INNOVATIVE PEDAGOGICAL STRATEGIES IN CHEMICAL ENGINEERING EDUCATION: HARNESSING THE POWER OF WOOCLAP FOR ACTIVE LEARNING

J. Carrillo-Abad, O. Gil-Castell, J. Ribes, R. Sanchis-Martínez, N. Martí, M.V. Ruano, J.B. Giménez, R. Serna-García J.M. Peñarrocha, L. Pastor, A. Cháfer, M. Izquierdo, A.L. Jiménez, J.D. Badia

Universitat de València (SPAIN)

Abstract

The use of Information and Communication Technologies (ICT) has been part of university life for over two decades, to the extent that those aimed at the educational world have evolved into Learning and Knowledge Technologies (LKT). In this context, Audience Response Systems (ARS) such as Wooclap, Kahoot, or Socrative allow teachers to create real-time questions, surveys, debates, and games.

Some studies have identified ARS as tools that encourage learning engagement, interaction and interest among students. In particular, Wooclap appears as an interesting alternative due to its wide range of question types. Furthermore, there are some studies in a wide range of high level education fields, showing Wooclap adaptability. In this sense, this work aim to study its application in 6 different courses from 4 different degrees, all in relation with the chemical engineering field.

121 students answered the survey about the use of Wooclap during the lessons. The 85% of respondents never used this application before, which highlighted the work novelty. More than 60% of students considered the use of Wooclap correctly integrated both in time and form into the lessons. In general, students considered that Wooclap enhanced the three pillars of engage learning index, highlighting the behavioural and cognitive engagement. Moreover, the 84% of respondents recommended the use of this application in other courses, especially in the theoretical ones. Finally, more than 80% of students pointed out that their experience with Wooclap was possitive. These results show that Wooclap is an efficient tool for attracting the students' interest and make their learning process easier.

Keywords: Higher education, active learning, audience response systems, Wooclap, chemical engineering.

1 INTRODUCTION

As Bruner wrote in the '60s "An effective learning takes place through a spiral-like way and not lineally" [1]. Therefore, the lecturer should repeat and review, frequently, the concepts previously presented to retain and strengthen the student learning process [2]. In this sense, ICT (information and communication technologies) appears as an alternative to describe that spiral way. The ICT resources employed in learning have been called by some authors as e-learning or Learning Knowledge Technologies (LKT) [3], [4]. The LKT resources not only permit online learning but also allow the learning process to be focused on the student, which means that they decide their learning rhythm, taking control of their process [5]. These e-learning tools appear in the academic literature as mandatory because lecturers are facing a student generation born in the internet era [6]. Amongst the high amount of software and applications generated to be used in the LKT, there is a group called audience response systems (ARS).

ARS have been widely used in different fields of high education due to the improvement of the lecturer-student interaction, especially when the course is attended by a high number of them [2], [7], [8]. Other of their main characteristics are enhancing students' interest and engagement, allowing quick detection of students at risk (by the analysis of the student's results in the application), permitting immediate feedback to students and promoting collaborative learning among students [4].

Nowadays there are a lot of commercial applications in the ARS field like Kahoot!, Socrative, Moodle, Wooclap, etc. Among them, this work is based on the study of the Wooclap application because is a platform that promotes the real-time interaction between professor and student both in face-to-face and

distant learning environments [4]. Furthermore, it allows transforming smartphones, usually considered a distraction source [2], into interactive learning tools to change the focus of the learning process from professors to students.

Wooclap has already been studied by some authors [9], where their impact on students' learning process has been evaluated. The fields where Wooclap has been applied are wide, including medicine, economy, chemical engineering, geology, journalism, etc. [6], [7], [9], [10], [11]. This diversity shows the adaptability of Wooclap's platform to different fields, from science to humanities subjects. Furthermore, Wooclap does not require the installation of any app and it has a friendly interface [6], [12]. Students can answer questions at any moment the lecturer prefers. It can be used at students' rhythm in a flipped-classroom approach, at course beginning to attract their interest, during the course to check concept understanding or at the end to know if they have understood the main ideas. In addition, Wooclap allows students to inform that they are confused *in situ*, which permits the lecturer to adapt their explanation, helping concepts assimilation.

Another advantage of Wooclap is the wide range of question types it has, such as multiple-choice, open questions, cloud words, fill the gaps, identify images, etc. [11]. All these characteristics have demonstrated an increase in the concept understanding and active participation of students, favouring the engagement, feedback and concentration in the classroom, the introduction of debate and collective reflection [6], [9], [13], [14], [15]. Some authors present Wooclap as a tool aligned with the four learning pillars defined by Stanislas Dehaene [16], which are in concordance with the four engagement modes defined by Chi and Wylie [17].

Previous works based on the use of Wooclap presented results obtained in single courses [4], [9], [18] in the same course in different degrees [2] or in different courses in the same degree under the same topic [6], [11], but no literature has been found comparing six different courses in the field of chemical engineering in four different degrees and one master course. In this sense, the present work aims to obtain a global image of the Wooclap use and acceptance in courses given by the Chemical Engineering Department from the Universitat de València.

2 METHODOLOGY

This work compares the sensations and experiences of using Wooclap by the students of 6 different courses in the field of Chemical Engineering at the University of València (UV), whose main characteristics are presented in Table 1. All the subjects presented different learning outcomes and dynamics and were given by ten different lecturers. This generates a heterogeneous sample of students that permits to determine the homogeneity in the use of ARS in higher education or finding out the possible differences between courses.

In all the courses, the implementation of Wooclap was carried out by including questions through the contents presented in the theory classes. To favour students' participation, the results of these questions did not weigh on students' assessment, according to previous works [11], [19].

Table 1: Main characteristics of the courses.

Course	*Degree*	*Course and semester*	*ECTS and typology*
Projects in Chemistry	Chemistry	4th A	6 Mandatory
Ambiental Engineering	Ambiental Sciences	2nd B	4.5 Mandatory
Energetic Technologies	Chemical Engineering	4th B	4.5 Elective
Industrial Security	Chemical Engineering	4th B	4.5 Elective
Process Engineering	Chemical Engineering	3rd B	4.5 Mandatory
Quality Management	Food and Science Technology	3rd B	4.5 Mandatory

The methodology employed for obtaining information was by conducting surveys with students through a common questionnaire. Surveys can be considered as data collection tools that allow extracting the required information by asking questions. In addition, they permit a quick and economic collection of data that is, usually, facile to manage [11].

The survey was structured into 8 different questions, the first of which was a control question about their genre. The following other questions, except Q3 explained afterwards, are nominal (where the Likert scale is replaced with sentences) and talk about the application frequency of use (Q2), the time dedicated to Wooclap (Q4), the implementation satisfaction (Q5), the recommendation in other courses (Q6) and the overall rating (Q7). Q3 is an evaluation of the main Wooclap advantages, such as enhancing attention, consolidating concepts, identifying doubts, etc. on a Likert scale from 1 to 5. Q3 is based on the Engaged Learning Index, which considers the psychological dimensions of engagement in learning, that is meaningful processing of information (cognitive engagement), focused attention on the course (affective engagement), and active participation during the course (behavioural engagement) [20], [21]. The last question (Q8) is an open-ended request to provide their opinion about the use of the app. This kind of question allows a greater depth and variety of responses from the audience, improving the results [11]. The surveys were carried out during the middle of the course (1st - 2nd March week 2024), except for the projects in chemistry subject, which were realized at the end of the 1st semester (last week December 2024). The questionnaire was answered by a total of 121 students. Table 2 summarizes the main characteristics of the study and Table 3 shows the description of the survey.

Table 2: Survey participation.

Course	Response date	Total Students	Attendance	% Participation
Projects in Chemistry	12/19/2024	73	62	89
Environmental Engineering	03/04/2024	37	20	80
Energetic Technologies	03/06/2024	16	12	75
Industrial Security	03/11/2024	20	17	76
Process Engineering	03/08/2024	53	38	66
Quality Management	03/06/2024	41	22	59

First, it is worth noting that there is a difference between the total enrolled students and those who attended the lessons. There are some cases where attendance is close to, only, 50% due to the high rate of absenteeism. The causes of the mentioned absenteeism are usually related to a high rate of repeaters and students who are in part-time jobs, which difficult for them to be present in class. In this work, the participation rate was calculated from the students who participated in Wooclap during the course and answered the survey.

Table 3: Survey questions.

Question	Text	Answers	Type
Q1	What is your genre?	- Male - Female - Fluid - Other - Don't want to answer	Nominal (five levels)
Q2	Did you use Wooclap previously?	- Never used it before - Punctually used - Other teachers employ it usually	Nominal (three levels)
Q3	Rate the following characteristics of Wooclap on a scale of 1 to 5 (1 implies a strong disagreement and 5 strong agreement)	- Improve the concept understanding. - Present a direct application of theory. - Facilitates the memorization. - Favours the emergence of doubts. - Facilitates the doubts resolution. - Increase the interaction with the lecturer. - Increases participation in the course. - Encourage class attendance.	Likert Scale (five levels)

Table 3: Survey questions (continuation).

Q4	Has Wooclap been correctly integrated into the course?	- It has been integrated disastrously. - It has been completed with difficulties. - It has integrated well in some points and badly in others. - It has integrated well. - It has been integrated harmoniously.	Nominal (five levels)
Q5	The time employed during the course to Wooclap was, from your point of view	- Excessive. - A lot. - Adequate. - Little. - Insufficient.	Nominal (five levels)
Q6	What is the general assessment of the use of Wooclap in the subject?	- Excellent - Good - Adequate - Bad - Unpleasant	Nominal (five levels)
Q7	Would you use Wooclap in other subjects?	- Yes, in all of them - Yes, but only in theoretical courses. - Yes, but only in practical subjects. - No	Nominal (four levels)
Q8	Have you any comments or suggestions about the use of Wooclap?		Open question

To determine the homogeneity of the responses obtained among the different groups, the Pearson Chi-square test was applied [11], as it allows testing differences between the course (with 5 categories) and each of the questions (nominal variables with 3 to 5 levels). In the nominal variables, the percentage of answers for each response was evaluated.

3 RESULTS

The main results for questions Q2, Q4, Q5 and Q7 are presented in Fig. 1. They show that Wooclap remains unknown in the degrees where the Chemical Engineering department from the UV participates as 85% of the respondents have never used it. It is worth noting that Wooclap seems to be often employed in the chemical engineering degree as they show a slightly higher trend. This result highlights the novelty of this study. Regarding the time dedicated to Wooclap activities and its integration into the course, the answers show different results depending on the subject, which is directly related to the heterogeneity of the samples, with a wide spectrum of students, course dynamics and lectures. However, in general terms, more than 60% of students thought that Wooclap was correctly integrated both in form and time dedication. Finally, 84% of respondents will recommend the implementation of Wooclap in other courses, especially (65%) in the theoretical ones. In all these questions were two courses (Ambiental Engineering and Quality Management) that presented the more critical answers. This could be associated with the minor affinity of these students to the chemical engineering subjects.

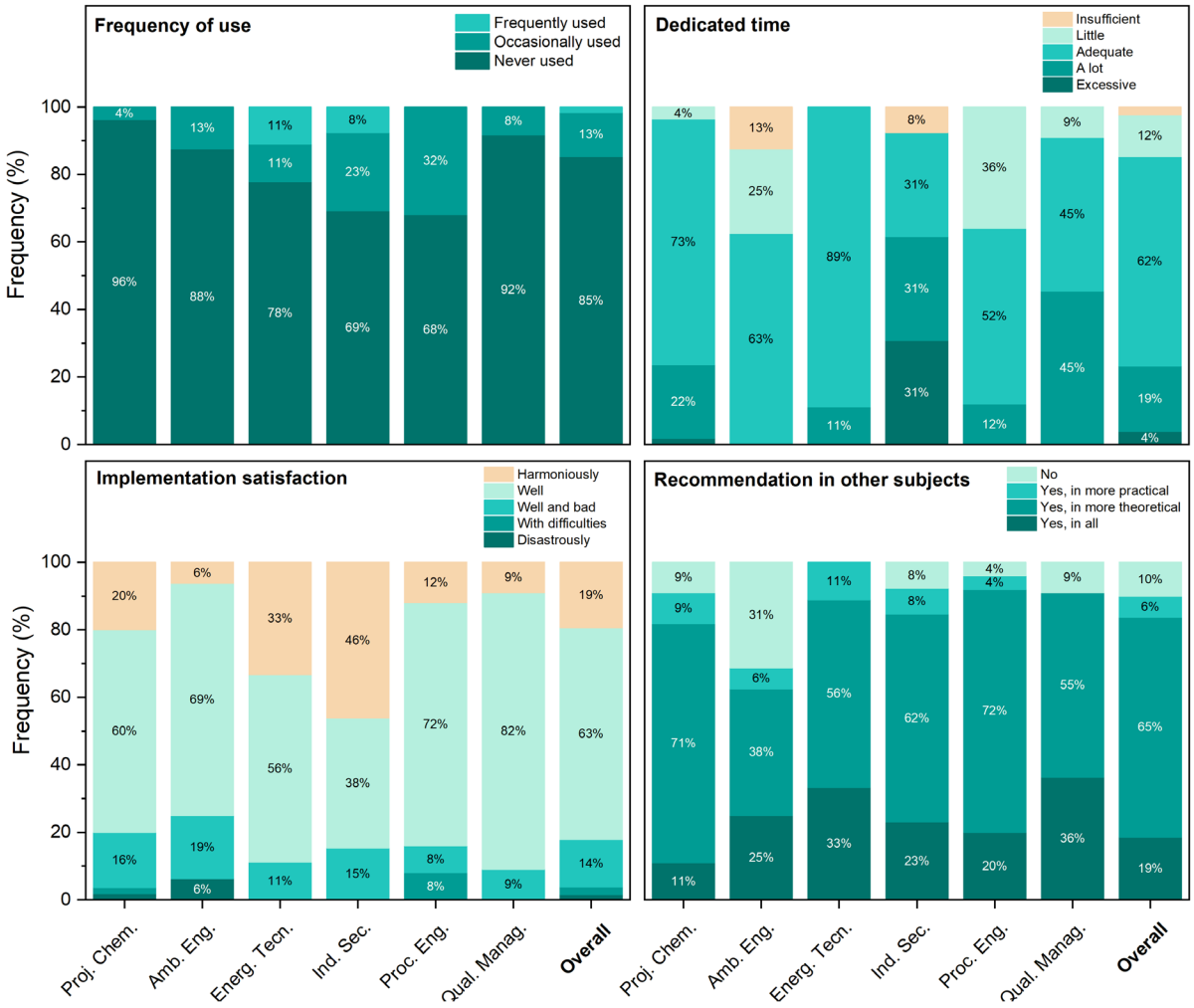

Figure 1. Results for questions about the (a) frequency of use, (b) dedicated time, (c) implementation satisfaction and (d) recommendation in other subjects.

Table 4 and Fig. 2 present individual (per course) and overall qualifications obtained in Q3, where the Engage Learning Index was evaluated. The three first items (attendance, participation, and interaction) are related to behavioural engagement; the following three (memorization, doubt resolution and concept understanding) can be associated with cognitive engagement; and the last two (concept application, doubt arise) are related to affective engagement.

Students generally consider the use of Wooclap as effective, given their agreement (mean value of 3.73) in the engagement of all three indexes. They highlight the improvement in behavioural engagement (3.98, excluding course attendance). The cognitive engagement presents values lower than the mean as the items regarding concept understanding (3.79) and doubts resolution (3.72) are close to the mean. However, the memorization item was marked by students with the second lowest value (3.53). Finally, affective engagement presented a mean value (3.79) higher than the general mean among indexes associated to the high mark obtained by the concept application item (3.93). These results are in concordance with those obtained by other authors [6], [9], [13], [14], [15].

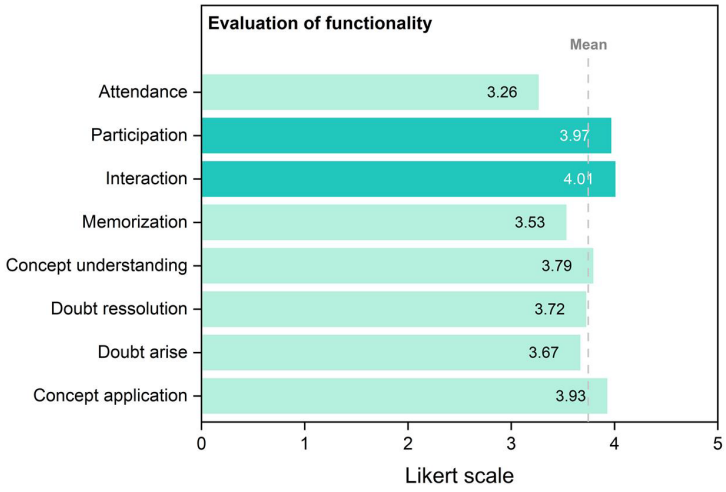

Figure 2. Results for the engage learning index ascribed to cognitive, affective and behavioural engagement.

Table 4: Results for the engage learning index ascribed to cognitive, affective and behavioural engagement obtained in the different courses.

	Topic / Course	***Proj. Chem.***	***Env. Eng.***	***Ener. Tech.***	***Ind. Sec.***	***Proc. Eng.***	***Qual. Man.***
Q3	- Attendance	3.4	2.6	4.1	4.1	3	2.3
	- Participation	4.2	3.3	4.3	4.2	4	3.3
	- Interaction	4.2	3.3	4.2	4.3	4	3.8
	- Memorization	3.6	3.4	3.8	4	3.1	3.6
	- Doubt resolution	3.9	3.2	3.6	3.9	3.6	4
	- Concept understanding	4.0	3.3	4.1	3.8	3.5	3.7
	- Concept application	4.1	3.5	3.9	4.3	3.8	3.5
	- Doubt arise	3.9	3.2	3.4	3.8	3.6	3.5

The value of doubt arise item and doubt resolution are wide among courses due to use of Wooclap carried out by the lecturers. For instance, in the courses where the questions were placed during the presentation (Projects in Chemistry, Industrial Security and Quality Management) the values are higher than those obtained at the courses where the questions were carried out at the end of each season. It is worth noting that courses with higher absenteeism were those that worst qualified the encouragement to course attendance item (Environmental Engineering, Quality Management and Process Engineering).

Regarding the general experience of the students using the Wooclap application, it can be appreciated in Fig. 3 that most of them qualified it as good or excellent, while 16.3% defined it as adequate and only 3.1% of respondents described it as bad or unpleasant. Therefore, Wooclap points out as an unknown application that attracts students and helps them with the three Engagement Learning Indexes, making their learning process easier.

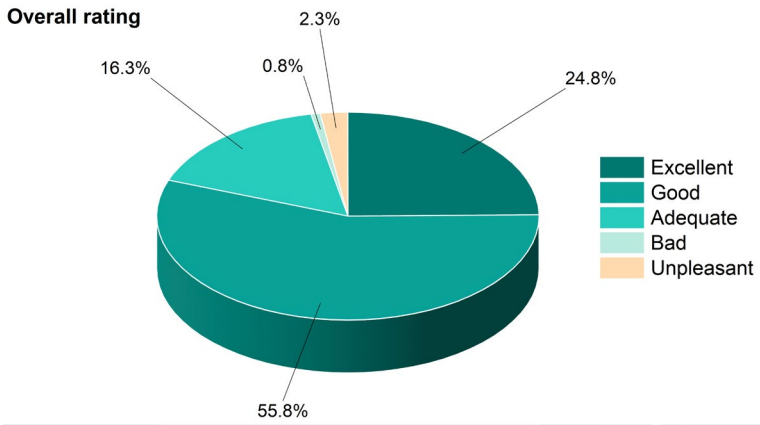

Figure 2. Results for the general experience and overall rating of Wooclap.

Despite the differences observed between the different courses, the Pearson chi-square test must be applied to verify whether these differences are the result of random error, or they are significant [11]. The null hypothesis is that there is no correlation between the course and the different assessments of the teaching methodology. This hypothesis can be verified for each answer using the % of respondents except for Q3 where the punctuation of the Likert scale was assigned a weight by the proportion of students from the total ones. The results of the Pearson test are shown in Table 5. Considering that the *p*-value is greater than 0.05, the null hypothesis is consistent with a confidence level of 95%. In other words, the Pearson Chi-square test shows no significant differences among all the six student groups, so the course to which students belong does not have any effect on the evaluation of teaching methodologies. Therefore, the Wooclap evaluation is independent of the course studied. Furthermore, there is only one question with a *p*-value close to 0.05, Q5 that is related to the different courses' dynamics and lecturers' style, that is, in each course the number of employed questions per lesson varied from 5 to 10, which can affect students' perception.

Finally, from the analysis of the open question (Q8), the different responses could be organized in some topics due to their similarity. According to this, most students (75) answered that everything was OK or nothing to add. 15 students talked about the lesson dynamization thanks to the use of Wooclap, which is directly related to high the punctuation obtained in the behavioural engagement. 13 respondents highlighted that Wooclap helped them to be more attentive during the lessons, which is associated to the affective engagement. It is interesting that 5 students marked that filling the gap questions were not useful for them because the correct answer was not clear sometimes.

Table 5: Pearson Chi-square test results.

Question	*Answers*	X^2	*p-value*
Q1	**Gender**		
	- Male	2.6583	1
	- Female	0.6562	1
	- Fluid	1.6063	1
	- Other	2.5313	1
	- Don't want to answer	2.5183	1
Q2	**Frequency of use**		
	- Never used it before	0.5660	1
	- Punctually used	2.1951	0.9991
	- Other teachers employ it usually	2.4298	0.9984
Q3	**Evaluation of functionality**		
	- Improve the concept understanding.	0.3433	1
	- Present a direct application of theory.	1.2143	1
	- Facilitates the memorization.	4.7243	1
	- Favours the emergence of doubts.	0.2763	1

Table 5: Pearson Chi-square test results (continuation).

Question	*Answers*	X^2	*p-value*
Q3	**Evaluation of functionality**		
	- Facilitates the doubts resolution.	0.8402	1
	- Increase the interaction with the lecturer.	2.1634	1
	- Increases participation in the course.	28.9659	0.9364
	- Encourage class attendance.	11.3210	1
Q4	**Implementation satisfaction**		
	- It has been integrated disastrously.	1.7398	1
	- It has been completed with difficulties.	2.5349	1
	- It has integrated well in some points and badly in others.	1.7485	1
	- It has integrated well.	5.8900	0.9999
	- It has been integrated harmoniously.	6.0509	0.9999
Q5	**Dedicated time**		
	- Excessive.	5.8693	0.9999
	- A lot.	35.3973	0.0628
	- Adequate.	4.7336	1
	- Little.	1.7719	1
	- Insufficient.	2.9642	1
Q6	Overall rating		
	- Excellent.	10.0640	0.9943
	- Good.	1.1156	1
	- Adequate.	7.4575	0.9995
	- Bad.	0.8202	1
	- Unpleasant.	2.4515	1
Q7	**Recommendation in other subjects**		
	- Yes, in all of them.	10.0640	0.9943
	- Yes, but only in theoretical courses.	1.1156	1
	- Yes, but only in practical subjects.	7.4575	0.9995
	- No.	0.8202	1

4 CONCLUSIONS

The increase in the use and affinity of new technologies by students is a fact that should be considered to transform potential distractions, such as mobile phones or tabletops, into potential interactive learning tools. In this sense Wooclap is an interesting alternative taking into account its good acceptance by students, their varied kinds of available questions, and the possibility of directly combine the lesson slides with the questions.

Furthermore, this work confirms, in a wide spectrum of students surveyed, that Wooclap favours the engagement learning indexes by increasing student's interactivity, easing the understanding of concepts by its direct application and the resolution, in-situ, of the doubts that may appear. However, a limitation of this manuscript is the study of the effect of this tool on qualifications due to the lack of data, which should be addressed in future works. Additionally, wider studies including more courses given by the chemical engineering department would be performed as recommended by the results obtained here.

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