learning being one of them.[6] Experiential learning allows the student to have outside the classroom learning experience to acquire the knowledge and skill, which otherwise would not have been possible with the regular didactic lectures. In this regard, the 1st-year medical undergraduates were taken to the molecular biology facility available in the institute to have exposure to all the basic molecular biology techniques. We then compared the ability of these students to answer the molecular biology questions to those who did not attend these sessions. With this, we aimed to study the impact of experiential learning to understand the molecular biology techniques which otherwise would be difficult with didactic lectures.

Subjects and Methods

- Study type: Randomized controlled trial
- Study year: 2018–2019 batch of MBBS students
- Type of sampling: Simple random sampling.

Institutional ethical committee clearance was obtained before the commencement of the study (JSSMC/IEC/04/0106/NCT/2018-19 dated June 16, 2018). Sixty-nine 1st-year medical undergraduates (batch 2018–2019) out of 200 students were selected by simple random sampling and were taken in small groups for a week's training and hands-on experience of the basic molecular biology techniques in the research facility available at our institute. Each group, consisting of not more than six students, was handled by one faculty along with one PhD scholar. Three to four such groups visited the laboratory in 1 day, and this exercise was carried out for 7 consecutive days.

Each group was demonstrated the basic molecular biology techniques, such as isolation of genomic DNA by spin-column technology, DNA gel electrophoresis, use of a spectrophotometer to analyze the quantity and quality of the DNA, preparation of the polymerase chain reaction master mix, programming the thermocycler, instrumentation required in the cell culture laboratory, demonstration of the preparation of gel for western blot, how to load the sample, preparation of the transfer sandwich, showing the parts of the high-performance liquid chromatography, and explaining its principle and basics of result analysis.

Student's perception was obtained on a 5-point Likert scale, the content validation of which was conducted through a face-to-face approach by an expert panel comprising six members. Content validation form with clear instructions was provided for this process. The experts were briefed about the study and were requested to critically review each item in the questionnaire before providing their scores. All the comments of the experts were taken positively to refine the questions. Before the calculation of content validity rate (CVR) and content validity index (CVI), the relevance rating was re-coded as 1 (for scale 3 and 4) or 0 (for scale 1 and 2). CVR was calculated using the formula: CVR = ([E – (N/2)]/[N/2]), where E is the number of experts who rated the question as relevant and N is the total number of experts. CVI was calculated using the formula: CVI = agreed item/number of experts. The overall internal consistency of the questionnaire was measured by Cronbach's alpha using the formula $\alpha = (k/[k-1]) \times (1 - [(\sum s_i^2)/s_t^2])$, where k = number of items in the questionnaire, s_i = standard deviation [SD] of the i^{th} item, and S_t = SD of the sum score. Questions on molecular biology techniques were incorporated into the internal assessment examination. The valuation of the answer sheets was done by the faculty who were blinded to the training status of the students. The scores of the internal assessment test, of the students exposed to the experiential learning sessions, were compared with the nonexposed group to know the outcome of these learning sessions. However, the nonexposed group too were demonstrated these techniques after the internal assessment.

Statistical analysis

Data collected were entered into MS Word 2010 and analyzed using SPSS version 24, Illinois, Chicago, USA. Descriptive statistical measures such as percentage, mean, and standard deviation were applied. Inferential statistical tests such as independent sample *t*-test and Spearman's rank correlation were applied. The differences and correlations were interpreted as statistically significant at $P < 0.05$.

Results

On CVR and CVI assessment, all the questions scored more than 0.70 and 0.85, respectively. Cronbach's alpha for the whole questionnaire was 0.85. The CVR can measure anywhere between −1.0 and 1.0. The closer

the measure is to 1.0; the more essential is the item under consideration. On the other hand, the closer the measure is to −1.0; the more nonessential is the item under consideration. All the items in our questionnaire measured above 0.70, indicating that they were essential components of the questionnaire. The CVI was calculated separately for each question. The questions whose CVI score is more than 0.75 is generally considered as an appropriate one. All the items in our questionnaire had a score of >0.85, deeming them as appropriate. The alpha score should be ≥0.8 to be acceptable of having overall internal consistency. The overall alpha score of our questionnaire was 0.85, indicating that the set of items is closely related as a group.

Among the total 69 students, 84.1% were aware of the molecular biology facility available in our institute. 58% of the students agreed and 40.6% of the students strongly agreed that experiential learning in molecular biology did complement their curriculum [Table 1]. 47.8% agreed and 49.3% strongly agreed that through this exercise, we were providing them with the opportunity to learn and practice the current laboratory techniques utilized by the scientists. 88.4% of the students mentioned that the time allotted for this exercise was sufficient for them to learn and understand the technique. 49.3% agreed and 47.8% strongly agreed that their visit to the molecular biology laboratory has increased their understanding of the molecular biology techniques, and they would recommend this visit to all the other students. None of the students disagreed with any of the above statements [Table 2].

The students who attended the experiential learning in molecular biology scored higher marks in the internal assessment, the syllabus of which mainly contained molecular biology. The mean internal assessment marks of these students were 40.03 ± 7.59, which was significantly more ($P = 0.006$) when compared to the other 131 students (36.03 ± 9.12) out of the maximum marks of 60 [Table 3]. There was a significant positive correlation between the feedback given by the student and the marks obtained by them in the internal assessment ($r = 0.6$ and $P = 0.04$) [Table 4].

Table 1: Frequency table analyzing the response of the students to question 1 and 2

Where you aware of the molecular biology laboratory in your institute before your visit		
Response	**Frequency**	**Valid percent**
No	11	15.9
Yes	58	84.1
Total	69	100.0
One of our goals is to provide experiences that complement your curriculum. Overall, how well are we meeting this goal?		
Response	**Frequency**	**Valid percent**
Cannot comment	1	1.4
Agree	40	58.0
Strongly agree	28	40.6
Total	69	100.0

Table 2: Frequency table analyzing the response of the students to question 3-6

Another goal is to provide students with the opportunity to learn about and practice current laboratory techniques utilized by scientists. How well are we meeting this goal?		
Response	**Frequency**	**Valid percent**
Cannot comment	2	2.9
Agree	33	47.8
Strongly agree	34	49.3
Total	69	100.0
Was the time allotted sufficient?		
Response	**Frequency**	**Valid percent**
Not sure	8	11.6
Yes	61	88.4
Total	69	100.0
The visit to the molecular biology laboratory has increased my understanding of molecular biology techniques		
Response	**Frequency**	**Valid percent**
Cannot comment	2	2.9
Agree	34	49.3
Strongly agree	33	47.8
Total	69	100.0
Would you recommend this visit and experience to others?		
Response	**Frequency**	**Valid percent**
Yes	69	100.0

Table 3: Student *t*-test to compare the marks of the study group and control group (maximum marks=60)

Group	*n*	Mean marks	SD	Significant (two-tailed)
Study group	69	40.03	7.59	0.006
Control group	131	36.03	9.12	

SD: Standard deviation

Table 4: Pearson correlation

Correlation	Feedback	
	r	*P*
Total marks	0.60	0.04
n	69	69

Discussion

Updating ourselves with the recent advances in molecular biology and biotechnology makes us understand the use of this technology in preventive medicine (vaccine preparation),[7] early diagnosis (identification of biomarker),[8] personalized medicine (production of drugs),[9] agriculture, and many other important areas. Exposing the 1st-year MBBS students to the basic techniques used in molecular biology becomes important to help them acquire the knowledge of scientific thinking.[10] Listening to the traditional descriptive presentations may not help

the students to develop the ability to analyze the experimental data. Interactive teaching in small groups has been well appreciated by the students who have shown better performance when compared to the traditional teaching–learning methods.[11] Subsequently, by providing them with the hands-on experience, we can help them to effectively obtain some amount of basic skills to practice the science of molecular biology.

Evidence-based medicine contributes significantly to the advancement of science, and it becomes the need of the hour that every doctor conducts research and contributes to the generation of evidence.[12,13] To conduct research, adequate knowledge, inculcating practical skills, and developing the right attitude become vital. In India, research methodology is not incorporated as a part of the medical curriculum. Keeping in mind the emerging trend of evidence-based medicine, it becomes necessary to modify the exciting system of medical education and promote the research culture. However, previous studies have shown that medical student's willingness to conduct research and adopt a career in the field of research is very minimum.[14] Possible reasons for this could be poor training in research skills during their medical curriculum.[15] Offering them with supportive research programs with skilled faculty mentoring them through this process increased their interest and productivity toward research.[16] To introduce the concept of research in the 1st-year medical undergraduates, we organized these experiential learning sessions. Various techniques that were already explained to them in the theory classes in the form of didactic lectures were demonstrated to them during these sessions. The students opined that this kind of experiential learning complemented the didactic lectures and lead to a better understanding of the topic or technique. They felt that they could now better apply these techniques during their research activity. It also increased their interest in molecular biology which was reflected by their improved marks in the subsequent internals. The overall feedback from this study indicates that the students were very receptive to this type of learning and enjoyed this new methodology. However, allocating only 1 week for this exercise was the limitation of the study as these techniques require a longer duration of training to gain the required skill. We not only collected and analyzed the feedback from the students but also compared their internal marks which have further helped us to strengthen our conclusion about the positive impact of experiential learning sessions.

Conclusion

Using multiple tools of teaching methodology for undergraduate medical students becomes necessary to make them understand difficult, but yet important topics such as molecular biology. Combining the traditional descriptive presentation, with that of demonstration of these basic techniques, compliments the curriculum of the undergraduate medical training.

We have already introduced techniques such as isolation of DNA, agarose gel electrophoresis, western blotting, and good cell culture practice as a part of their regular practical's during undergraduate training. We also plan to introduce the working protocol and instrumentation of the clinical biochemistry laboratory as well, to the 1st-year medical graduates.

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Conflicts of interest

There are no conflicts of interest.

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