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THE USE OF "PERSONAL RESPONSE SYSTEMS" (CLICKERS) FOR TEACHING ANALYTICAL CHEMISTRY

Subtítulo

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1. ABSTRACT:

The "Personal Remote Systems" (PRS) or "clickers" are digital units that hand on to the professor's computer the students answers to multiple choice questions projected in a screen in real time. These new devices can be used either anonymously or even assigned to a specific student to evaluate the previous knowledge, to check what they have understood during class allowing an immediate feedback or to do the exams.

In this work, the results of the use of PRS as a complementary teaching tool in five different subjects of analytical chemistry are presented. The study was performed in three different courses of the degree in Chemistry given in the University of Basque Country.

2. **KEYWORDS** (lengua propuesta)**:** Personal Remote Systems, clickers, Analytical Chemistry, Multiple Choice Questionaries

3. **ÁREA DE CONOCIMIENTO:** Indicar el área a la que corresponde el contenido de la propuesta:

- Arte y Humanidades

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- Ciencias Experimentales y de la Salud X
- Ciencias Sociales y Jurídicas
- Ingenierías y Arquitectura
- Más de un área

4. **ÁMBITO TEMÁTICO DEL CONGRESO:** Indicar el ámbito temático al que es propone adscribir la comunicación:

   - Evaluación y calidad institucional
   - La cooperación en y por el conocimiento
   - Innovación en el enseñamiento superior X
   - El aprendizaje autónomo del alumno
   - La internacionalización de la universidad

El Comité Científico se reserva el derecho de decidir el ámbito final de las propuestas.

5. **MODALIDAD DE PRESENTACIÓN**:

   - Comunicación oral
   - Comunicación póster X
   - Comunicación electrónica

El Comité Científico se reserva el derecho de decidir el formato final de las propuestas.

6. **DESARROLLO:** tendrá una extensión de entre 7.500 – 10.000 caracteres (con espacios)

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a) Aim and Objectives

The main aim of this work was the evaluation of the use of PRS as a complementary teaching tool in different subjects of Analytical Chemistry of the Degree in Chemistry. This active teaching methodology has been used and evaluated according to two different purposes:

(i) To encourage the student's participation during lecturers in which responses were collected anonymously.

(ii) To evaluate the use of clickers as an assessment tool during lecturers in which responses assigned to each student were collected using the clickers in anonymous way

b) Description of the work

The success in the student´s knowledge about a subject depends on the equilibrium among the tasks proposed by the professor, the good fulfilment of such activities by the students and the interaction between them. However, one of the greatest difficulties often found during a lecture is the scarce participation of the students in the teaching-learning process. This lack of participation makes difficult to evaluate properly their abilities and skills or to check if they have understood the new explained concepts. Once entered into the XXI century it is not possible to understand teaching at the university within the most traditional technical paradigm, in which the teacher is a mere transmitter of the contents that the student must understand and memorize. Nowadays, the teaching-learning process is based on the comprehensiveness of theoretic concepts and their application to real or practical situations [1]. In this sense, the European Convergence Programmes may be considered as new teaching tools to change the teaching-learning methodology from passive to active improving the communication between the professor and the students [2].

In the present society in which children are educated using technological and visual methodologies, the use of new information and communication electronic devices is highly required. It is extensively proved that this type of devices enhance and transform our manner of communicate, work or even think and argue [3,4]. This is the reason why the use of these devices

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should not be limited to an only subject of a specific field of knowledge. Furthermore, clickers should be used not only in own-work activities but also in daily group activities in order to guarantee a real advance in this new teaching-learning methodology. However, the new teaching context makes necessary a previous training of the professor in order to (i) choose the teaching modality the most suitable for the use of such technologies, (ii) prepare examples and exercises that can be performed via new technologic systems and (ii) establish information searching and transferring devices between institutions and groups. All of these is needed in order to make possible autonomous learning [1,4].

The Personal Remote Systems (PRS), commonly known as "clickers" (see Figure 1), are digital units that hand on to the professor's computer the students answer to multiple choice questions projected in a screen in real time. The use of PRS in lectures given at the University has opened new communication ways between the professors and the students [5].

Figure 1 – A student using a clicker during a lecture.

The PRS can be used either in formal or informal modes due to the fact that the way in which the response is collected can be chosen, i.e. anonymous responses or assignation of a single device to a specific student can be selected. On the one hand, if the formal mode is employed, the obtained results can be very useful to evaluate the knowledge of the student during the lecture or even at the end of the course. On the other hand, if the informal mode is used, it is a powerful tool to test if the students have understood the explained item in real time and therefore to check the efficiency of the class or the necessities to improve it.

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The exercises performed by means of PRS are multiple choice questions using specific software and the responses are saved allowing their study and interpretation. In fact, the assessment of these tests is performed very easily downloading the results in the PC in which the software is installed. These devices are very useful providing immediate results for those professors that use active and cooperative teaching methodologies in their lectures [6, 7]. It is also possible to show automatically after each of the questions the percentage of answers for each option together with the correct one, which improves the discussion in the classroom.

The time and effort necessary to plan good questions and to reorganise the course activities is one of the main challenge to use PRS successfully. In this sense, it will be necessary to prepare multiple choice questions which allow testing the student´s critical thinking and arguing. The researches about PRS have provided specific pedagogic recommendations which are in agreement with the educational goals. Firstly, the professor must propose questions suitable for the knowledge level of students that drive them to reflect on and arguing and not only remembering. Secondly, the questions and even the answers given by students can help to improve the teaching-learning process successfully. The efficiency of teaching depends on the previous knowledge student have so that having this information often is crucial when an advanced item is going to be explained. Thus, both the questions and the wrong responses given by students provide this information [8]. Using PRS devices to analyse the opinion of the students and to get information about they have learnt requires an active attitude of the students and the professor. Surely, the success of this methodology resides on it since master classes and boring presentations can be replaced successfully by active learning [9,10].

The last works dealing with the use of PRS at the high grade levels show very promising and positive results. Both students and professors indicate that they had positive experience about using clickers especially related to the attendance and motivation of the students during the course [11,12].

Thus, these relatively new devices can be used for different purposes such as exams, satisfaction queries, as evaluation tools during the lectures or as feedback tools in order to guarantee the comprehension of the new concepts.

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c) Results and/or discussion

This work has been carried out during the 2011/12 academic course in four different subjects that are given by lecturers and professors of the Department of Analytical Chemistry of the Faculty of Science and Technology of the University of the Basque Country (UPV/EHU):

- Analytical Chemistry I (2nd course, Grade in Chemistry)
- Analytical Chemistry (3rd course, Degree in Chemistry)
- Advanced Analytical Chemistry (4th course, Degree in Chemistry)
- Chromatography and Related Techniques (elective subject of 4th or 5th course, Degree in Chemistry)

During the 2011/12 school-year material has been prepared in order to use the clickers in the subjects above mentioned. With regard to the proposed question, in all the cases the questions were prepared as multiple choice response tests, with three or more answer options. Three main question types were proposed: i) the ones aimed to discuss or evaluate completely theoretical concepts (see example in Figure 2), ii) the ones to apply theoretical concepts to interpret a result (Figure 3) and iii) queries having numerical answers, aimed to calculate the values for a parameter, to calculate a recovery of an analytical procedure or so on (Figure 4).

The PRS systems offer the possibility to work both in the anonymous and identified (personalized) that allows to obtain different information. Actually, both forms were used within the framework of the mentioned subjects to perform general and individual assessment, of knowledge, at different times. For instance, clickers were used at the beginning of the course to know the overall knowledge acquired during the previous courses, to evaluate the general comprehension level after finishing a lecture or as a discussion tool in seminars. More detailed

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examples of the use of clickers and the main particular results and conclusions obtained in each of the subject are stated further below.

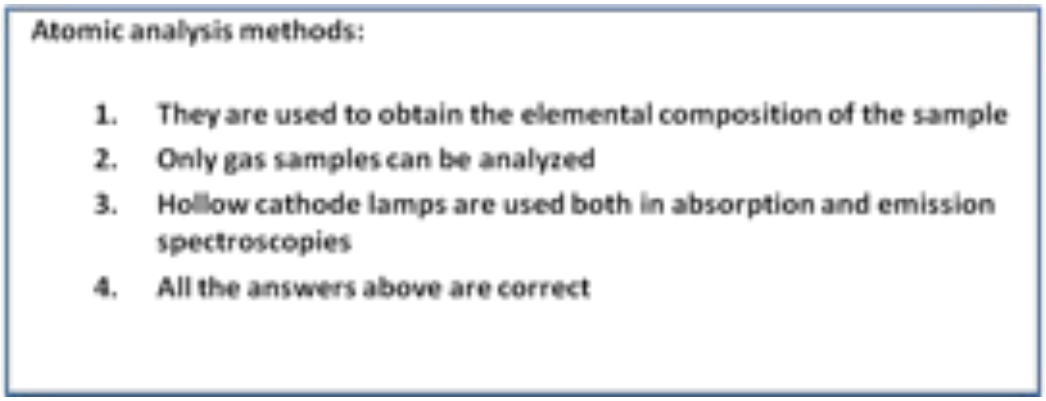

Figure 2- Example of a question aimed to discuss theoretical concepts

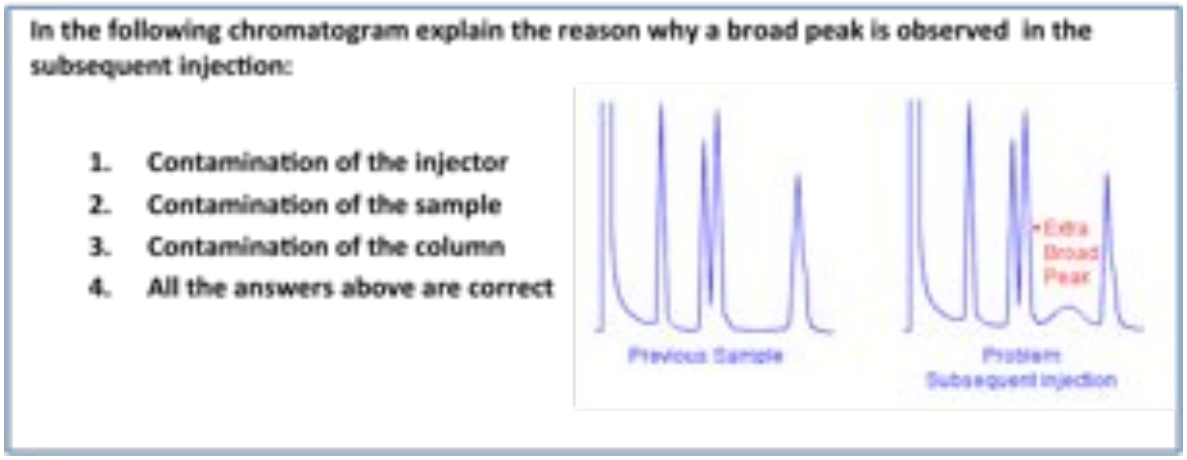

Figure 3- Example of a question aimed to apply theoretical concepts to interpret a result

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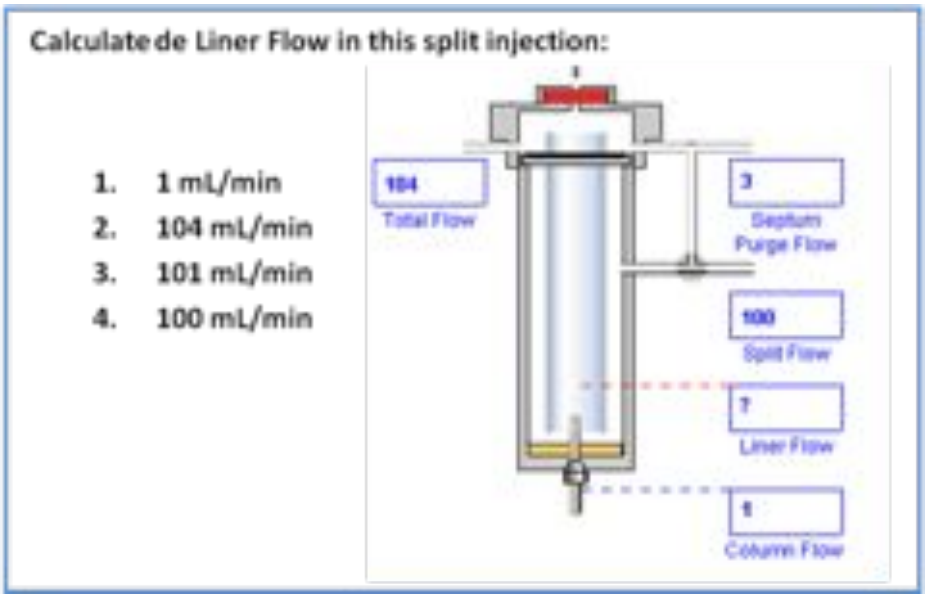

Figure 4- Example of a practical question aimed to do a calculation to get a numerical response.

Moreover, in order to study the opinion about the use of clickers we prepared a test to pass to the students at the end of each subject. The satisfaction survey allowed to obtained information about topics such as the number of times they have used clickers or if students are more motivated to participate in classes in which clickers are used. Open questions about the advantages and disadvantages about this methodology were also asked. Therefore, a template of the prepared questioner is the following:

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1. Class ID: _____
2. What grade are you in (circle one)? _____
3. Gender (circle one) **Male** **Female**
4. How comfortable are you with technology? **(circle one)**

   Not at all comfortable **Somewhat Comfortable** **Comfortable** **Very Comfortable**

5. On average, how much do you participate in class when clickers ARE NOT used? **(circle one)**

   Not at all **Some of the Time** **Most of the Time** **All of the Time**

6. Did you use clickers before this class?

   Yes/ No

7. If so, in what subjects did you use clickers?

Item	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
8. I was more motivated when clickers were used	1	2	3	4	5	6	7
9. I was more engaged in the lesson when clickers were used	1	2	3	4	5	6	7
10. I participated much more than I normally do when clickers were used.	1	2	3	4	5	6	7
11. The class was in control when clickers were used	1	2	3	4	5	6	7

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Item	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
12. I liked seeing what other students in the class selected for answers.	1	2	3	4	5	6	7
13. Using clickers was a good way to test my knowledge	1	2	3	4	5	6	7
14. Verifying the answer just after the question helped me to clarify concepts and to realise about my misunderstandings	1	2	3	4	5	6	7
15. I liked using clickers for tests	1	2	3	4	5	6	7
16. I did not feel bad when most students got an answer right and I didn't.	1	2	3	4	5	6	7
17. Using the clickers generated more class discussion	1	2	3	4	5	6	7
18. I learned more when clickers were used	1	2	3	4	5	6	7
19. When clickers were used, the class was better	1	2	3	4	5	6	7

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Item	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
20. Being able to answer questions anonymously using PRS was important to me	1	2	3	4	5	6	7
21. I don´t like having limited time for answering the questions	1	2	3	4	5	6	7

Short open questions:

22. In your opinion, what was the main advantage of using PRS?

23. In your opinion, what was the main disadvantage of using PRS?

In the subject "Analytical Chemistry I" in the 2nd course of the Grade in Chemistry, the PRSs were used in two different ways: i) to evaluate the student knowledge and ii) to evaluate the general understanding of the subject (in an anonymous way). In all the cases the students enjoyed the experience. The principal advantage for the lecturer is that the results of the test are quickly checked, numerically and graphically, so the subject reinforcement is immediate. For example, after the each question of the anonymous tests, the obtained results were discussed in class so the active learning was encouraged. On the other hand, when the PRSs were used to evaluate the students' knowledge their experience was also positive and they felt less stressed than in a normal test. Moreover, being able to check for the validity of the answers immediately makes it more useful for the students as they can see what the right answer was or in which areas they are having trouble.

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In the subject "Analytical Chemistry" in the 3rd course of the Degree in Chemistry, the PRSs were also used in the two forms: i) by assignation of the clicker to each of the students to evaluate the individual knowledge and ii) in an anonymous way to evaluate the general understanding of the subject. In all the cases the results of any of the test types were checked and discussed just after each of the questions in order to promote an active learning.

This was the first subject of the Degree in Chemistry that students used clickers as a learning tool. The most remarkable results obtained according to the satisfaction were that the 94% of students of "Analytical Chemistry" subject said to feel comfortable when using clicker technology and the 88 % preferred this form instead of doing tests on paper. All the students slightly agreed (16 %) to completely agree (58 %) when they were asked if to know the correct answer immediately helped them to notice their errors and their knowledge (ignorance) level. Furthermore, the 53 % liked to see the responses of classmates (helps to know, as they stated, "if it is necessary to get one's act together"), against the 42% that did not mind or did not want to know them.

The use of clickers was widely accepted and most of the students recognize that such methodology increased their interest and motivation for the subject. However, in general terms students do not feel comfortable when the time for answering the questions is limited and this is the main reason why only the 30 % of the students liked the evaluation way whereas the 100 % would prefer a typical exam as a final test. According to students' opinion, it is a disadvantage not to be able to administer the time to invest, for example, much time in some of the questions. Even more, making an exam by using PRSs does not allow to go back to a previous question (for instance to revise the answer) or to chose the order in which the student prefers to complete the exam.

The PRSs were also used in the subject "Advanced Analytical Chemistry" in the 4th year of the Chemistry Degree. In this case, the main aim was to review and ascertain the students knowledge about concepts studied during the previous academic course, that is, in the subject "Analytical Chemistry" in the 3rd year. The multiple choice response tests were answered in anonymous way in order to evaluate the overall knowledge of the class and the particular beliefs about some

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specific topics. The obtained results were discussed and reinforced in class so that the active learning was guaranteed. The experience was really positive considering that it was the first time that they used PRSs.

The satisfaction survey was also passed to the student since this subject is the only subject from the first semester of the school year 2011-2012. According to the results most of the students (80 %) felt more comfortable and motivated using this methodology in an anonymous way, being their participation in the discussion much higher than in a normal class. One of the most interesting aspects of this experience was that it greatly helped in discovering and pointing out common or rather extended mistaken concepts or ideas and disbeliefs about particular topics that, if it not were because of the shelter and the false impression of security that anonymity conveyed them, would have gone unnoticed in a 'normal' class interaction. Although they could immediately see what the correct answer was the 60% of the students think that they do not learned more than in lectures given in traditional way. Open questions provide also information about the advantages and disadvantages of the use of this type of technological devices during class. One of the most mentioned advantages described by the students was the possibility of doing the tests anonymously (50 %), the possibility to know the overall responses of the class (45 %) and the possibility to discuss the answers simultaneously. Moreover, they also think that using clickers is original and amusing. Regarding to the disadvantages, 40% of the students found some difficulties to answer the questions in a very limited period of time (1 minute to answer the question). Some of them (30%) pointed out that since they had only one chance to resolve the question, they had not the possibility to go over the marked answers. 50 % of the students thought that it was surprising but at the same time, time consuming.

In the case of the subject Chromatography and related techniques (4th year in the Degree of Chemistry) the clickers have been used for exams both to test previous knowledge on Chromatography and to test the minimum knowledge of the student. The students start to study some Chromatography during the 3rd year in the Degree in Chemistry in the within the subject "Analytical Chemistry". This previous knowledge exam was carried out in the anonymous way and allowed both the teacher and the students to test their baseline knowledge. Besides, the PRS systems have been used for minimum knowledge exams. Problem Based Learning (PBL)

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approach is being used in this subject and after certain activities of the students minimum knowledge tests are passed in order to guarantee that all the students in the different groups working on a project are acquiring the minimum knowledge of chromatography established for this level in the Degree in Chemistry. During the tests carried out both a fixed time has been given to the students and after each question the students know both the answer and the percentage of people answering the right question. As commented before by the students in the subject "Analytical Chemistry", even if all the students got the answer before the fixed time (90 s in the first test and 60 s in the rest since 90 s turned out to be too long), having a countdown clock put too much pressure to the students. After each question, the right answer was also clicked during these test-type exams and the number (in percentage) of students answering each question was obtained. This type of in-time feedback put also too much pressure on the students.

d) Conclusions and Future Challenges

The experience of the use of Personal Response Systems has been completely satisfactory from both students and lecturers point of view. Among the asking forms the anonymous one is the most preferred regardless the course and the subject. Students agree that this form promotes the participation, although, in general terms the students are more motivated in any of the test types. In lecturers' opinion, the anonymous form is a valuable tool to find out terrible concept errors and misunderstandings, whereas the personalized one is an immediate evaluation tool, because a report including issues such as "results by question" or "results by participant" can be automatically generated after each session.

Concerning future uses of clickers, the goal is to extend their use to one or two questions test aimed to (i) instantaneously get the comprehension of not an entire subject but a specific concept and (ii) to promote a discussion on the specific (short) topic exposed during the previous minutes of the lecture. The use of clickers as an evaluation tool of a typical final exam is not considered in the next future. However, this option it is not ruled out since, as already mentioned, this is the first year that clickers were used. We strongly believe that a larger pool of data is necessary to perform an integrated assessment of the results obtained to state as an example if the use of

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clickers is more accepted by males or females, if there is any real difference among the opinions of student of different years, if the use of clickers is more accepted or even it is more adequated when active learning methodologies (as Problem based or Project based learning) are used etc.

For all these reasons, we will come to extend the use of clickers to subjects that are being introduced in next academic years.

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