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Improving motivation and continuous assessment in engineering classrooms through Student Response Systems

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ABSTRACT

The use of Student Response Systems (SRS) is highly recommended to encourage the active and meaningful learning of students in each lecture. SRS promotes the motivation of students and improves the system of continuous assessment. One of the most popular applications designed for SRS is *Socrative* (Socrative n.d.). The use of *Socrative* gives real meaning to continuous assessment, since the teacher has an easily manageable record of the evolution of their students'learning and will help the teacher to schedule both formative and summative assessment. The application allows the detection of topics that each student may not have understood and determines the percentage of the entire class with the same difficulty.

Beyond the use of *Socrative* as an evaluation instrument, sufficiently referenced, in this article we present different methodologies supported by SRS implemented in engineering studies at the University the Salamanca. The methodologies aim to promote autonomous work outside the classroom, and in face-to-face classes, to maintain the attention and lead the reasoning of the students to facilitate learning. The influence of the methodologies proposed by the authors on a series of indicators related to the motivation and commitment of the students to the subjects will be presented. To the best of our knowledge, most of the work on SRS have been applied to non-university educational levels and for assessment purposes and very few of them have applied SRS to undergraduate engineering studies. The novelty of this work lies in introducing new methodologies supported by SRS in university engineering studies.

1 INTRODUCTION

1.1 Student Response Systems

Among the difficulties of engineering studies, we can mention that the concepts are complex, that a solid mathematical and physical foundation is required, and that the student must dedicate a significant amount of time to individual study. The exercises that are proposed in technical subjects tend to be complex and tedious since data obtained from tables are required or these data must be obtained by previous calculation. Often, these exercises involve approximate solutions, simulations, and complex mathematical calculations. All of this makes it difficult for students to participate in the activities programmed by the teacher, whether as autonomous work or in the classroom. In addition to all these difficulties, it must be added that sometimes the groups are large (Caserta, Tomaiuolo, and Guido 2021, 46 [1]).

Researchers have agreed that active participation in classroom discussions improves student learning and that student-centered methods lead to an increase in satisfaction, engagement, and learning (Diaz, Hrastinski, and Norström 2023, 1 [2]). In this same sense, after several years as teachers, we realised that successful students are generally those who are more active throughout the course in the classroom, those who are capable of reasoning and raising doubts and difficulties related to the matter. These same successful students try to solve the exercises proposed by the teacher even if they do not solve them completely. From there, our teaching activity seeks to gradually introduce methodologies that increase students' commitment to study and class participation, while teaching them to reason and think.

A wide variety of works have been found in the literature in which Student Response Systems (SRS) are used to assess academic performance (Diaz, Hrastinski, and Norström 2023, 1 [2]; Squire 2023, 1 [3]; González-Campos, Castañeda, and Campos 2018, 667 [4]), but few are applied at the university level (González-Campos, Castañeda, and Campos 2018, 667 [4]; Bello and de Cerio 2017, 72 [5]; Bullón et al. 2018, 1818 [6]) and even fewer present their use in university engineering studies (Sun, and Lin 2022, 104430 [7]). Kocak (2022, 2771 [8]) reviewed 77 articles about the use of SRS but only 6 include the use of SRS in Engineering. Some experience carried out in Electronic Engineering (López-Quintero et al. 2016, 183 [9]; McLoone et al. 2013, 1 [10]), Mechanical Engineering (López, and Vinken 2013, 652 [11]); Biomedical Engineering (Tan 2017 [12]) and some study including several engineering (Barragués et al. 2011, 572 [13]; De Grez, and Valcke 2013, 1 [14]). In all of them, the main advantage of using SRS is that engagement is improved (Kocak 2022, 2771 [8]), improves classroom interaction and students' motivation with their study (Diaz, Hrastinski, and Norström 2023, 1 [2]; Kocak 2022, 2771 [8]).

Two systematic reviews investigating the use of SRS in health care studies (Grzeskowiak et al. 2015, 261 [15]) and in pharmacy studies (Hussain, and Wilby 2019, 1196 [16]) showed that the use of SRS improved participation, commitment, attention in class and even enjoyment according to the opinion of the students. In health care studies (Grzeskowiak et al. 2015, 261 [15]) better results were obtained when using SRS than when teaching took place through one-way lectures but did not improve compared to lectures with interactive questions.

One of the most popular apps designed to be used as an SRS is *Socrative* (*Socrative* n.d.). In its basic version it is a free distribution program that can be used from the computer or through mobile devices (http://www.socrative.com). Once a question or quiz is posed, the system captures student responses and instantly generates graphs or statistics from the responses. It supports short answers, multiple choice, or true/false questions. The use of Socrative in the classroom helps to carry out both a formative and summative evaluation since the teacher has an easily manageable record of the learning progress of their students (Santos, Merchán, and Prieto 2019, 111-134 [17] de Moffarts, and Combéfis 2020, 1 [18]). The global analysis of the results makes it possible to detect those aspects of the syllabus that each student has not understood, and even to determine the percentage of students who have the same difficulty.

According to Kocak, (2022, 2771 [8]), despite the great potential of the use of SRS, the best results are obtained by integrating educational technologies in the classroom with the appropriate pedagogical approaches, so more studies are needed on how to use SRS in the classroom that involve novel educational methods. With this idea in mind, and to encourage the active participation of the students, we present five activities supported by the use of Socrative that focus both on the orientation and correction of practical exercises, as well as on the guide of individual reasoning during the lectures of theoretical content. The proposal intends to motivate and to improve the performance of the students of the different engineering degrees of the University of Salamanca (Chemical Engineering, Mechanical Engineering and Materials Engineering). The activities have been tested for at least 4 academic years in the subjects of Thermodynamics, Chemical Kinetics and Electronics, with groups with a number of students between 40 and 140. To the knowledge of the authors, there is only one article for the use of SRS in chemical engineering with Kahoot! (Caserta, Tomaiuolo, and Guido 2021, 46 [1]), none in this specialty using *Socrative* and no studies considering different methodological uses of SRS in engineering studies and in different subjects.

A series of indicators related to class attendance, motivation and success rate have been defined. The results obtained in comparison with academic courses in which a traditional expository methodology was followed reflect that the implemented methodologies supported by the use of Socrative will improve the defined indicators.

2 METHODOLOGY

Five types of teaching methodologies combined with SRS have been implemented to create an active attitude during classes. The questionnaires that have been carried out are of two main types, those that aim to evaluate the work and study carried out by the student individually, and those that aim to guide the work and reasoning during the classroom activity.

In Engineering degrees there are usually abundant **laboratory sessions**. The degree of use of these practices depends largely on the fact that the students previously know the theoretical foundation of what is going to be studied and how the results should be treated. For the students to carry out the practices in the most autonomous way possible, the flipped classroom methodology is introduced. For this purpose, videos describing the practices: objectives, materials, realisation, etc. have been previously elaborated. Students must watch these videos before attending the laboratory. Subsequently, at the beginning of each practice session, they answer a questionnaire. In these questionnaires, they are asked about the practical work to be carried out that day. The usefulness of the questionnaires lies in the fact that they allow students to be aware of whether they have fully understood the practice or if, on the contrary, there are points that they must review before doing it. They can also be used as an additional element in grading students. An example of one of these questionnaires can be found at the link:

https://drive.google.com/file/d/1FVuJ2uA1mZ0-uT4SeIzsb_ZJoXDv_aW6/view?usp=share_link

Another of the applications that we have found to motivate students to work individually at home is based on the **correction of a previously requested model exercise**. The teacher selects a model exercise from the collection of exercises and its delivery is requested one week in advance. Before the student submits his solved exercise, the teacher launches the questionnaire about the problem, the students respond with their solved exercise in front of them, and in a maximum of 10 minutes the teacher has an Excel document with the grade of all the students, based on the solutions provided. The link shows an example of a questionnaire for the guided resolution of exercises in the classroom:

https://drive.google.com/file/d/1Hmv-5JR9w0rj1yG7Jy0aTDZE2v0eYrBw/view?usp=sharing.

Regarding the activities that are based on using the SRS in the classroom, it is worth noting **the guided resolution of exercises**. As already mentioned, the problems in these subjects are complex and lengthy. In the problem-solving seminars, teachers discuss step-by-step the procedure for solving the problem, but it is up to the students to work on it. To keep the students active at certain times, questions are sent through *Socrative* so that they can give partial solutions corresponding to some of the key sections. The link shows an example of a questionnaire for the guided resolution of exercises in the classroom: https://drive.google.com/file/d/108fVEpx6sgvCxUOdPCxnYFxswT-86cng/view?usp=share_link

The use of **SRS in expository sessions** is very useful as they help to dynamize the rhythm, so the student will be more focused on the development of the session. Although pre-designed questionnaires can be used in these sessions in the same way as in the examples previously mentioned, in this case it is particularly appropriate to use the Quick Answers option that *Socrative* offers. These questions are arising by the teacher during the lesson, which implies that, in the case of a multiple-choice question, the answers should be displayed on the black board so that students can choose between them appropriately. The use of this option changes the rhythm of the session and strongly involves the students, who go from being passive subjects to active ones, being also motivated by the competitive factor of seeing their answers projected on the blackboard.

One of the activities that is carried out with engineering students and that is proving to have great potential is the **classroom experiences** carried out by the teacher during a theoretical class session, with the collaboration of the students. They are carried out at the beginning of a content block, to awaken and clarify previous knowledge. For example, before beginning the study of Chemical Kinetics, the material is brought to the classroom to observe the effect of the initial concentration of a reagent and of the temperature on the reaction rate of decolorization of phenolphthalein in a basic medium. After discovery learning, it is essential to draw conclusions about the observed phenomenon. The SRS have proven to be very useful for obtaining information on the hypotheses and conclusions established by the students. Through SRS, the teacher asks about the effect that the experimental parameters have had on the rate of chemical transformation, and the statement of a general law is requested. The link shows an example of SRS to establish the behaviour observed during classroom experiences:
https://drive.google.com/file/d/1-xxKtWy_OiIl7VMCm19Xy9SR_NYWPGn-/view?usp=sharing.

3 RESULTS: *STRENGTHS AND WEAKNESSES OF THE USE OF SRS IN ENGINEERING CLASSROOMS*

To evaluate the impact of the methodologies used in the different subjects, specific indicators are defined for each of them. The comparison with the indicators has been made between academic courses in which the described methods were and not were used, as indicated in Table 1 (results without SRS and with SRS). The selected indicators are: 1: Average marks in continuous evaluation, 2: Attendance at the classroom. 3. Attendance at the final exam. 4. Prior knowledge of laboratory work. 5. Success rate.

Table 1: *Results of indicators: Academic years with innovative methodologies and SRS (with SRS) and academic years without SRS (without SRS).*

Studies	Subject	Methodology	Indicator	without SRS	with SRS
Chemical Engineering	Physical Chemistry	Previously requested exercices	Average marks in continuous evaluation	7,2	5,3
		Classroom experiences	Attendance at the classroom	74%	92%
	Thermodynamics	Previously requested exercices	Average marks in continuous evaluation	7,5	5,4

		Classroom experiences	Attendance at the classroom	54%	80%
	Engineering Thermodynamics	Guided resolution of exercises	Attendance at the classroom	53%	74%
	Physics I	Laboratory Sessions	Prior knowledge of laboratory work	30%	75%
Materials and mechanical Engineering	Fundamentals of Electronics	Expository sessions	Attendance at the final exam	89%	100%
			Attendance at the classroom	70%	90%
			Success rate	70.8%	100%

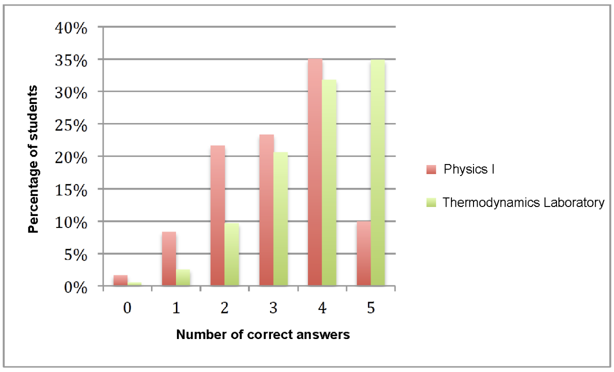

Fig. 1. Percentage of students with a certain number of correct answers, 0 (all wrong) to 5 (all right), for two different subjects.

Fig. 2. Classroom full before the call for a test with SRS.

Regarding the use of SRS before the **laboratory sessions**, one indicator is whether the students have acquired the necessary knowledge before attending the laboratory. Fig. 1 shows the percentage of students with a given number of correct answers, from 0 (all incorrect) to 5 (all correct), for two different subjects. Physics I is a subject of the first year of the Chemical Engineering Degree, while Thermodynamics Laboratory belongs to the second year of the Physics Degree. As can be seen, in both subjects the results are very good, with a percentage of students answering 4 or 5 questions correctly of 45% in Physics I and 65% in Laboratory Thermodynamics. It can be affirmed that 75% have previously worked at home on the scripts of the practical sessions or watched the videos, since they know that they are going to be surveyed with SRS. When this methodology was not used, only about 30% had done the previous preparation.

According to the bibliography consulted, the use of SRS has been aimed at assessment; SRS has not been used to check the understanding of the subject matter to be studied in the practical sessions in the laboratory. With this methodology the greater commitment of the students is remarkable, which results in a better performance of the laboratory work.

The use of SRS for “**correction of previously requested model exercise”**, results in increased student attendance in the classroom and more participatory correction of exercises. Considering the continuous assessment ratings indicator, in which the average of the 3-year ratings with and without SRS has been presented (from 2013 to 2016) without using SRS and with SRS (from 2020 to 2022) a decrease from 7.2 to 5.3 was observed. This result has been interpreted as a more faithful evaluation of the exercises the student has performed. When nothing is asked about the problem, the exercises are often copied among students and that is why the average mark is higher, and the attendance indicator increases (Table 1). Once more, we haven't found papers that describe the use of SRS to increment the individual work of students.

In the “**guided resolution of exercises”** methodology, one indicator is whether there is a difference between the number of students attending theory class and problem seminars. In Engineering Thermodynamics, it has been found that the number of students attending the problem seminars in which SRS are used, is approximately 20% higher than the number attending the lectures where SRS are not used (Fig. 2). The results match with those found by various authors, such as González-Campos, Castañeda, and Campos (2018, 667 [4]): the use of SRS reduces the number of absent students in the subject.

The use of the **Quick Answers option in expository sessions** in Electronics Fundamentals (on the degree in Materials Engineering and Mechanical Engineering) the attendance rate when using SRS has gone from 70% to 90%, approximately. On the other hand, the number of students who pass the subject has increased to 100% in the course where SRS have been used, compared to 70.8% in the previous course where SRS were not used. This result coincides with what is presented by López-Quintero et al. (2016, 183 [9]) which states that this methodology contributed to a better knowledge of theoretical concepts. In addition, the number of students who attend the exam increases from 89% to 100% in the course that we have used SRS. This increase means that students are more committed with the subject matter. Similar results have been obtained by Gonzalez-Campos et al (2018, 667 [4]) with a higher pass rate, better grades and higher attendance among students assessed with SRS compared to those assessed with the traditional system.

The use of **“classroom experiences”** has been valued very positively by students in satisfaction surveys carried out at the end of the subjects (90% of students value this activity with 9 out of 10). Even though the concepts introduced through the experiences are general, the perception of the students is that they better interpret the topic in which some experience is developed. The attendance indicator increases when some experience is previously announced. This match with what Gonzalez-Campos states: when using interactive tools to answer the proposed questions, all students showed a high degree of attentional focus, developing the psychological skill of attention-concentration (González-Campos, Castañeda, and Campos 2018, 667 [4]). However, Grzeskowiak (2015, 261 [15]) indicates that the use of SRS does not improve results when compared to lectures with interactive questions.

It should also be noted that, in general, attendance at lessons or seminars in which an SRS is announced has increased (Fig. 2). At the laboratory the attendance is mandatory, whereby the attendance has not been evaluated.

After several years using SRS with different teaching methodologies in engineering courses, we can summarise its main strengths and weaknesses in Table 2.

Table 2: *Weaknesses and strengths of the use of immediate response systems in the classroom.*

Strengths of SRS	Weaknesses of SRS
• Very intuitive. • Easy to learn how to use. • Daily and personalized monitoring of students. • Detects less understood concepts (formative evaluation). • Provides a record of the learning evolution of each student (summative evaluation). • Increases student motivation for the subject and attention during classes. • Encourages the participation of insecure students. • Enables participation from outside the classroom (incompatibility of students). • Increase attendance if SRS sessions are scheduled.	• Answers are inevitably directed. • Discussion, analysis, and reflection are limited. • It does not allow to improve the written expression. • Motivation is fostered only by rewards. • Enables participation from outside the classroom (absence of new students).

4 SUMMARY AND ACKNOWLEDGMENTS

Different activities and methodologies supported by SRS that have been used in several Engineering studies at the University of Salamanca are presented: test prior to the laboratory sessions, correction of previously requested model exercises, in the guided resolution of exercises, in expository sessions, after a classroom experience.

In general, attendance at lessons or seminars in which there are pre-announced SRSs has increased. In the practical sessions, the use of SRS increases the number of students who have worked the practice scripts before entering the laboratory, improving performance. In type-correction exercises requested as individual work, the evaluation is more reliable, and the grades are lowered. All the indicators analysed lead us to think that these methodologies reduce dropout and facilitate student success by increasing their commitment to study.

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