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Original Article

Evaluation of interactive teaching for undergraduate medical students using a classroom interactive response system in India

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ABSTRACT

Background: The classical didactic lecture has been the cornerstone of the theoretical undergraduate medical education. Their efficacy however reduces due to reduced interaction and short attention span of the students. It is hypothesized that the interactive response pad obviates some of these drawbacks. The aim of this study was to evaluate the effectiveness of an interactive response system by comparing it with conventional classroom teaching.

Methods: A prospective comparative longitudinal study was conducted on 192 students who were exposed to either conventional or interactive teaching over 20 classes. Pre-test, Post-test and retentions test (post 8–12 weeks) scores were collated and statistically analysed. An independent observer measured number of student interactions in each class.

Results: Pre-test scores from both groups were similar ($p = 0.71$). There was significant improvement in both post test scores when compared to pre-test scores in either method ($p < 0.001$). The interactive post-test score was better than conventional post test score ($p < 0.001$) by 8–10% (95% CI-difference of means – 8.2%–9.24%–10.3%). The interactive retention test score was better than conventional retention test score ($p < 0.001$) by 15–18% (95% CI-difference of means – 15.0%–16.64%–18.2%). There were 51 participative events in the interactive group vs 25 in the conventional group.

Conclusions: The Interactive Response Pad method was efficacious in teaching. Students taught with the interactive method were likely to score 8–10% higher (statistically significant) in the immediate post class time and 15–18% higher (statistically significant) after 8–12 weeks. The number of student–teacher interactions increases when using the interactive response pads.

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Introduction

In a classical study by Stuart et al, the attention span of a medical student was found to be optimal till 20 min following which it rapidly faded off.¹ In order to improve the classic lecture, interactivity between participants is a must. This promotes active learning, heightens attention and motivation, gives feedback to the teacher and student, and increases satisfaction for both.² Interaction in teaching has been attempted by numerous methods. The interactive response system is one such tool which aims at improving the conventional lecture. It is a handheld device which has the ability to transmit and receive data from the teacher's computer during the class.³ In this way it promotes interaction and gives immediate anonymous feedback to the teacher. The ability of these tools to engage passive listeners and 'back-benchers' in a classroom has been aptly demonstrated.^{4,5} Newer research suggests that such a tool significantly impacts the learning process and improves retention rates of factual information when compared to a conventional didactic lectures.⁶ However, there are some reports of this new tool failing to deliver expected results and demonstrating no significant benefit.^{7,8} Such techniques have not been evaluated before in the Indian medical education setting and studies are needed to establish the efficacy of the method. The present study aims to compare the effectiveness of an interactive response system with conventional classroom teaching in the Indian classroom of a medical school.

Material and methods

The present study was carried out at a medical college which offers a homogenous mix of students fairly representative from across the country. The study was done on 192 undergraduate students pursuing the MBBS course in subjects of ENT and Physiology. Students of each discipline were divided into equal groups of 48 students each using alphabetically generated roll numbers (ENT-1, ENT-2, PHY-1 and PHY-2). The study was designed to be a prospective longitudinal comparative study (Experimental design). An informed consent was taken from the subjects and institutional ethical clearance taken.

The intervention was the conduct of theory teaching using either conventional classroom method or interactive method in the groups. It is imperative to explain the interactive method further to understand the intervention.

The device used for interactive teaching was a commercially available teaching tool known as Interactive™ PRS by M/S eInstruction. It consisted of a hand-held battery powered interactive response pad called clicker issued to each student (Fig. 1). Each clicker has a unique ID which identifies it distinctively and linked to a student database. The clicker has an alphanumeric keypad and screen for input and output. It transmits and receives information wirelessly to the teacher's computer. Multiple type/true false/other type of objective questions are inserted into a conventional PowerPoint presentation which is being used for teaching.

Usually one question is placed after 7–8 min or on completion of one learning objective. During the class, as the interactive question comes up, students respond using the clickers within a stipulated time frame (Fig. 2). The answers are then available with the teacher who may choose to display these aggregate results to the students in an anonymous way. The correct answer is subsequently displayed and the teacher can discuss it. It also offers a teacher the feedback about the pace of class and understanding of learning objectives.

In the present study, the study material was especially chosen to include topics of study from the 'desirable to know' area of the syllabus. Each topic constituted a class and taught in a conventional classroom method using a Microsoft PowerPoint presentation (Classroom Method) or using the interactive response pad method by the same teacher (Interactive Method). The classes were designed to be of 30–40 min duration each and it was ensured that there was no difference in the content. Ten such classes were prepared and internally peer reviewed (Table 1).

The class began with the pre designed pre-test of ten questions each. Each correct response carried one mark and there was no negative marking. This was followed by the conduct of the class and then a post class test (post-test) immediately after. At the end of approximately 8–12 weeks duration the entire class was administered a combined 'retention test'. The answers of the retention test were separated based on type of class exposed to i.e. interactive vs conventional and averaged. Only those data observations where all three scores (pre-test, post-test and retention test) were valid and available were used for the statistical analysis. All the assessments were based on MCQs and designed by the teachers themselves.

Additionally each class was observed by an independent observer and student–teacher interaction events were counted based on number of clarifications sought and questions asked by the students. This total score in a 40 min class was averaged for interactive method and conventional method. This measure was labelled the student participative index and used to compare the two methods.

The average results of the pre, post and retention test was obtained and used to compare the differences. The pre-test results were compared to see if there was parity in the pre-existing knowledge in the two groups. To demonstrate the efficacy of the teaching methodology, comparison of pre and post test scores was done using a paired t test for both groups separately. Similarly comparisons between pre-test and retention test scores were compared using a paired t test.

To demonstrate the difference in two teaching methods, the unpaired t-test was used to compare the post test and retention test scores of interactive and conventional groups. Additionally to estimate the magnitude of benefit, 95% confidence Intervals were calculated for difference between two means.

Results

The study was conducted in a reputed medical college from 2008 to 2009. A total of 192 students took part in the study. This

Fig. 1 – Clicker of Interwrite PRS used for the study.

included 96 each from I MBBS and III MBBS. There were 153 boys and 39 girls representing a sex ratio of 4:1.

A total of 20 classes were held for the purpose of the project using either conventional classroom teaching or interactive response pad system (Table 1) in a predetermined way. 10 classes were conducted with each method. With 48 students per batch included for data analysis, data from 480 observations

was collected in conventional and interactive teaching methods each. During analysis it was found that 444 responses out of 480 (92.5%) collected were found to be suitable for further analysis in the interactive method and 437 out of 480 (91%) responses were valid in the conventional group (Table 2).

All the pretest scores, post test scores and retention test scores were collated separately for conventional and

Fig. 2 – Interactive class in progress using handheld clickers.

Table 1 – List of classes conducted in both groups.

S No	Class ID	Interactive method	Classroom method
1	Phy-A – Physiology of vascular endothelium	Group PHY-1	Group PHY-2
2	Phy-B – GERD and Achalasia pathophysiology	Group PHY-2	Group PHY-1
3	Phy-C – Pathophysiology of sleep disordered breathing	Group PHY-2	Group PHY-1
4	Phy-D – High Altitude disorders	Group PHY-1	Group PHY-2
5	Phy-E – Physiology of smell	Group PHY-2	Group PHY-1
6	ENT-A – Alaryngeal speech	Group ENT-1	Group ENT-2
7	ENT-B – Physics of lasers	Group ENT-1	Group ENT-2
8	ENT-C – Recurrent respiratory Papillomatosis	Group ENT-2	Group ENT-1
9	ENT-D – Stroboscopy	Group ENT-1	Group ENT-2
10	ENT-E – Endoscopic surgery in ENT	Group ENT-2	Group ENT-1

interactive teaching groups. The mean score so obtained in each category was used for analysis and expressed as a percentage. A 95% confidence Interval of the score so obtained was also calculated. The scores so obtained are shown in [Table 3](#) and graphically in [Fig. 3](#).

Pre test scores from both groups were subjected to statistical analysis to ensure that both groups are comparable in their pre class knowledge. The unpaired t-test (two sample assuming unequal variances) was used to compare pre test scores. No statistical difference was found ($p = 0.71$).

The efficacy of teaching was judged by a significant increase in the average score in both post class test and retention test. The paired t test was used to compare the scores before and after the teaching. There was significant improvement in post test scores and retention test scores when compared to pre test scores ($p < 0.001$). The results for both methods are as shown in [Table 3](#).

To compare the two teaching methods directly, post test scores were compared using an unpaired t test. Also 95% confidence Intervals were calculated for difference of two means and results are as shown in [Table 4](#).

As can be seen, the scores obtained by the students who underwent interactive teaching were consistently more than those who underwent conventional teaching. Using confidence intervals, it could be seen that the student taught by the interactive methodology was more likely to score a statistically significant 8–10% more than his counterpart. The improvement was more remarkable in the retention test scores where this difference in scores in the two teaching groups reaches statistically significant 15–18%.

The number of participation events by students during the class was recorded by independent observers who were residents/teachers sitting at the back. Only those event initiated by the students themselves were considered and questions asked by the teacher to students omitted. There were a total of 51 students–teacher participative events in the interactive teaching method and 25 in the conventional class. This translated to an almost doubling of interactions in the same time duration with same number of students and similar content. The participative index calculated as the mean of events per class was 2.5 in classroom method and 5.1 in teaching using the interactive response pads.

Table 2 – Valid data in both groups.

	Datasets enrolled in study	Valid datasets available for analysis	Cause of dropout and non-inclusion in analysis
Conventional	480	437	Identification failure – 14 Illegible responses – 08 Missing response sheet – 10 Retention test not given – 11 Total: 43
Interactive	480	444	Faulty operation by student – 14 Battery failure – 05 Corrupted data – 09 Retention test not given – 08 Total: 36

Table 3 – Mean percentage scores in each group in Pre, Post and Retention Test.

	Pre test score (%)	Post test score (%)	Retention test score (%)
Conventional (n = 437)	6.82% (95% CI $\pm$ 0.61)	73.59% (95% CI $\pm$ 0.85) ($p < 0.001$)	45.88% (95% CI $\pm$ 1.38) ($p < 0.001$)
Interactive (n = 444)	6.98% (95% CI $\pm$ 0.61)	82.84% (95% CI $\pm$ 0.65) ($p < 0.001$)	62.52% (95% CI $\pm$ 0.82) ($p < 0.001$)

Fig. 3 – Average performance in sequential tests as a percentage.

Discussion

The drawbacks of didactic lectures in a conventional classroom are primarily a lack of attention, inadequate development of independent thinking and limited opportunity for the student to self-assess. To improve the classical didactic lecture numerous methodologies have been devised. Multimedia has been incorporated in lectures to convey information. Though this has enabled more content to be placed intuitively, an inappropriate usage of the presentation tool can make the student paradoxically more inattentive.⁹

Educators have resorted to novel student participative techniques in an effort to achieve complex learning objectives.^{10–12} However it is difficult to standardize some of these tools. In one such example, dance has been used to convey the basics of echocardiogram, a novel concept but difficult to adapt to all situations.¹³

Lectures, however have stood the test of time and may have been unfairly criticized. A trial that compared live lectures with video podcast of the lecture found no improvement of the newer technology over the traditional lecture.¹⁴ A multinational randomised study comparing didactic lectures with case scenario in a medical simulation course demonstrated a need for lecture preceding a demonstration/simulation.¹⁵

A change in the time tested methodology of teaching requires justifications and scientific evidence to demonstrate objective improvement. The present study was undertaken with the aim to make scientific conclusions about the hypotheses of interactive teaching using interactive response pads being better than conventional didactic lectures.

To demonstrate the efficacy of a teaching learning method, the present study used a pre-test and post-test comparison of scores. This methodology has been used by numerous studies and has been shown to be valid and reliable in other studies also.¹⁶ To study the efficacy of the lecture over a longer period, a post test after a period of 8–12 weeks was also done as a test for retention of knowledge.

Interactive response pads have been now used in various fields of education and have evolved with various types of technology and software.¹⁷ Their usage has also prompted practice guidelines to be issued in certain cases.¹⁸ Most literature on the issue worldwide supports the better outcome of teaching with interactive pads over conventional lectures in the short term.^{19,20} This is probably due to the assumption that the students are more attentive and engaged during these lectures. The present study too seems to follow these results and there seems to be a statistically significant 8–10% better score in the students using interactive response pads immediately after the class.

The present study supports the thought that interactive response pads increase not only the short term scores but also the medium term retention of a topic by 15–18% at least till 8–12 weeks. This finding is also supported by Crossgrove who suggested a similar trend when retests were administered after four months.²¹ A period of 8–12 weeks was chosen as a measure as we think it to reflect a sufficiently long period when short term memory is not playing a part. Since the topic of the class were not from conventional “must know” parts of the syllabi, there was no reinforcement of the topic in the intervening period which may have confounded the retention test results.

The present study not only demonstrated a statistically significant improvement in test scores but also attempts to statistically quantify this improvement in the short and intermediate term. This improvement of scores by 8–10% in short term and 15–18% in medium term highlights the role interactive devices may have over a period of time.

This improvement of scores may not be always the case and certain authors do not report such a dramatic improvement.^{7,8} Even though some of these studies do not report significant academic performance, many still report the system to be beneficial due to increased acceptance by students.

Table 4 – Comparison of various test results and their difference.

Parameters compared			Statistical tool used	Result
Interactive post test score (82.84%)	vs	Conventional post test score (73.59%)	unpaired t-test	p < 0.001
Interactive post test score (82.84%)	vs	Conventional post test score (73.59%)	95% CI for difference of two means	8.2 %–9.24%–10.3%
Interactive retention test score (65.52%)	vs	Conventional retention Test score (45.88%)	unpaired t-test	p < 0.001
Interactive retention test score (65.52%)	vs	Conventional retention Test score (45.88%)	95% CI for difference of two means	15.0 %–16.64%–18.2%

It may be possible that if the conventional lecture is modified by adding interaction and MCQs using any other convenient method, similar improvement would also be noted. The present study however attempts to analyse the improvement only using one such particular tool which adds interaction.

It may also be possible that certain topics are more suited to teaching using interactive response pads. This was seen by a study in which significant improvement of post test scores was observed only in one group being taught an introductory biology class and the other group learning genetics did not have a change in scores.²¹ Similarly, a recent study highlights the improvement of scores in most subjects taught with the notable exception of one.²² This effect was not seen or specifically studied in the present study. In case this observation is valid, it raises the question of identifying topics more suited for interactive teaching using voting pads, a matter outside the purview of the present study. Perhaps, the answer may lie in the choice of right questions to ask in class and the skill needed to prepare them.

Another point which needs to be addressed is the impact these interactive tools may have in a complex teaching environment where teaching objectives are being met by multiple methods like lectures, clinics, group discussions, tutorials etc. The present study has used less taught topics to eliminate this and the results might not be similar in case the topics being taught were main-stream since there is bound to be reinforcement of learning objectives over time in the various teaching learning activities. It is however safe to assume that since the newer tool improves test scores vis-a-vis conventional teaching in isolated topics, the effect is likely to be positive in a complex teaching environment also.

However despite these limited drawbacks and shortcomings some studies including the present one may have, the tool has consistently proved to have a positive influence on the student teacher interaction in the class. This makes the results noteworthy and merit further actions based on them. Moreover, the total lack of such data in the Indian medical teaching scenario makes these findings important.

The time period in which a technology becomes outdated is becoming short by the time a newer technology makes full impact, another is ready to replace it. Interactive response pads too are no different and vulnerable to being overtaken by newer technology. Mobile phones have been put to similar use in a Mobile response system by using SMS technology with specially developed software.²³ This seems to be a promising development as the mobile phone is a tool students are already familiar with. In the present study, though clickers have been used, the satisfactory outcomes would probably be similar with any such device like cell phones etc. With rapid incorporation of touch screen tablet devices in the education domain, it is just a matter of time when applications serving similar purpose to the interactive voting pad are developed for them. This may eventually lead to platform independent systems where the software adapts to a variety of student owned devices to use as response pads.

The present study addresses the need for interactivity using technology rather than the need to have the device itself. Consequently, the results demonstrate the need for an electronic interactive response system which may be of any

type. Even the newer technological tools being developed would have similar outcomes if not better.

Conclusions

The present study found the interactive teaching tool proved equally efficacious as a teaching method and demonstrated statistically significant improvement in test scores immediately after the class and after 06 weeks. It also demonstrated statistically significant superior outcomes when compared to conventional classroom teaching in terms of post class test scores and retention test scores after 6 weeks. As per the data of this study, an improvement of 8–10% score immediately after the class and 15–18% improvement in long terms retention has been demonstrated.

Based on these findings, the authors would like to recommend the adoption of technology driven interactive teaching technologies in undergraduate medical educations to make the lecture room more interesting and engaging. Many such tools have already been incorporated in leading universities of the world in various disciplines and a strong push is needed to use them in medical schools. Challenges in the form of faculty development, technology upgradation and standardization need to be addressed energetically. Further research in interactive teaching techniques could address more complex issues.

Conflicts of interest

All authors have none to declare.

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REFERENCES

1. Stuart J, Rutherford RJ. Medical student concentration during lectures. *Lancet*. 1978 Sep;2:514–516.
2. Steinert Y, Snell LS. Interactive lecturing: strategies for increasing participation in large group presentations. *Med Teach*. 1999;21:37–42.
3. Beekes W. The 'Millionaire' method for encouraging participation. *Act Learn High Educ*. 2006 March 1;7:25–36.
4. Guthrie R, Carlin A. Waking the dead: using interactive technology to engage passive listeners in the classroom. In: *Tenth Americas Conference on Information Systems*, New York. 2004.
5. Graham CR, Tripp TR, Seawright L, Joeckel G. Empowering or compelling reluctant participators using audience response systems. *Act Learn High Educ*. 2007 November;8:233–258.

6. Schackow TE, Chavez M, Loya L, Friedman M. Audience response system: effect on learning in family medicine residents. *Fam Med*. 2004 Jul–Aug;36:496–504.
7. Vana KD, Silva GE, Muzyka D, Hirani LM. Effectiveness of an audience response system in teaching pharmacology to baccalaureate nursing students. *Comput Inform Nurs*. 2011 Jun;29(6 suppl 1). TC105–13.
8. Graeff EC, Vail M, Maldonado A, Lund M, Galante S, Tataronis G. Click it: assessment of classroom response systems in physician assistant education. *J Allied Health*. 2011;40:e1–e5. Spring.
9. Southwick FS, Theodore E. Woodward Award: spare me the PowerPoint and bring back the medical textbook. *Trans Am Clin Climatol Assoc*. 2007;118:115–122.
10. Latham L, Macdonald A, Kimball AB, Langley RG. Teaching empathy to undergraduate medical students using a temporary tattoo simulating psoriasis. *Emerg Med J*. 2012;29:559–564.
11. Patel J. Using game format in small group classes for pharmacotherapeutics case studies. *Am J Pharm Educ*. 2008 Feb 15;72:21.
12. Narayanan SN, Kumar RS, Nayak S. Student-involved demonstration approach to teach the physiology of vestibular apparatus for undergraduate medical students. *Teach Learn Med*. 2011 Jul-Sep;23:269–277.
13. Schultz KK, Brackbill ML. Teaching electrocardiogram basics using dance and movement. *Am J Pharm Educ*. 2009 Jul 10;73:70.
14. Schreiber BE, Fukuta J, Gordon F. Live lecture versus video podcast in undergraduate medical education: a randomised controlled trial. *BMC Med Educ*. 2010;10:68.
15. Li CH, Kuan WS, Mahadevan M, Daniel-Underwood L, Chiu TF, Nguyen HB. A multinational randomised study comparing didactic lectures with case scenario in a severe sepsis medical simulation course. *J Am Acad Dermatol*. 2012;67:93–99.
16. Grieve C. Knowledge increment assessed for three methodologies of teaching physiology. *Med Teach*. 1992;14:27–32.
17. Cain J, Robinson E. A primer on audience response systems: current applications and future considerations. *Am J Pharm Educ*. 2008 Aug 15;72:77.
18. Mareno N, Bremner M, Emerson C. The use of audience response systems in nursing education: best practice guidelines. *Int J Nurs Educ Scholarsh*. 2010;7. Article32.
19. Palmer EJ, Devitt PG, De Young NJ, Morris D. Assessment of an electronic voting system within the tutorial setting: a randomised controlled trial [ISRCTN54535861]. *BMC Med Educ*. 2005;5:24.
20. Pradhan A, Sparano D, Ananth CV. The influence of an audience response system on knowledge retention: an application to resident education. *Am J Obstet Gynecol*. 2005 Nov;193:1827–1830.
21. Crossgrove K, Curran KL. Using clickers in nonmajors- and majors-level biology courses: student opinion, learning, and long-term retention of course material. *CBE Life Sci Educ*. 2008;7:146–154. Spring.
22. Fitzpatrick KA, Finn KE, Campisi J. Effect of personal response systems on student perception and academic performance in courses in a health sciences curriculum. *Adv Physiol Educ*. 2011 Sep;35:280–289.
23. Lee AWM, Ng JKY. Do Not Turn off Your Mobile Phones in My Lectures—A Mobile Phone Based Response System. 2008.