



## Teaching statistics to medical undergraduates using interactive and participatory sessions

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### Abstract

**Introduction:** In India, medical undergraduates think that statistics is difficult to understand. Often, it is taught just before final assessment examination using didactic lectures, with little use of medical examples and less focus on application. Hence, we prepared interactive, participatory sessions for teaching biostatistics to medical undergraduate.

**Methods:** The sessions were delivered by a facilitator. It had clearly specified objectives and teaching learning strategies. A needs assessment was done by interviewing the students who had undergone traditional biostatistics teaching methodology. Specific learning objectives for the sessions were finalized using the Delphi technique and review of University syllabus. Two trained Community Medicine faculties designed the lesson plans 'backwards' from desired outcome to content, teaching/learning strategies, assessment and evaluation process (Outcomes-based lesson planning). Forty, third-semester (Para-clinical phase of the second year) medical undergraduates undertook these seven teaching sessions. The session followed adult learning principles and included group discussions, games and reflections. We evaluated the impact of the sessions using in-depth interviews, retrospective post-then-pre-self-assessment and a pre-announced written test.

**Results:** With traditional statistics teaching methodology, students perceived it as a standalone subject and were not interested in statistics. Students who underwent the sessions commented that the sessions were enjoyable, interesting, and participatory and more than %90 of them felt they were engaged throughout the session. They also narrated various instances where they could apply the biostatistics learning. In the post-then-pre-assessment median post-session scores for all the objectives were significantly higher ( $p < 0.050$ ).

**Conclusion:** Use of interactive, participatory sessions for teaching biostatistics to medical undergraduates resulted in a positive reaction and better learning. They also applied these concepts while reading textbooks, listening to lectures and during clinical postings.

**Keywords:** Biostatistics, Teaching, Medical undergraduates

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*Please cite this paper as:*  
Mahalakshmy T, Dongre A  
R, Kalaiselvan G. Teaching  
statistics to medical  
undergraduates using  
interactive and participatory  
sessions. J. Adv Med&Prof.  
2013;1(4):106-112.

Received: 4 April 2013  
Accepted: 2 July 2013

### Introduction

The World Federation of Medical Education global standards envisage incorporation of biostatistics as part of behavioural and social sciences so as to enable effective communication and clinical decision making by graduating doctors (1). Vision 2015 of Medical Council of India identifies competencies for training of medical undergraduates to function as a

competent "Physician of First Contact". One of these competencies is the ability to collect, analyze and utilize health data. This requires understanding of principles of biostatistics (2). Swift et al. also recommended teaching statistics to medical undergraduates by highlighting the subject's relevance in their career as a doctor (3). However, medical undergraduates in India believe that statistical concepts are difficult

to understand (4). Some of the challenges faced in teaching biostatistics to medical undergraduates are -diverse backgrounds/teaching skills of instructors of statistics; focus on memorisation of the statistical formulas; focus on mastering in computation of various statistical measures; and less focus on applied statistics especially in medical profession (5, 6). In India, biostatistics is taught by the statistician cum lecturer with qualification of Masters in statistics (7) who have varying experience in the application of statistical principles in Medicine. Often, biostatistics is taught just before final assessment examination using didactic lectures with less involvement of students. Hence, we prepared interactive, participatory sessions for teaching biostatistics to medical undergraduates. The sessions were held by a facilitator. It had clearly specified objectives, i.e. teaching learning strategies.

## Methods

**Setting and study design:** This study was done at the Department of Community Medicine, Sri Manakula Vinayagar Medical College and Hospital in rural Puducherry, South India. The department is refining and strengthening its teaching learning strategies for medical undergraduate. The college admits 150 medical students per year for a five and a half year course. This innovation was done in three phases. The first phase was needs assessment and finalization of the objectives of the biostatistics sessions for medical undergraduates. The second phase comprised of outcome based lesson planning of the sessions and its implementation. The third phase included an appraisal of the student's learning experience and assessment of the impact of the sessions.

**Phase I: Needs assessment and finalisation of the objectives of the biostatistics sessions for medical undergraduates:** We did need assessment by conducting in-depth interviews. An assistant professor of the department trained in qualitative research interviewed the students. Final year medical undergraduates who had passed Community Medicine final examination were interviewed with the objective of understanding the students' learning experience with the current biostatistics teaching methodology. The students from various performance grades in university examination, who were willing and expressive, were purposefully selected. They were interviewed till the saturation and there were nine interviews of 40-50 minutes each. The interview was done during their free time in the college campus. The interview summary was shared with the students and was participant validated.

Delphi Technique was used for finalization of the objectives of the sessions (8). Delphi panel consisted of geographically scattered, eight public health experts in India, who were willing to participate. Panel members were involved in teaching biostatistics for medical undergraduates for more than five years. Four rounds were undertaken in the Delphi method. In the first round, experts were asked an open ended question to list the outcomes/competencies pertaining to biostatistics that is expected of a medical undergraduate. Content analysis of the responses was done and a list of outcomes was derived. In the second round, panel members rated the importance of these outcomes in a four point scale. Consensus measure, expressed in percentage, was obtained for the outcomes. The consensus percentage was provided to the panel members and they were asked to review their individual rating in view of the group's response. This constituted the third round. Consensus percentage was calculated for the third round and Delphi panel members had an opportunity to reconsider their rating. This was the fourth round. A value above %80 was considered as good consensus.

**Phase II: Outcome based lesson planning of the sessions and its implementation:** Based on the outcomes shortlisted by the Delphi Technique and review of University syllabus, specific learning objectives for the sessions were formulated. Two faculty members of Community Medicine trained in medical education designed the lesson plans 'backwards' from desired outcome to content, teaching/learning strategies, assessment and evaluation process (Outcomes-based lesson planning) (9). The findings of the needs assessment (in-depth interview) and the Delphi Technique were triangulated while planning the sessions. Seven sessions were planned with two to three specific learning objectives in each session. Teaching/learning strategies were formulated based on adult learning principles, and principles for effective facilitation of small group teaching (10-12).

One batch of third-semester (Para-clinical phase of second year) medical undergraduates consisting of forty students undertook these seven teaching sessions during the classes allotted for teaching biostatistics. We had one session per week, each lasting for two hours. The sessions were made interactive, activity based and facilitated by the first author. The second and third authors observed the sessions and gave feedback. The session started with a recapitulation of the previous sessions and listing of the specific learning objectives of this session. At each session, facilitator briefed the 40 students, and then they

worked in small groups of eight each and presented their group work to the bigger group of 40 students. Every session had group activities to reflect on the application of these concepts in their professional life. They were also given the flexibility to comment on the application of the concepts in personal/day-to-day life. This was done to create interest, stimulate participation of all group members, and add fun to the session. The facilitator was always appreciative, encouraging and followed principles for facilitating adult learning (12). Games using colored balls for sampling techniques, concept of sample size, cup of sand for explaining normal distribution, tossing of the coin for role of chance, and voting for classification of variable were used. Some sessions used activities such as interpretation of given data set/scenario. Activities such as sharing of experience of students who had done research projects, group quiz and giving feedback on the group's presentation were included to encourage constructive competition between the groups. Students were given hands-on experience for basic analysis using the Epi\_info software package.

**Phase III: Qualitative and quantitative assessment of the impact of the sessions:** We evaluated the student's perception and impact of the session quantitatively and qualitatively. Qualitative method used was in-depth interviews. During the interview, they were asked about their learning experience, feedbacks, and benefits of the knowledge gained in the session. Interviews were conducted by a faculty member not involved in facilitating the session outside the department within the college campus. Interview was done till saturation and we finally did six interviews of around 45 minutes each. Quantitative methods used were retrospective post-then-pre self-assessment and a pre-announced written test. At the end of each session, retrospective post-then-pre self-assessment was obtained from students anonymously using six point scales. It assessed the extent of achievement of the session's learning objectives. The 'retro-pre design' was adopted to control response 'shift bias' which could appear due to limited knowledge of students on biostatistics at the start of the session (13). A pre-announced written test was conducted after all the sessions. It included short answer and application type of questions based on the learning objectives of the session. A senior batch of students who had undergone traditional teaching of biostatistics also undertook the same evaluation. The scores of both the batches were compared.

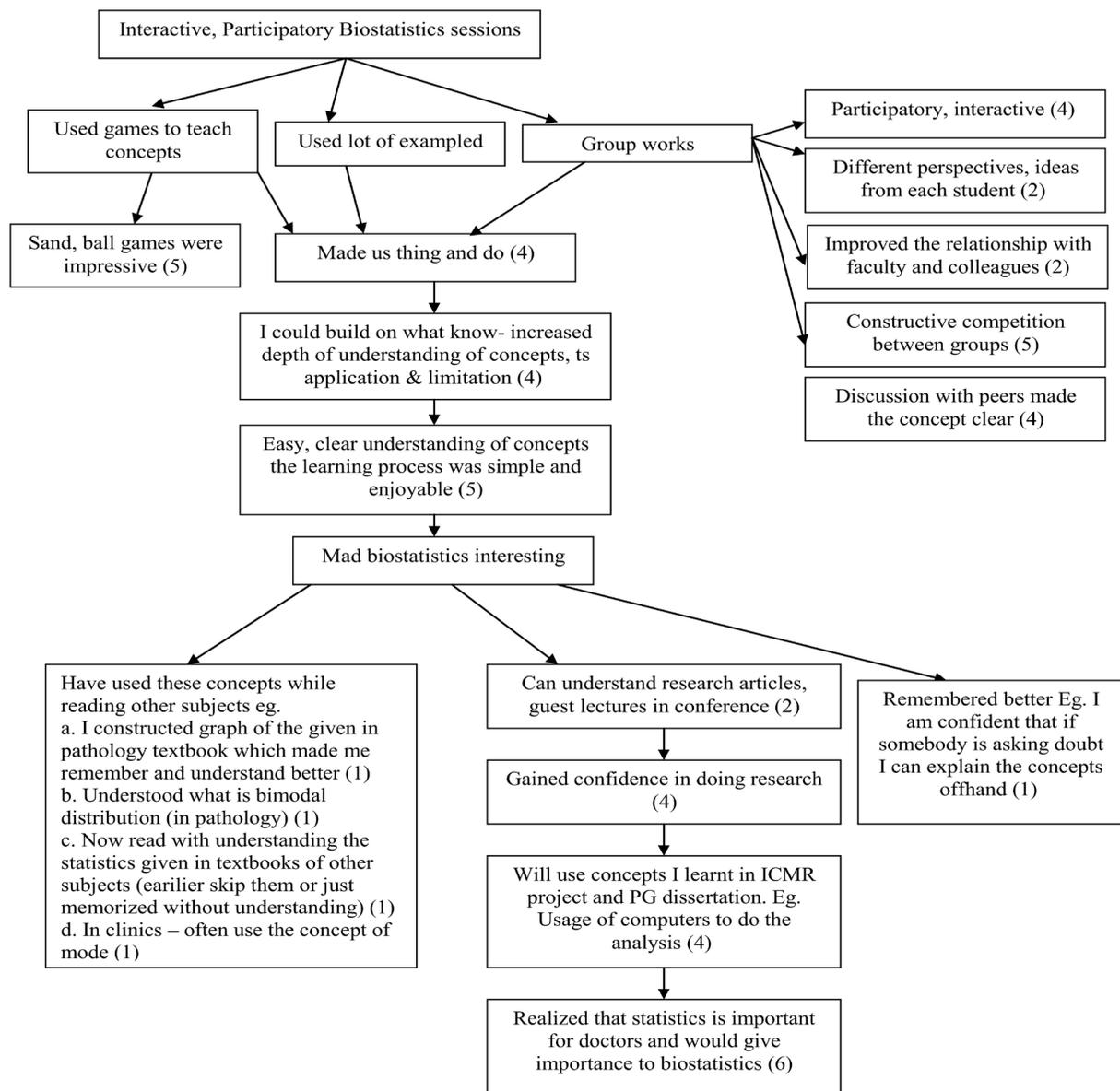
**Data Analysis:** Interviews were audio recorded and transcribed later. Manual content analysis of the qualitative data was done by first author and the

second author reviewed it. The interview summary was participant validated. The results of the content analysis were depicted in the form of conceptual framework. Quantitative data were analysed using SPSS version 11.5. Wilcoxon signed rank test was applied to find out statistical significance of the difference in median pre-and post-scores of the retro-pre design. Non-parametric test was used as these scores had non-normal distribution. Unpaired-t-test was used to compare the written test score of the students taught using these interactive, participatory sessions and the traditional training. Approval was obtained from the Institutional Ethics Committee.

## Results

**Learning experience of students with traditional teaching of biostatistics:** Learning experience shared during the in-depth interview by the final year medical undergraduates who had undergone traditional teaching of biostatistics is summarized in Figure 1. Students just memorized answers for commonly asked examination questions and learned to solve a set of statistical exercises. They were disinterested in biostatistics. Reasons for this could be grouped into four broad categories. They were factors related to teachers, topic (biostatistics) features, reading material (books) and student's attitude (Fig 1). Students' attitude varied with some being interested and others not interested in biostatistics. A student raised a query *Is biostatistics important for doctors? Why should we read biostatistics?* An interested student expressed *I did a short term student project and I know the importance of statistics but I did not understand it. When my friends and I presented the project in the conference, we were asked about p value, I could not answer it. When we were not able to answer, people think our work is fake. Now, I lost interest in statistics.* Two students were also worried that *if we don't read during MBBS how we would read the basics (biostatistics) during PG (post-graduation). During PG nobody would teach us.* Another remark was *for us statistics was taught just before the exam. We did not get a chance to apply and understand. If we were taught some basic statistics in second year then reinforced regularly during theory and clinical posting, our understanding of statistics would be better.*

**Delphi Panel Technique:** By Delphi Technique in the fourth round, seven outcomes showed good consensus (>%80). These outcomes were (a) present data in tables and interpret it, (b) present data in graph and interpret it (c) differentiate the types of variables (d) measures of central tendency and its application, (e) measures of dispersion and its application, (f) know sampling frame and be able to do sampling using



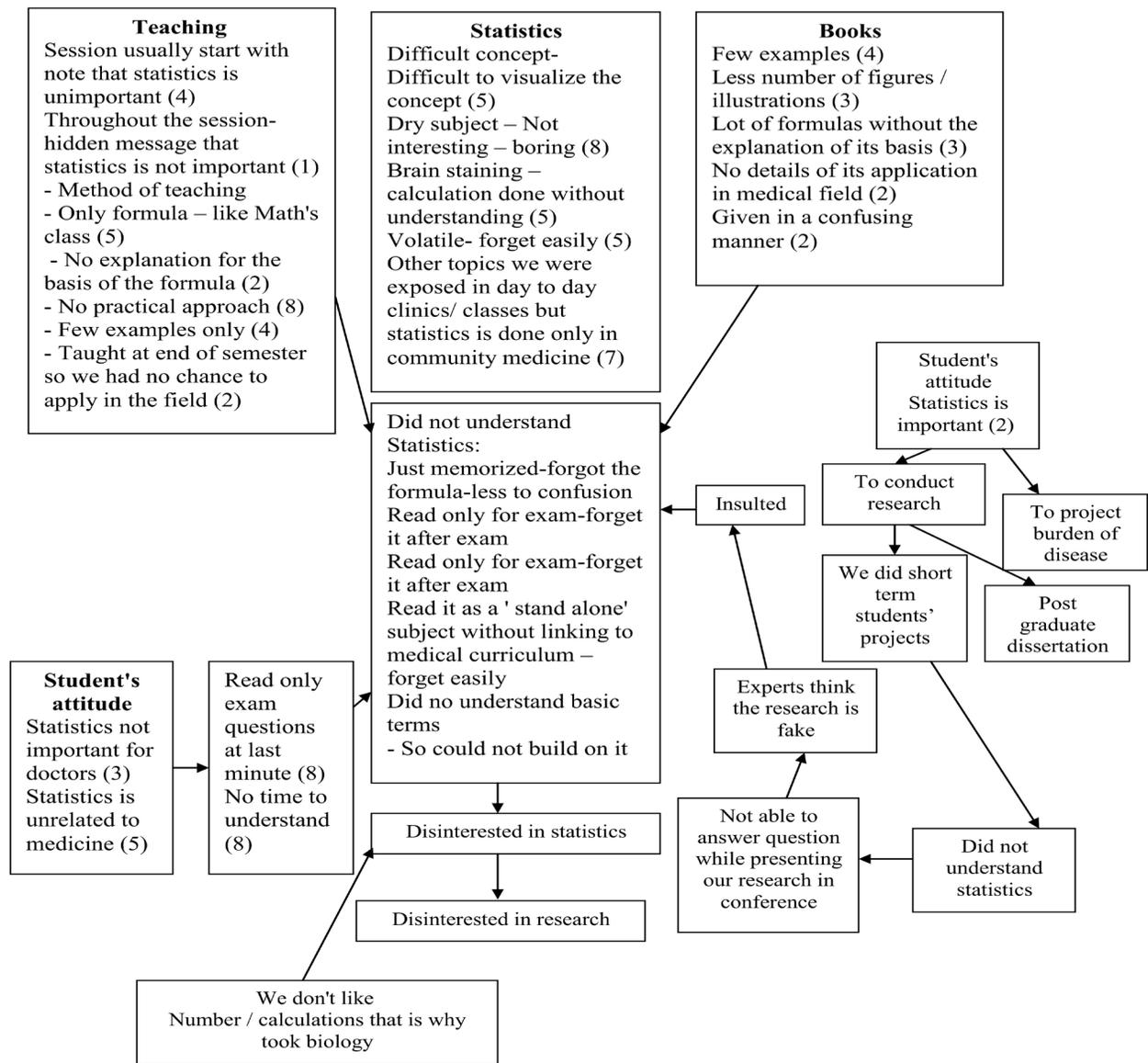
**Figure 1.** Conceptual framework of biostatistics learning experience by traditional teaching methodology

various procedure,, (g) understand the concept of the normal curve and the standard normal curve.

**Qualitative Assessment of the Impact of these Sessions:** The results of the content analysis of the in-depth interview with respect to the evaluation of the sessions are summarized in Figure 2. In the interview, students commented on the benefit of group work - *discussing with friends was nice. We could get concepts very clearly..* Students expressed that they have become interested in research, as they learnt the basics for doing research. Students believed that biostatistics are interesting and important for doctors. Students appreciated the classes which had ball games, games with sand and the session on graphs, classification of variables and framing of hypothesis. Students opined that session on measures of dispersion needs more interaction. Students narrated how they had used these concepts while reading textbooks, listening to lectures and during clinical posting. One student said that *when*

*reading my pathology textbook I could understand what bimodal distribution is. I was happy when I could apply. I also converted a table given in textbook into a pie chart. This made me remember better.* Another student told *I pointed out in a lecture class that mean should be a single number; it cannot be expressed as a range. My teacher appreciated me. I was happy.* These narrations show that students could link their learning to their own practice. Early exposure to the sessions in second year gave them lots of opportunities to apply and learn.

**Quantitative Assessment of the Impact of the Sessions:** Feedback of students on the sessions was good. Most of them (%90 to %96) felt that the materials covered in various sessions were just right. Less than %10 of the students believed the sessions were too basic. The majority of students (%100 to %91.3) felt that they were engaged throughout the sessions. An



**Figure 2.** Conceptual framework of biostatistics learning experience of students exposed to these interactive, participatory sessions

average of 35 students attended each of the session. Median post-session score for all objectives of the sessions were significantly higher ( $p < 0.05$ ). The pre-announced test was taken by 38 students in the new teaching methodology group and 29 students in the traditional teaching group. In the pre-announced written test, the students who underwent the new teaching methodology of biostatistics scored %57.5 points ( $SD=19.6$ ). The senior batch of students, who underwent traditional teaching of statistics, scored %43.7 points ( $SD=14.5$ ). This difference was statistically significant ( $p=0.002$ ).

**Discussion**

The students taught by the traditional teaching methodology considered statistics as a standalone subject and were disinterested in statistics. Usually biostatistics is taught in the last semester, so the students believed that they had few opportunities to

apply these concepts. Hence the biostatistics sessions were done in the third semester. Hence, we prepared an interactive, participatory session for teaching medical undergraduates. The sessions had many group activities and games. The student’s learning was evaluated for their reaction, learning and self-reported changes in behaviour. These belong to levels 1, 2 and 3 of the Kirkpatrick Assessment Model (14). Reaction (level 1) was evaluated qualitatively using an in-depth interview, immediate feedback with respect to the student’s involvement. Students commented that the sessions were enjoyable, interesting, and participatory; more than %90 of the students believed they were engaged throughout the session. Students’ learning (level 2) was assessed by post-then-pre assessment and written test. In the post-then-pre assessment median post-session scores for all the objectives were significantly higher. They also scored better on the written test as compared to the students

who underwent traditional teaching of statistics. The level 3 evaluation was preliminary and only self-reported changes in behaviour were assessed. In the in-depth interview, the students narrated various instances where they could apply the biostatistics learning.

Students who underwent traditional teaching of biostatistics told that statistics was not interesting and boring. However, the students who underwent the interactive teaching method felt the session was enjoyable (Kirkpatrick level 1). Positive reaction and attitude to the sessions will facilitate learning and application of the learning (15). Students felt engaged throughout the session as they were given the opportunity to share their knowledge, assume different roles in a group and assume responsibility for the presentation. This followed the adult learning principle of autonomy (12).

Scores obtained in post-then-pre assessment and written test showed that knowledge of students improved with the sessions (Kirkpatrick level 2). Learning was facilitated by the activities which incorporated adult learning principles such as providing many health related examples (being practical and problem oriented), asking students to give similar examples (capitalizing on their experience, integrating new ideas with the existing knowledge), low risk small group activity (promote their self-esteem); all discussions were appreciative and encouraging (show respect to individual learners). Students also commented that group discussions/group works facilitated their learning from peers and facilitated clear understanding of the concepts.

Though Kirkpatrick level 3 evaluations were preliminary, the students narrated examples where they applied these concepts while reading textbooks of para-clinical and clinical subjects. These would enable the students to gain full understanding of the subject matter explained in textbooks, thereby facilitating deep learning (16). Students also commented that they would use their learning on biostatistics for doing research in the future. Learning of biostatistics has increased the confidence of students to research. It is also identified that limited familiarity with statistics is identified as one of the barriers for involvement in clinical research (17).

## Conclusion

Some of the successful innovations used in teaching biostatistics in developed countries have used multidisciplinary approach, problem based learning and stimulations on the internet (18-20). The sessions were prepared taking into consideration the present learning environment, background of entry level undergraduates of local setting and that the students

were in the early years of undergraduation. While planning the teaching/learning methods, we used the lessons learnt from review of literature. For example, teaching biostatistics to medical undergraduate students should be to instill concepts, application of the concepts rather than numerical skills (21) and that the use of many common examples to explain biostatistics is effective (22).

The limitation of the study was that there could be a social desirability bias, but we tried to control it by keeping the feedbacks anonymous. We also did not evaluate the long term impact or retention of the learnt biostatistics skills. The objectives of our sessions were shortlisted by the Delphi Technique considering the learning environment, background of entry level undergraduates in India. The sessions were different from traditional teaching methods in that it incorporated small group teaching with the same staff, active learning, emphasizing the application of the concepts, insisting on conceptual understanding of statistics rather than the mathematical calculation, done during the early years of under-graduation course. Considering the above factors, it could be replicated in other medical colleges with the existing resources.

## Acknowledgement

We also acknowledge PSG-FAIMER Regional Centre, Coimbatore, India fellows for their help.

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