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RADIOLOGICAL EDUCATION

Use of remote response devices: an effective interactive method in the long- term learning

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Abstract

Objectives The aim of this study was to evaluate whether the use of personal response systems (PRS) or clickers improved learning and retention of radiology concepts within a group of medical students.

Materials and methods A total of 175 medical students attended 17 thoracic radiology lectures. Half of the information was taught with traditional teaching methods. The other half was performed using multiple-choice Power Point slides with PRS. Three months later, the students were tested using questions about the topics explained with and without PRS. We compared the average numbers of correct answers, wrong answers and unanswered questions between the topics explained with PRS and those without.

Results The average number of correct answers was significantly higher in the interactive teaching (PRS) questions than in the passive education questions (63.6 vs. 53.2 %, $p<0.05$). The percentages of wrong and unanswered interactive teaching questions were significantly lower than those in the passive education questions (23.4 vs. 27.4 % $p<0.005$ and 13 vs. 19.5 % $p<0.005$ respectively).

Conclusions Interactive learning with the use of remote response devices (PRS) is an effective method in teaching radiology because it improves learning and retention of knowledge.

Key Points

- *Education techniques have greatly evolved in recent years.*
- *There are various methods of teaching the subject of radiology.*
- *Different studies have demonstrated students' preferences regarding interactivity.*
- *Personal response systems are an effective tool to encourage student participation.*
- *Personal response systems or clickers also improve learning and retention of concepts.*

Keywords Premedical education · Premedical students · Learning · Educational models · Radiology

Abbreviations

PRS	Personal response systems
MCQ	Multiple choice questions

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Introduction

Radiology has become more important for medical students in the last few years. Several benefits of an earlier introduction of radiology in the teaching curriculum have been demonstrated [1–6]. A lack of early exposure to diagnostic imaging in the preclinical undergraduate years was highlighted in 2013 by Nyhsen et al. [1, 7, 8]. Furthermore, the earlier introduction of radiology also makes a greater impression on students which persists even after graduating [5, 9].

In another study, Oris et al. [4] recalled the different learning methods. At the beginning of the twentieth century they were mainly focused on a science-based method consisting of a preclinical and a clinical part. Radiology was always included in the clinical part. Around the mid-twentieth century, problem-based instruction was incorporated which comprised blocks of the body's systems, each one with a preclinical and a clinical part. Radiology interconnected both parts in the different blocks. Nowadays, outcome-based education is being introduced in the modern curriculum; this involves an enhancement of the previous blocks, which adapts core professional competencies related to specific contexts while making use of a generic knowledge base, with the added purpose of emphasizing multidisciplinary education and removing boundaries between professions [10]. These innovations affect the teaching of radiology in Europe, as was confirmed in the first European benchmark study that was carried out in 2008 [4].

There are various methods of teaching the subject of radiology. Many different studies have been published, showing the students' preference: in 2011, Nyhsen et al. evaluated these preferences between junior doctors on general medical/surgical rotations. Interactive case-based discussion was clearly the favourite teaching technique, followed by interactive system-based discussions [11, 12]. Other techniques such as Power Point-aided lectures, examination-style viva sessions and self-directed e-learning modules were rated between good and normal. Original research articles, journal review articles and radiology textbooks were rarely used. Dedicated online learning material was moderately to regularly accessed, but was used less than other web resources, such as Google or Wikipedia [11].

Different studies have demonstrated students' preferences regarding interactivity. Malek et al. showed that subjectively, interactivity improves concentration and enjoyment with significantly better learning outcomes using case-based teaching in radiology [12–16].

Personal response systems (PRS) provide an excellent tool for improving interactive learning. Many studies highlighting PRS, promote active participation; however, their impact on short- and long-term retention is still unclear. Different studies have been conducted to evaluate the learning effect of these devices [17–27]. Our purpose was to study the preference of students in the various teaching methods of radiology, to evaluate the use of PRS, in our study clickers (Fig. 1), in teaching radiology and its utility in learning.

Material and methods

From January to May 2012, a prospective study with 175 medical students in their fourth year of medicine at the University of Navarra was performed. The study protocol was approved by our institutional review board.

Fig. 1 The personal response system (PRS) or clicker used by the medical students

The students all attended 17 different thoracic radiology lessons together, which contained topics about semiology and pathology of the lung, mediastinum, heart, pleura, diaphragm and chest wall. All the lectures belonged to the clerkship called Clinical Radiology I. Each lesson contained about 145 radiological images and took around 50 min.

At the beginning of the year, a basic radiology textbook (*Fundamentals of Chest Radiology*, Ketai LH et al. (eds.), Médica Panamericana, 2007), which covered all the theoretical aspects of the lectures, was given to every student.

Before every lesson, all the students were informed about the topic of the lecture. The day before, they received a document with all the images (about 145 images per lesson) corresponding to the next lesson, so that they could work with the images during class. At the beginning of every lesson, all the students answered five questions about the theoretical aspects of the lecture, which were taken into account for their final grade (Fig. 2). With this short test, we made sure that all the students had read the lesson before it began.

During the lecture, all the images of the document were displayed in 50 min. In this time we emphasized the practical approach of the differential diagnosis and radiological signs of images, whereas theoretical aspects of the lecture's topic were superficially reviewed.

At the end of every lecture, there were five interactive questions about the images, which were answered using clickers (Fig. 3). Students had only 20 s to answer each question with clickers. After that, they could see if they had chosen the correct answer. As in the previous test, the purpose

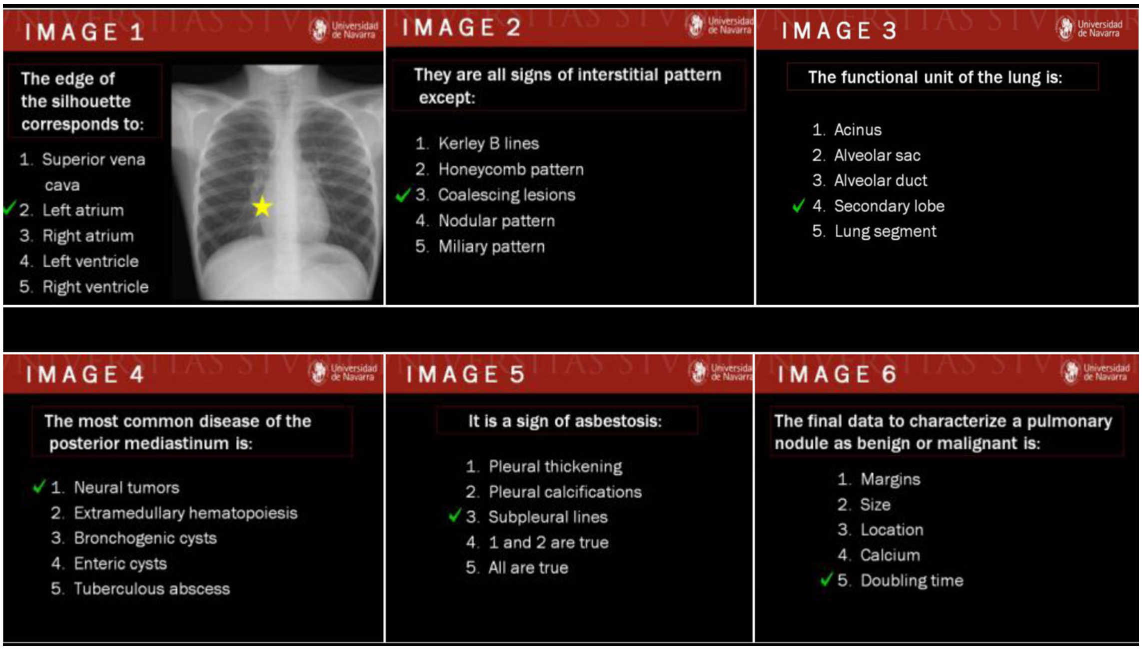

Fig. 2 Examples of questions about theoretical aspects answered at the beginning of every lecture (*images 1–6*)

of considering the results of these questions for their final grade was only to ensure that students paid attention to the explained lesson.

Three months later, there was an image-based examination with 68 multiple-choice questions (MCQ), with a 1:4 negative rate. Half of the questions (two questions from each of the 17 lessons) were about images that were previously answered with clickers (Fig. 4, images 13–15), whereas the other half (also two questions from each of the 17 lessons) were about images from the documents not answered with clickers (Fig. 4, images 16–18). MCQs in the lecture and in the test 3 months afterwards were not the same. Sometimes the images were repeated, but the wording or concepts questioned in these cases were modified. The remaining questions concerned concepts or images from the basic radiology textbook or images from our centre's Picture Archiving and Communications System. There was no particular difference in the level of difficulty.

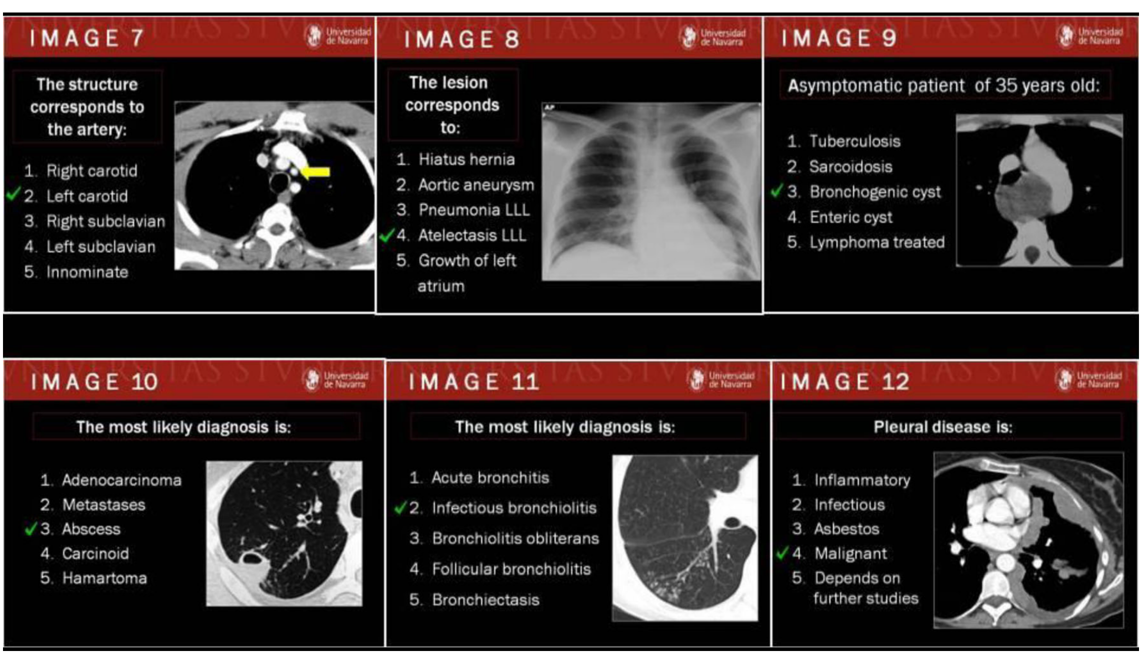

Fig. 3 Examples of interactive questions about the images answered using clickers at the end of every lecture (*images 7–12*)

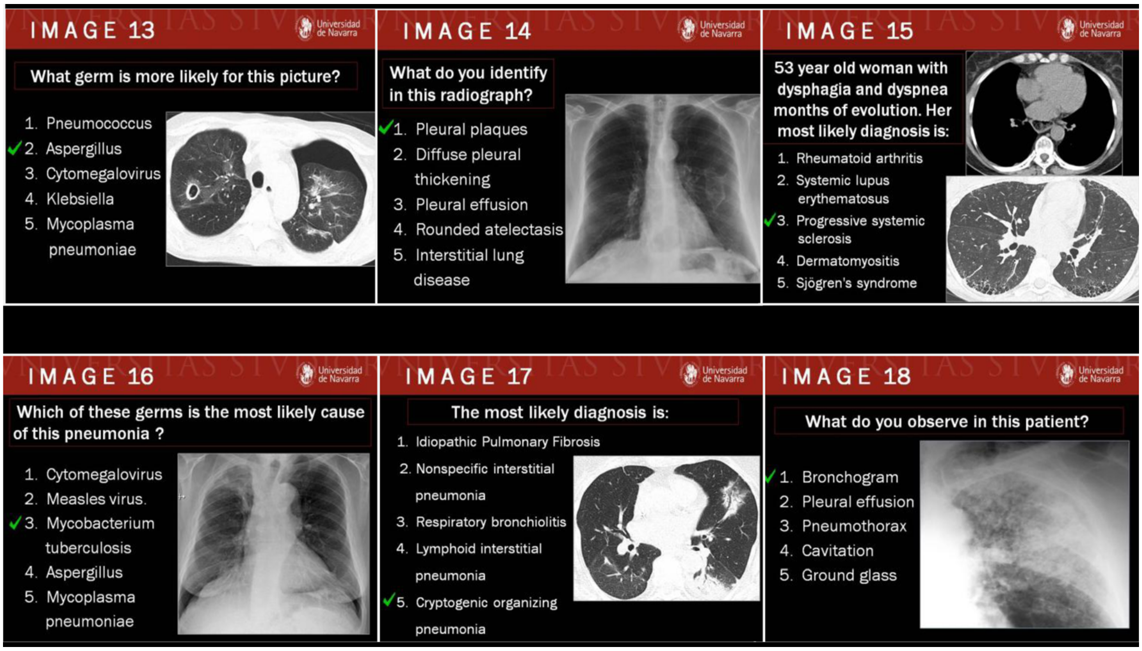

Fig. 4 Examples of multiple-choice questions answered 3 months after the lectures (*images 13–18*)

This was the first year this subject was offered, so students did not know if the examination images belonged to the images displayed in the document or if they were images worked on with clickers. As this work was a prospective research study, special care was taken with students to avoid any suspicion about the possible origin of test images.

To compare the difference in the degree of learning achieved between both methods, we evaluated the difference in the index of correct, wrong and unanswered questions between the topics explained with clickers and those without.

For the statistical analysis of the two different learning methods we used a Student *t* test with the 15.0 SPSS software (Chicago, Illinois, USA).

Results

The results of the two teaching methods are summarized in Table 1.

The average number of correct answers in the interactive teaching (clickers) group was 63.6 %, compared with the passive education group where it was 53.2 % ($p<0.05$). The difference was an average of 10.4 % more in the clickers group.

In average percentage of wrong answers in the interactive teaching group was 23.4 %, whereas in the passive teaching group it was 27.4 % ($p<0.05$). The difference was an average of 4 % less in the clickers group.

The percentage of unanswered questions in the interactive teaching group was 13 %, whereas in the passive education group it was 19.5 % ($p<0.05$). The difference was an average of 6.5 % less in the clickers group.

Discussion

Different studies have demonstrated that students prefer to use interactive teaching methods rather than the classical passive methods. One of these methods is the PRS or clickers. They have also been proven to increase students' attention, make lessons more fun and encourage attendants' participation [1, 12].

To date, the results of studies about knowledge retention with the use of clickers have been mixed [20]. While a variety of studies have not demonstrated an improvement in compression and retention [21, 25], some studies have confirmed only a short-term retention [18], and others have shown an improvement also in long-term retention [26, 28, 29]. However, no studies have objectively shown the positive effects they have on long-term retention of knowledge from radiology lessons given to medical students. Hence, our purpose was to evaluate if this was possible.

The increased importance that the subject of radiology has been acquiring has led different authors to investigate its teaching in medical schools [3–5].

Many educators believe that their ability to teach effectively relies on their instinct and experience [30].

Oris et al. [4] described a modern curriculum based on formal radiology teaching with earlier exposure to radiology, and which includes more active and integrated obligations.

Table 1 Results of correct, wrong and unanswered questions

		Average (%)	Standard error	CI (95 %)		*p* value
Correct answers	Clickers	63.6	0.014	63.57	63.63	0.01
	No clickers	53.2	0.013	53.07	53.12	
Wrong answers	Clickers	23.4	0.011	23.38	23.42	0.01
	No Clickers	27.4	0.011	27.38	27.42	
Unanswered questions	Clickers	13	0.011	12.78	12.92	0.01
	No clickers	19.5	0.013	19.37	19.43	

CI confidence interval

In another study, Branstetter et al. [5] concluded that exposing students to radiology in the first year of medical school improves their impression of radiology and increases their interest in radiology as a specialty [31, 32]. Furthermore, students performed better on a test of basic radiological knowledge. In contrast to our study, they determined the improvement in the learning of basic radiological principles through a test of only five basic MCQs.

However, in our study we have demonstrated that the introduction of clickers in radiology lessons improves long-term retention of knowledge. We analysed the degree of this improvement further, and therefore based our examination on 68 radiological images that required advanced radiological knowledge.

On the basis of the results of the examination performed 3 months after the classes, we found that the topics explained with clickers were better assimilated than the topics explained with classical passive teaching methods. The percentage of correct answers was significantly higher (10.4 % difference, $p<0.001$), showing that the level of knowledge of the topics explained with clickers was significantly higher than in the passive teaching group.

The study of memory consolidation has been a topic of interest to researchers because of its importance in different forms of learning.

In a study by Cohen-Matsliah et al. different temporal phases of memory were distinguished: acquisition, consolidation and retrieval [33]. Memory consolidation is the process of transformation of short-term to long-term memory; during the time after acquisition that memory is still susceptible to distractions [33–37].

Studying actively improves the degree of retention of knowledge as students become more interested in those subjects. In the case of using clickers, more effort is made to resolve the questions and if you fail one of these questions, you will remember this topic more easily later on.

Diemand-Yauman et al. [38] affirm in two studies that disfluency, the subjective experience of difficulty associated with cognitive operations, leads to deeper processing and this deeper processing can lead to improved memory performance. Bjork [39] reaffirms that in some cases, making material harder to learn can improve long-term learning and retention. It is not the difficulty in itself which produces improvements in learning but rather the fact that the student engages in the learning process [40, 41].

Kihlstrom [37] also describes a type of learning by direct experience, like "trial and error" learning. He thinks that the more effort you expend, the better you will remember. Simply by trying to retain the correct answer in memory, it appears to improve the acquisition of that answer.

We have also observed that in the topics explained with clickers, students presented a significantly lower percentage in the number of unanswered questions than in the passive teaching topics (6.5 % of difference, $p<0.05$). They answered more questions even though they knew failed questions were penalized. This finding may reflect that students feel more confident about their knowledge of the topics explained with clickers. They take a greater risk because they have a greater confidence in themselves.

Bandura [42] explained that the higher level of induced self-efficacy, the higher the performance accomplishments with lower emotional arousal. He thinks that depending on how people judge their capabilities and their self-perception of efficacy, the motivation and behaviour will be different. He found that students with a high perceived self-efficacy as learners are associated with more cognitive effort and superior learning than students that consider it difficult [42–44].

It is important to emphasize that in our study, great care was taken to avoid students suspecting the type of questions asked. After the examination, an oral interview was conducted with students, in which it was found that they were not aware that there had been two sets of questions. They had not distinguished between the questions on topics previously worked on with clickers and those without using clickers. Additionally, nobody realized during the year that a study was being conducted.

Recent studies have described the different applications of PRS. The utility of the clicker is not only for multiple choice answers. They also let you answer true/false questions, open questions to provide possible diagnoses, radiological signs and protocols. Furthermore, an instructor will be able to create questions and obtain responses during the presentation.

Twelve tips for successful use of clickers in the classroom have also been numerated [45–47].

Some problems with the current use of PRS have been identified. However, confirmation from students that PRS encourage active participation, increase motivation and the perception that residents learned more effectively with these devices, motivate faculty members to use this approach more [22, 23, 47, 48].

In radiology, we have to promote the use of PRS or clickers because as we have shown in this study, apart from making classes more fun, it stimulates learning and retention of knowledge in practical classes with cases. So far, different methods of learning the different subjects required for a medical career have been developed, but not for the subject of radiology. The importance of these interactive methods is to allow identification of specific radiological signs and make specific diagnostics and maximum likelihood diagnostics. Therefore, it would be interesting to gradually introduce the use of clickers in radiology classes with cases to improve long-term retention, as we have demonstrated in our study.

It would be also interesting to try to introduce PRS in radiology theory lessons or in radiological conferences, as has already been studied for urology conferences [49], and to study its benefits.

In conclusion, we have shown that the use of a PRS or clickers (an interactive method) increases test participation and improves outcomes and long-term retention of knowledge of radiology. This is interesting because recently, the use of interactive methods has become increasingly popular in scientific meetings, where they probably achieve similar good results.

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Methodology: prospective, experimental, performed at one institution.

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