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RESEARCH ARTICLE

Measuring and Promoting Self-Regulated Learning Using Spaced Questionnaires

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ABSTRACT Self-Regulated Learning addresses key students' competences for performance in higher education, particularly in engineering disciplines. Assessing these competences helps identify students' gaps and provide appropriate support towards their development. Currently, the main self-regulated learning assessment tools are questionnaires with a large number of items administered in one session, for example, the MSLQ has 81 questionnaire items. Rather than snapshotting the students' self-regulated learning competences in a single session, this manuscript proposes a novel assessment approach, the SMSRLQ, which includes 150 questionnaire items (81 from the MSLQ and 69 from other questionnaires) but spacing the items weekly and providing feedback monthly. The spaced approach was experienced on several Egyptian universities using a social network service (Facebook) and distributing students into control (113) and experimental groups (107). Many variations in the students' answers are observed, with statistically significant differences between 11% to 30% in MAE and MAPE indicators. Variations in standard deviation, reliability and clustering between the approaches also were identified, demonstrating that there are clear differences between the two administration approaches. Regarding monthly feedback, the results show that it enhances students' participation and improves their self-regulated learning competences: 77% of the experimental group respondents found that their self-learning knowledge was developed after the study, compared to 50% of the control group respondents.

INDEX TERMS Higher education, self-regulated learning, spaced questionnaires.

I. INTRODUCTION

Self-Regulated Learning (SRL) is a "self-directive process by which learners transform their mental abilities into academic skills" [1]. It is a comprehensive term that encompasses multiple components, like self-efficacy, volition, cognition, metacognition, and motivation [2]. SRL is a transversal topic that can be applied to various academic disciplines including the field of engineering education. According to [3], self-regulated learners are the "*masters of their personal learning activities*". They are active, self-aware, knowledgeable, and capable of planning, setting goals, organizing, scheduling, self-monitoring, self-evaluating, and deciding their proper learning approach. Learners adopt different SRL strategies according to contextual factors like self-belief, social support, cultural background, and the subject natures. However, the basic elements of SRL are the same [4], [5], [6], [7], [8].

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Equipping higher education students with a balanced combination of SRL competences is an essential element for them to achieve their learning objectives, evaluate their progress, and finish their college education successfully [9], [10], [11]. The difference in students' SRL competences can explain their different learning progress and academic accomplishment [12], [13]. Nevertheless, the appropriate development of SRL competences can be problematic because it involves many components: motivation, emotion regulation, goal management, time management, task value and understanding, environment structuring, resource management, help seeking, peer learning, evaluating, monitoring, learning strategies, etc. This can be particularly challenging for first year University students, as they face difficulties in gaining experience and being acquainted with the University life during the transitional period between high school to higher education [14], [15]. Moreover, the students' need to enhance their SRL capacities has become more urgent after the outbreak of the COVID-19 pandemic [16], [17]. The pandemic outbreak resulted in an increasing adoption of online learning. This mode of learning demands higher SRL capacities to achieve the learning outcomes.

The lack of students' self-regulation can cause suboptimal performance and the use of SRL strategies can predict dropout rate [18], [19], [20]. This problem is obvious in engineering education that witnesses a high dropout rate of students [21], [22]. For example, the dropout rate among the Spanish students in the discipline of Engineering and Architecture reached a significantly high level of 36%. Most of the dropouts were among the novice first year students [21]. In addition, SRL can also contribute to support the development of students' soft skills, which are highly required for the engineering graduates entering the industry.

The good news is that SRL promotion can occur gradually via learning and practice [23], [24]. Different frameworks [16], [25], [26], exist to analyze, recognize, and support learners' SRL development. Among all the elements involved in SRL competences development, assessment of the actual student competences is a key one [27]. Nowadays, self-report instruments are the most popular ones. They are provided either as large questionnaires including questions for the bulk of the SRL components, or as shortened questionnaires considering just some components. In both cases, these questionnaires are usually administered in a unique session to measure students SRL skills.

Currently, the most popular SRL questionnaire is the Motivated Strategies for Learning Questionnaire (MSLQ). This includes 81 questions, but it is also available in shortened versions with less than half of these questions. Despite psychometric problems [28], MSLQ is a benchmark in measuring the application of students' strategies to be self-regulated [29]. This approach has shortcomings:

1) For large questionnaires, respondents may tend to answer carelessly or even quit answering.
2) For reduced questionnaires, they also reduce the coverage of the variety of SRL competences.
3) One-time questionnaires provide a snapshot instead of a dynamic view about the learners' SRL development over time [30].
4) Questionnaires are susceptible to multiple biases that negatively affect the reliability of the gathered data [31]. For instance, students may overestimate their SRL capacities. Existing research has shown discrepancies between their self-reported data and their actual behaviors [32], [33].

Considering these previous shortcomings, we envisioned a novel approach to measure and promote SRL competences: spacing questionnaire items over time. This approach is based on dividing a large questionnaire into small chunks and administering questions on a spaced basis. As the questionnaire period is prolonged, it can include a larger number of questions. Particularly, we propose the Social Media Self-Regulated Learning Questionnaire (SMSRLQ), involving 150 questions, 81 ones from the original MSLQ [34]. In addition, students receive monthly feedback as an SRL competence report based on the collected answers.

For this new spaced approach, the following research questions are considered:

- RQ1: Do differences exist due to the two administration approaches? We wonder if the students' answers vary between the single session and the spaced administration and if there is a pattern in such variation.
- RQ2: Does the feedback provision enhance the students' participation and cause a difference in their SRL competences development? We wonder if the provision of feedback to students can enhance their participation and cause any difference in their SRL competences development.

The structure of the rest of the manuscript is as follows: Section II reviews the related literature. The third section discusses the used data gathering instruments, the study design, and the methodology. Section IV presents the results of the SMSRLQ and compares them against the MSLQ results, considering specially the questions in the SMSRLQ taken from the MSLQ. Section V discusses the results against the proposed research questions. Finally, section VI includes the conclusions, limitations, contributions, implications, and future work suggestions.

II. LITERATURE REVIEW

During the last decades, the focus on learning and pedagogical theories has shifted from external regulation by instructors to the empowerment of students as main characters. Particularly, a plethora of prior research stressed the constructive influence of SRL on the higher education students' academic achievement. It showed that self-regulated learners surpass their counterparts who lack SRL skills [35], [36]. SRL practices endorse adaptation to novel contexts, tasks, and situations, and therefore can lessen the effect of

TABLE 1. Previous work contributions.

Scientific contribution	Reference(s)
Demonstrating that self-regulated learners surpass their counterparts who lack SRL skills	[35], [36]
Demonstrating that SRL practices can lessen the effect of surprising circumstances such as COVID-19 on the students' academic performance	[37]
Demonstrating that more successful learners are engaged in greater and more complicated SRL behaviors than other students.	[38], [39]
Demonstrating that the improvement in the students' SRL partially mediates their achievement	[40]
Demonstrating that the difference between high achievers and low-achieving students lies principally in the quality rather than the quantity of the utilized SRL strategies	[41]
Demonstrating the shortcomings of self-report instruments in assessing the learners' SRL.	[42], [43]
Demonstrating the recent trend towards data analytics approaches due to the self-report instruments shortcomings.	[42], [44], [45]
Demonstrating that the instruments based on data analytics try to track and directly analyze the genuine experience of learners, rather than the learners' perceptions	[46]
Demonstrating that SRL measurement by data analytics can take place either solely, or with other self-report measures to obtain data triangulation, recognize the different students' SRL behaviors more exactly, comprehensively understand the contextual effects, guide students, and better forecast their performance.	[42], [44], [47]
Examining the evolution of engineering students' SRL and its positive influence on their achievement.	[48-50]
Demonstrating the limitations of data analytics techniques in SRL assessment.	[30], [51]
Demonstrating the advantages of Questionnaires in SRL assessments and their usage in various learning environments.	[30], [52]- [56]
Demonstrating the significance of properly designed SRL interventions.	[57-61]
Introducing the third wave of SRL assessment that combines measurement and intervention.	[51]
Guidelines for the provision of effective and efficient interventions in higher education settings.	[40]

surprising circumstances such as COVID-19 on the students' academic performance [37]. More successful learners are engaged in greater and more complicated SRL behaviors than other students [38], [39]. On the contrary, [40] found that the improvement in the students' SRL partially mediates their achievement and [41] found that the difference between high-achieving and low-achieving students lies principally in the quality rather than the quantity of the utilized SRL strategies.

A great proportion of previous research has focused on using self-report instruments for SRL assessment. Of course, these instruments rely on the self-assessment information provided by learners. Such information is susceptible to bias and can be inaccurate because of factors such as the learners' memory retrieval capacity, perceptions, and points of view. Moreover, these measurements do not present a dynamic view of the learners' SRL evolution through the learning process [42], [43].

Due to the self-report instruments shortcomings, there is a recent trend towards data analytics approaches [42], [44], [45]. These instruments try to track and directly analyze the genuine experience of learners, rather than the learners' perceptions [46].

SRL measurement by data analytics can take place either solely, or with other self-report measures to obtain data triangulation, recognize the different students' SRL behaviors more exactly, comprehensively understand the contextual effects, guide students, and better forecast their performance [42], [44], [47]. In the engineering context, [48] examined the evolution of students' SRL profiles over time using longitudinal clustering, the results of [49] revealed better performance and higher achievement of highly self-regulated engineering students in comparison to their minimal self-regulated colleagues, and [50] showed a positive relationship between an SRL based approach and engineering students' success. To the best of the authors' knowledge, the application of data analytics techniques has been solely in lab experiences. In addition, they have limitations in observing or monitoring the students' offline activities and behaviors [30], [51].

Therefore, despite criticisms, questionnaires are the most suitable option to assess SRL competences for higher education students. They are more feasible technically, economically, and easier to apply for large-scale assessments [30]. Questionnaires provide valuable insights about the students' SRL perceptions, beliefs, attitudes, and behaviors at a coarse-grained global level [52], [53]. We cannot neglect the learners' perceptions as they offer vital information for investigating SRL [54]. Information provided by questionnaires is exceedingly difficult or even impossible to obtain by other ways, particularly learning analytics [55]. In addition, despite questionnaires being principally for face-to-face classrooms, their usage involves also measuring SRL in online learning environments [56].

Regarding SRL intervention, a plethora of studies have emphasized the significance of intervention to improve the achievement of students; particularly those with low SRL levels [57], [58]. Several intervention methods have been tested to foster the students' SRL. The intervention can take place implicitly or explicitly. Despite achieving better academic achievements, the application of explicit SRL interventions is rare compared to implicit interventions [59], [60].

Many authors have demanded the need for a third wave of SRL assessment combining measurement and

TABLE 2. MSLQ scales, components, and categories based on [74].

Scale	Components	Category	Description
Motivation	Value components	Intrinsic goal-orientation	The degree of students' perception to their participation in academic tasks as an end all to itself, rather than a means to an end
		Extrinsic goal-orientation	The degree of students' perception to their participation in academic tasks as a means to an end
		Task value	The degree to which students perceive learning tasks as interesting, significant, and beneficial
	Expectancy components	Control of learning beliefs	The degree to which students believe that their efforts yield positive results
		Self-efficacy for learning and performance	The degree of students' ability to motivate themselves and control their emotions
	Affective components	Test anxiety	The degree to which students possess negative emotions and thoughts about tests and exams
Learning Strategies	Cognitive and metacognitive strategies	Rehearsal	The degree of using strategies like rereading and memorizing
		Elaboration	The degree of using strategies like summarizing and paraphrasing material
		Organization	The students' capacity to identify and organize the main course ideas
		Critical thinking	The degree to which students compare their performance against criteria like previous performance, others' performance, or an absolute performance level
		Meta-cognitive self-regulation	The degree to which students observe how they progress toward achieving their learning objectives [1]
	Resource management strategies	Time and study environment	The goodness of students' use of their time, schedule, and study place
		Effort-regulation	The degree of students' dedication to manage their efforts to accomplish their goals against various difficulties. The degree of using strategies like rereading and memorizing
		Peer learning	The degree to which students collaborate with their counterparts to achieve their goals
		Help-seeking	The degree to which students ask for assistance from peers and instructors to achieve their goals

intervention [42]. The intervention design must be proper to obtain a desirable effect, otherwise the students' dissatisfaction will ruin its effect [61]. The intervention design can follow guidelines like those of [40] for the provision of effective and efficient interventions in higher education settings. Table 1 presents a summary of the scientific contributions in the reviewed literature.

III. METHODS

A. INSTRUMENTS

The study involved two questionnaires:

- MSLQ is the most used questionnaire to measure SRL learners' competencies in higher education settings [62], [63]. It includes 81 items divided into two major scales, 5 components and 15 categories (see Table 2).
- SMSRLQ is composed of 150 items including the 81 MSLQ items and 69 items from 11 other questionnaires: Metacognitive Awareness Inventory (MAI) [64], Patterns of Adaptive Learning Scales (PALS) [65], Regulation of Learning Questionnaire (RLQ) [54], Self-Regulated Knowledge Scale-University (SRKS-U) [66], Self-Regulated Learning Questionnaire (SRLQ) [67], Self-Regulation Strategy Inventory–Self-Report Questionnaire (SRSI-SR) [68], Student Learning Strategies Questionnaire (SLSQ) [69], Students' Adaptive Learning Engagement in Science (SALES) [70], Survey of Academic Self-Regulation (SASR) [71], Survey of Self-regulated Learning with Technology at the University (SRLTU) [45], and Revised Two Factor Study Process Questionnaire (R-SPQ-2F) [72] (see Table 3). REVERSED questions from the MSLQ were taken as indicated, including the Test Anxiety category questions.

The SMSRLQ items were spaced so that only 3 questions were presented to each participant daily. The spaced repetition learning technique was selected because it includes repetitive long inter-trial intervals, and therefore leads to more robust memory [73]. SMSRLQ contents are displayed in Appendix A (see Table 9). In this manuscript we use mqSMSRLQ to refer to the answers collected on the SMSRLQ corresponding to the 81 MSLQ questions.

Both questionnaires were in two languages, English and Arabic, to encourage the participation of none-English speakers. The questionnaires' responses were based on a five-point Likert scale ranging from "1" which corresponds to "Strongly Disagree" to "5" which corresponds to "Strongly Agree".

B. CONTEXT, PARTICIPANTS, AND PROCEDURE

Students participating in this experience belong to three colleges in two different Egyptian Universities. The majority (416) belong to the College of Management & Technology within the Arab Academy for Science, Technology & Maritime Transport (AASTMT). The minority are students in the

TABLE 3. Number of SMSRLQ items taken from other questionnaires.

Questionnaire	Intrinsic goal-orientation	Extrinsic goal-orientation	Task value	Control of learning beliefs	Self-efficacy for learning and performance	Test anxiety	Rehearsal	Elaboration	Organization	Critical thinking	Meta-cognitive self-regulation	Time and study environment	Effort-regulation	Help-seeking	Peer-learning	Total number of items
MSLQ	4	4	6	4	8	5	4	6	4	5	12	8	4	4	3	81
MAI	1			1			1	1	1	1	10	1				17
PALS	2	2		1		1										6
RLQ			1										1			2
SRKS-U							1									1
SRLQ											2					2
SRSI-SR					1							4		2		7
SLSQ	1	1		1	1						2		1			7
SALES			3							1		1				5
SASR			1	1	2	2			1		1	1		1		10
SRLTU								1	2						4	7
R-SPQ-2F		1		1	1					1		1				5
Total	**8**	**8**	**11**	**9**	**13**	**8**	**6**	**8**	**8**	**8**	**27**	**16**	**6**	**7**	**7**	**150**

College of Languages & Communication in the AASTMT (11) and the Faculty of Nursing in Helwan University (51). All participants were seeking bachelor's degrees in the previously mentioned colleges and universities.

The study procedure is displayed in Fig. 1. The MSLQ administration took place in a single session at the beginning of the academic semester 2021/2022, during the inaugural lectures. Students were also introduced into the whole study procedure. The students participating in this initial session (N=478) read and signed an informed consent. 383 participants filled in physical pen and paper questionnaires, and the rest filled it electronically. This initial stage was conducted between October 23, 2021, and November 5, 2021. After filling in the questionnaire, the participants were asked to set up their Facebook accounts for the second stage.

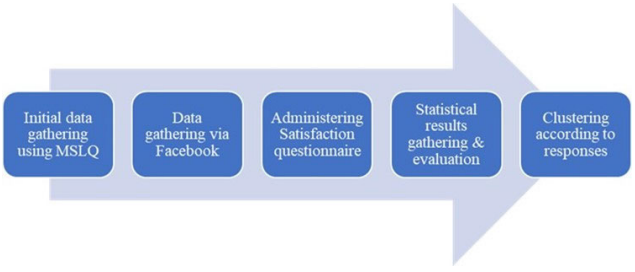

FIGURE 1. Study procedure.

The SMSRLQ was applied to the students who voluntarily continued participation online (N=220). In this way, MSLQ and the SMSRLQ were compared to answer RQ1.

Regarding RQ2, we randomly assigned the students involved in the SMSRLQ in two groups. An experimental group named "SRL 2021-2022 (1)" (N=107) was provided with feedback every month and comprehensive feedback about their SRL performance at the end of the study period. A control group named "SRL 2021-2022 (2)" (N=113) did not receive any feedback.

The SMSRLQ stage extended over a 10-week period via Facebook from November 6, 2021, to January 7, 2022, excluding the mid-term exam period between November 20 and November 26, 2021. The SMSRLQ questions distribution was every two days in the early morning. Triggering mobile notifications in the early morning rather than the evening or unexpected moments leads to better SRL results as indicated by [75]. Every question was in the form of a Facebook poll (see Fig. 2). Facebook responses were collected manually and then entered into Excel files for further processing.

As participation decreased with time, we eliminated the responses of 136 participants: 61 from the experimental group and 75 from the control group. As a result, there was an uneven distribution of students, according to gender and academic year, among the experimental and control groups. 70% of the experimental group participants were female students in comparison to a mere 26% of the control group participants. 63% of the experimental group participants were novice students in comparison to 45% of the control group participants. Table 4 summarizes the demographic data of participants in both approaches.

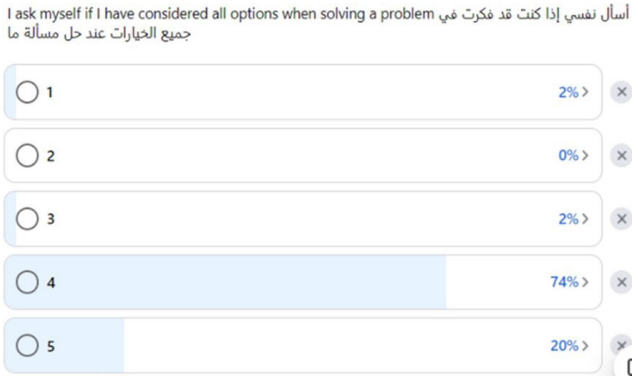

FIGURE 2. SMSRLQ question poll in english and arabic.

TABLE 4. Participants' demographics.

	MSLQ N=478	SMSRLQ N=84	SMSRLQ (Experimental group): N=46	SMSRLQ (Control group): N=38
Gender	Males: 61% Females: 39%	Males: 50% Females: 50%	Males: 30% Females: 70%	Males: 74% Females: 26%
Academic year	1st and 2nd year: 56% Elder: 44%	1st and 2nd year: 55% Elder: 45%	1st and 2nd year: 63% Elder: 37%	1st and 2nd year: 45% Elder: 55%
Age	19.46 ± 1.63	19.33±1.44	19.07±1.36	19.66±1.49
Number of subjects in the term	6.04±0.65	6.17±0.51	6.11±0.43	6.24±0.59

After the experience, we excluded the data of those students who did not participate. To do this, students with more than 50 missing questions were removed. The closing number of students was 84: 46 students in the experimental group and 38 students in the control group. In addition, questions over 130 were removed because their percentage of missing answers was over 10% [76]. This can have a significant effect on the ''Test anxiety'' and ''Effort regulation'' categories as the number of MSLQ questions reduced from 4 to 2, namely 50%. For the rest of the students and missing answers it was performed an imputation process, using the Expectation-Maximization (EM) algorithm, provided by the IBM SPSS Version 29.0.1.0 (171). The total number of imputations was 610 for the 130 questions and 84 students (6%).

Depending on the mean score of the experimental group participants, the feedback was categorized into low, medium, and high categories for each SMSRLQ competence. Three feedback events were provided: the first by the end of the first month of the study, the second by the end of the second month, and the final feedback after the end of the study. The feedback, whose content is adapted from [74] and [77], was in the form of a personalized Facebook message for each active participant in the experimental group. While the 1st and 2nd monthly feedback events evaluate the students' responses and provides recommendations only for the questions asked during the 1st and 2nd months of the study respectively, the final feedback evaluates the students' overall performance and offers final recommendations. The feedback includes 3 sections:

1. Section I includes a summary of the feedback's goal and structure: how to interpret the scores, the participant's mean score in relation to the mean score of all participants, the participant's number of responses, and response rate in relation to the average response rate of all participants. Moreover, the final feedback compares the participant's response rate in the first and second months of the study.
2. Section II includes a thorough analysis of the participant's performance in every SRL category, and suggestions based on the mean score in each category.
3. Section III concludes the participant's performance and provides final recommendations.

IV. RESULTS

A. DESCRIPTIVE STATISTICS

Initially, items marked as ''reversed'' were reversed subtracting the original score from 6. Then, students' answers from the initial MSLQ and the spaced SMSRLQ were processed to calculate the mean for each student per SRL category, (see Table 5), considering the values of the answers given by each student. This mean value is considered an indicator of the level of SRL competency of the student in such category. The mqSMSRLQ represents the results of the MSLQ answers collected on a spaced basis during the administration of the SMSRLQ.

The columns 2 to 4 of Table 5 show the mean and standard deviation of all the students SRL competencies in such category. Surprisingly, the standard deviation values are much lower in the SMSRLQ for all SRL competences. Indeed, standard deviation is double for the MSLQ than for the SMSRLQ. In any case, the most significant differences are in comparing the mqSMSRLQ to the MSLQ, as they are the same questions answered by the same students and the standard deviation is lower for the mqSMSRLQ in all the cases. This could be a consequence of the imputation performed on the SMSRLQ missing answers. Maximum and minimum mean values in each of these two columns are in bold font. The mqSMSRLQ has 8 maximum values and MSLQ has 6. Self-efficacy has the same result.

The last four columns of Table 5 show the Mean Average Error (MAE) and Mean Average Percentage Error (MAPE) comparing the SMSRLQ vs. the MSLQ and the mqSMSRLQ vs. the MSLQ. All MAE differences are greater than 0.4 and 11%. This shows major differences in the students' answers depending on how they are collected. A difference in the first comparison can be accepted, as the questions in both instruments are different. Nevertheless, there is also a similar difference in the second comparison, and this is a bit weird, as the questions are exactly the same. The difference

TABLE 5. Mean, standard deviation, MAE, and MAPE values of SRL categories in the 3 combinations for all participants.

SRL category	SMSRLQ	mqSMSRLQ	MSLQ	MAE (SMSRLQ-MSLQ)	MAPE (SMSRLQ-MSLQ) %	MAE (mqSMSRLQ-MSLQ)	MAPE (mqSMSRLQ-MSLQ) %
Intrinsic goal-orientation	4.22±0.31	3.95±0.37	**4.03**±0.62	0.46	11.08	0.47	12.09
Extrinsic goal-orientation	3.75±0.47	4.17±0.48	**4.18**±0.59	0.62	17.42	0.46	11.24
Task value	3.84± 0.38	**4.14**± 0.42	4.12± 0.58	0.56	14.84	0.50	12.27
Control of learning beliefs	3.70± 0.28	3.67± 0.40	**3.71**± 0.58	0.47	12.67	0.47	13.05
Self-efficacy	3.93± 0.36	3.99± 0.34	3.99± 0.60	0.49	12.67	0.47	12.02
Test anxiety	3.24± 0.80	**3.52**± 0.87	2.88± 0.97	0.75	**24.16**	0.90	**26.60**
Rehearsal	4.05± 0.43	**4.10**± 0.42	4.09± 0.64	0.46	12.21	0.47	12.32
Elaboration	4.11± 0.35	**4.08**± 0.41	4.04± 0.41	0.51	12.76	0.53	13.53
Organization	3.66± 0.48	3.65± 0.56	**3.94**± 0.77	0.65	**18.58**	0.68	**20.19**
Critical thinking	3.86± 0.34	**3.92**± 0.35	3.87± 0.68	0.51	13.37	0.49	12.83
Metacognitive self-regulation	3.91± 0.34	**3.88**± 0.36	3.76± 0.58	0.46	11.80	0.42	11.06
Time and study environment	3.27± 0.37	3.38± 0.47	**3.64**± 0.60	0.52	16.38	0.47	14.75
Effort regulation	3.67± 0.45	**3.88**± 0.46	3.48± 0.73	0.59	16.37	0.64	16.59
Help-seeking	4.03± 0.42	**4.03**± 0.54	3.60± 0.67	0.63	15.61	0.66	16.28
Peer-learning	2.78± 0.52	3.07± 0.54	**3.35**± 0.78	0.82	**31.09**	0.61	**20.75**

is quite large in some categories (in bold), over 20% for: Test anxiety, Organization and Peer-learning. Differences in Test anxiety could be a consequence of the reduction of questions from 4 to 2. The same statistics were calculated considering the control/experimental group, gender, and academic year, but they provided analogous results. In any case, when comparing the results according to gender and academic year across the experimental and control groups, we must consider the uneven distribution of participants. As explained previously, this was not due to a careless study design, but a result of the uneven participation and involvement of students in the experimentation.

B. INFERENTIAL STATISTICS

Considering the previous results, we conducted ANOVA [78] and t-student [79] to statistically evaluate the significant differences in the SRL categories. Table 6 shows the p-value results of the analysis involving the SMSRLQ, mqSMSRLQ and MSLQ. Numbers in bold indicate the existence of significant differences in several categories as they are lower than 0.05.

As previously mentioned, we can easily explain the differences between SMSRLQ and MSLQ as they include different questions. Nevertheless, we also observe relevant differences between mqSMSRLQ and MSLQ (last column). Particularly, the last 5 rows including the ''Resource Management Strategies'' component and the ''Metacognitive self-regulation'' category show significant differences. Again, the ''Test Anxiety'' also shows a significant difference, but this could be a consequence of the reduction of questions from 4 to 2.

C. RELIABILITY

Cronbach's alpha coefficient [80] was used to evaluate the reliability and internal consistency of the instruments, considering also the MSLQ questions performed in the SMSRLQ spaced questionnaire (see Table 7). The values under 0.500 are in bold, indicating they are under the acceptable threshold for reliability. As observed, all the three instruments have values under this threshold: 6 for the SMSRLQ, 8 for the mqSMSRLQ and 2 for the MSLQ. Again, it is quite surprising that the mqSMSRLQ and the MSLQ provide so different results.

However, higher Cronbach's values are not a guarantee of better reliability. Reliability measures the test scores not the test itself and is dependent upon the tested sample [81], [82]. In this way, the lower values on the mqSMSRLQ may be because of spaced questions. This means that the reliability of students' answers decreases when they answer over time.

The MSLQ values are higher in all categories. Nevertheless, for the ''Test anxiety,'' ''Time and study environment'' and ''Peer learning'' the SMSRLQ provides better results.

TABLE 6. ANOVA and t-student results p-values.

SRL category	ANOVA (SMSRLQ, mqSMSRLQ, MSLQ)	t-student (SMSRLQ, mqSMSRLQ)	t-student (SMSRLQ, MSLQ)	t-student (mqSMSRLQ, MSLQ)
Intrinsic goal-orientation	**0.020**	**E-18**	**0.003**	0.237
Extrinsic goal-orientation	**E-12**	**E-24**	**E-09**	0.833
Task value	**E-05**	**E-26**	**E-05**	0.708
Control of learning beliefs	0.805	0.226	0.952	0.592
Self-efficacy	0.609	0.002	0.353	0.910
Test Anxiety	**0.001**	**E-04**	**E-03**	**E-05**
Rehearsal	0.827	**0.013**	0.565	0.924
Elaboration	0.692	**0.029**	0.371	0.667
Organization	**0.002**	0.601	0.001	0.001
Critical thinking	0.704	0.581	0.408	0.477
Metacognitive self-regulation	**0.063**	**0.007**	**0.013**	**0.041**
Time and study environment	**E-06**	**E-05**	**E-08**	**E-05**
Effort regulation	**E-05**	**E-06**	**0.014**	**E-06**
Help-seeking	**E-07**	0.841	**E-08**	**E-07**
Peer-learning	**E-08**	**E-11**	**E-09**	**E-04**

D. CLUSTERING

Clustering is an unsupervised data mining technique used to describe data into meaningful or useful groups [83]. The K-means algorithm [84] was applied to cluster the differences in the mean values in each category among all instruments. Fig. 3 shows a box and whisker plot for the differences between the mqSMSRLQ and the MSLQ. In this figure, there is a displacement in almost all categories towards lower values. There are two categories doing the opposite: ''Text anxiety'' and ''Effort regulation.''

Taking the differences in all categories, two clusters were found by the elbow method. One cluster related to the students who progressed in almost all the categories. The other related to those with deteriorated values. 10 out of 12 (83%) students of the ''progressed'' cluster belong to the experimental group.

We repeated the cluster analysis excluding the ''Test anxiety'' and ''Effort regulation'' categories, as they can introduce some kind of bias because their questions were reduced from 4 to 2. In this case, the number of clusters provided by the elbow method was 3. Fig. 4 displays the cluster centers. Cluster 2 shows progress in all categories, while cluster 1 shows deterioration in ''Organization'' and ''Time and student environment'', and cluster 3 deteriorates in ''Peer learning'' and ''Help seeking''. The ANOVA analysis of this clustering supplies values under 0.01 for all the categories, meaning they are all significant.

Table 8 shows the students assigned to each of the three clusters. Most students of cluster 2 belong to the experimental group. Meanwhile, control group students belong to cluster 1, and experimental group students are assigned also to cluster 3.

TABLE 7. Cronbach's alpha values of the three variants.

SRL Category	SMSRLQ	mqSMSRLQ	MSLQ
Intrinsic goal orientation	0.401	0.259	0.587
Extrinsic goal orientation	0.435	0.182	0.341
Task value	0.763	0.622	0.770
Control of learning beliefs	0.154	0.129	0.395
Self-efficacy	0.707	0.540	0.862
Test anxiety	0.836	0.734	0.799
Rehearsal	0.510	0.017	0.647
Elaboration	0.550	0.550	0.790
Organization	0.596	0.611	0.722
Critical thinking	0.468	0.129	0.760
Meta-cognitive self-regulation	0.783	0.616	0.822
Time and study environment	0.696	0.532	0.637
Effort regulation	0.307	0.483	0.643
Help-seeking	0.390	0.468	0.571
Peer-learning	0.619	0.294	0.559

E. SATISFACTION QUESTIONNAIRE

Following the data collection, a satisfaction questionnaire adapted from [85] was administered to both groups to assess the participants' general satisfaction with the study concerning the interaction, the instruction, the instructor, and the used technology. 23 students participated voluntarily and anonymously: 13 from the experimental group and 10 from the control group. The questionnaire included 16 items: 13 items validated against a 5-Likert scale and 3 exploratory questions. The satisfaction questionnaire contents are displayed in Appendix B (see Table 10).

The responses to the Likert scale items are positive in general. Nonetheless, the acceptance levels of the experimental group respondents were higher in nearly all aspects than those of the control group respondents (see Fig. 5).

77% of the experimental group respondents, in comparison to 60% of the control group respondents, stated that the study kept them alert and focused. Keeping students thinking about their SRL behaviors can be related to the

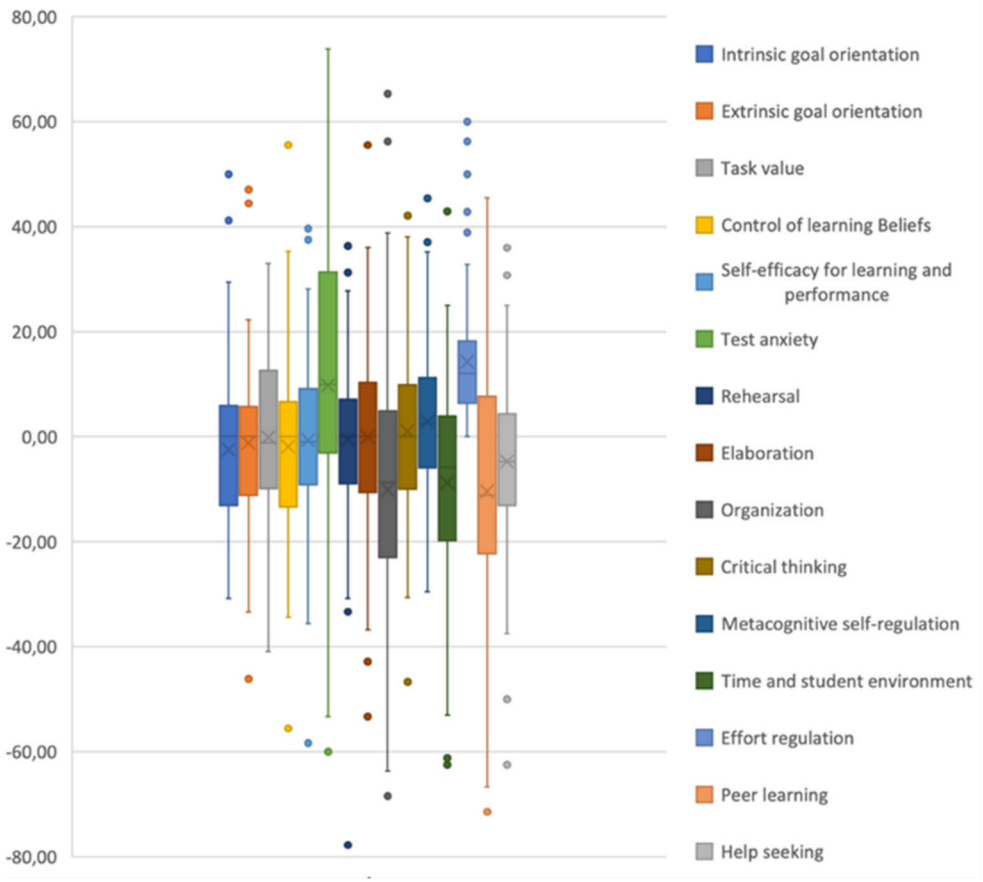

FIGURE 3. Box and whisker plot for the differences between means of mqSMSRLQ and MSLQ.

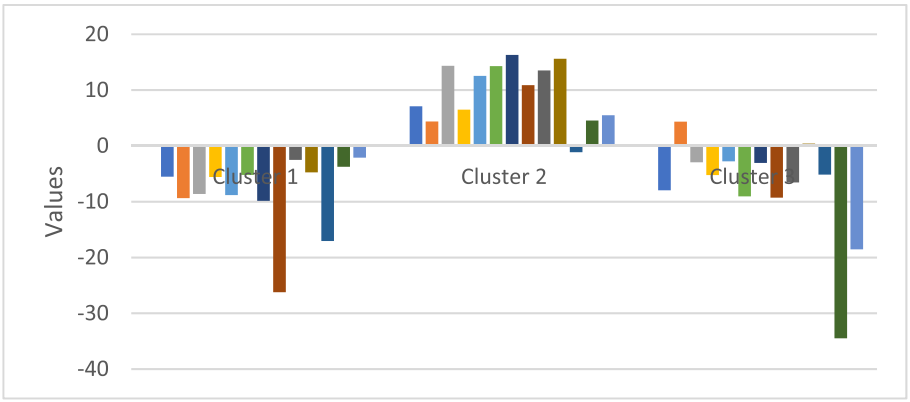

FIGURE 4. Cluster centers for the differences between the mqSMSRLQ and MSLQ excluding "Test anxiety" and "Effort regulation."

spaced repetition learning technique that includes repetitive long inter-trial intervals, and therefore leads to more robust memory [73]. 85% of the experimental group respondents were satisfied with the interaction with the lecturer and found that the feedback was timely throughout the study period, in comparison to 70% of the control group respondents. Only 70% of the control group respondents were pleased with their participation in the study, while all the experimental group respondents were satisfied. 85%-90% of respondents from the two groups think the study encouraged them to assess the way they learn and study. 77% of the experimental group respondents found that their self-learning knowledge developed after the study, compared to 50% of the control group respondents. This variation can be due to the influence of interaction with the lecturer and feedback. 60% of the control group respondents (in comparison to 92% of the experimental group respondents) find the study instructions clearly communicated.

Regarding the exploratory questions (see Fig. 6), approximately 96% of the respondents in the two groups use social

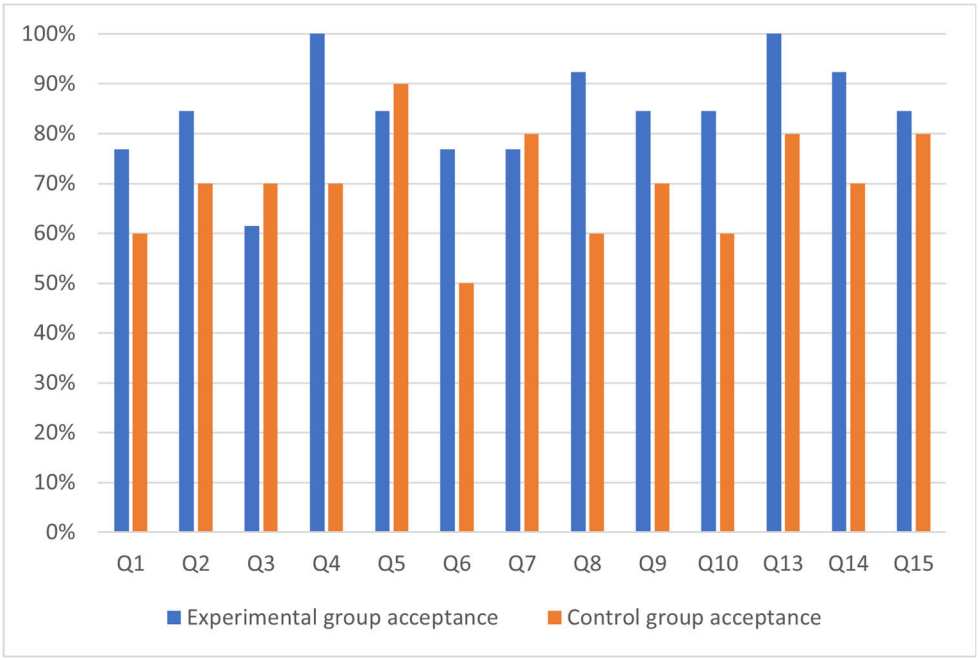

FIGURE 5. Satisfaction questionnaire Likert scale responses across the experimental and control groups.

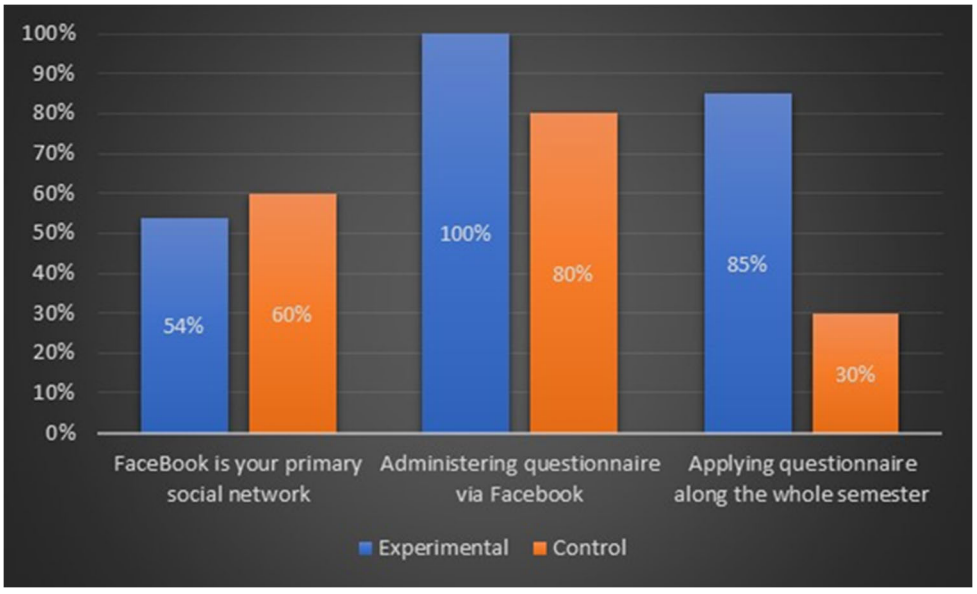

FIGURE 6. Satisfaction questionnaire exploratory questions responses in the experimental and control groups.

TABLE 8. Number of students of the experimental and control groups in the 3 clusters.

Group	Cluster 1 (N=34)	Cluster 2 (N=25)	Cluster 3 (N=25)
Experimental	7 (21%)	19 (76%)	20 (80%)
Control	27 (79%)	6 (24%)	5 (20%)

media platforms daily. Facebook is the main social media platform for 60% of the control group respondents and 54% of the experimental group respondents. 100% of the experimental group respondents favor questionnaires administration via Facebook instead of the traditional pen and paper questionnaires. This preference is 20% less in the control group respondents. This result is in line with responses to a Likert scale item; where 92% of the experimental group respondents view Facebook compatible for this study compared to 70% of the control group respondents. 85% of the experimental group respondents (compared to 70% of the control group respondents) have a tendency towards administering questionnaires on a spaced basis rather than a solitary session. On the one hand, some proponents of administering questionnaires on a spaced basis stated that "*it helped me already to know my strengths and weaknesses and highlight it while I'm studying already*", "*it will help me to recover*

information'', ''*it keeps me engaged*'', ''*I am evolving and can change my perspective about certain things*''. On the other hand, some antagonists stated that ''*single session saves time and effort*'', ''*single session approach is more motivating, facilitate, and clarify questions*'', ''*my answer would be more honest*'', and ''*single session because sometimes I lost interest in the middle of the study, but your feedback motivated me to get back and answer the questions so you can evaluate me*''.

V. RESULTS DISCUSSION

The main motivation of this study is introducing a novel approach to measure and promote SRL adoption among higher education students via spacing questionnaire items and providing feedback over an extended period. The obtained results are compared against those of the popular MSLQ. In this section, we discuss the results against the proposed research questions.

RQ1: Do differences exist due to the two administration approaches?

The literature has identified a reciprocal relationship between the number of questions and the students' participation rate [34]. In this way, the distribution of questions in small chunks should improve participation. Nevertheless, the data provided does not support this statement, as the participation of students in the MSLQ was higher than in the spaced questionnaire. Of course, this result can be obvious and understandable, as the MSLQ answers were mainly collected in the context of a face-to-face section, while the SMSRLQ was administered online on a voluntary basis. In any case, the open answers to the satisfaction questionnaire also show how some students prefer to fill in the large questionnaire in a single session that spaced over time. Of course, answering questions over a certain period requires more effort and constancy, but learning also requires repetitive practice. Therefore, students may prefer a single session effort, but if learning comes from repetition, a spaced approach is more valuable.

Regarding RQ1, it is obvious that the performance of questionnaire items on a spaced basis introduces variations in responses between the MSLQ from one side, and the SMSRLQ and mqSMSRLQ from the other side. The variations between MSLQ and mqSMSRLQ are more relevant as both questionnaires involved exactly the same questions. These variations are clear in the high MAE and MAPE differences between the corresponding categories in the conventional MSLQ and mqSMRLQ. The lower standard deviation values of the SMSRLQ and mqSMSRLQ could indicate better reliability than the MSLQ [86]. The lower Cronbach's values of the SMSRLQ and mqSMSRLQ may be because of the questions spacing. Moreover, the p-value results of the ANOVA and t-student inferential statistics reveal the existence of variations between students' responses in the MSLQ and their responses in the mqSMSRLQ. Nevertheless, we cannot discard that these response variations between the instruments may be a result of a change in the SRL adoption by students over time. Despite this, their answers could also be more honest in one case than another. Recent research has shown that different ordering of questions can cause considerable changes in the respondents' attitudes [87]. The results provided in this manuscript confirm it considering not just changes in the ordering of questions, but also on their spacing along time.

RQ2: Does the feedback provision enhance the students' participation and cause a difference in their SRL competences development?

Regarding RQ2, the results show that the experimental group members participated more actively than their control group counterparts. Nevertheless, in both cases a decrease in participation with time was experienced. 46 experimental group members actively participated throughout the study period in comparison to 38 members of the control group. In general, students tend to modify their SRL behaviors over time [48], [88]. By tracking the cluster membership, we can explore the SRL evolution of students over time. 76% of the improving students in all SRL categories belong to the experimental group. Regarding the other two clusters, 79% of the students who deteriorated in ''Organization'' and ''Time and student environment'' belong to the control group. Oppositely, 80% of the students who deteriorated in ''Peer learning'' and ''Help seeking'' belong to the experimental group. Overall, 41% of the experimental group members belong to the ''Progressed'' cluster in comparison to a mere 16% of the control group members. The lower percentage of progressing participants in the control group could be related to the lack of feedback. These findings demonstrate the feedback influence on the SRL progression of the experimental group members.

When analyzing the satisfaction questionnaire results, the findings verify that the feedback provision results in a better SRL performance. The performance improvement via feedback is matching with a surplus of prior research such as [89] and [90]. Personalized feedback motivates students and keeps their concentration on their tasks [91]. Social comparison feedback benefits students, as they know how others perform [92].

VI. CONCLUSION

This manuscript introduces a spaced approach to measure and promote SRL among higher education students, including engineering students. It is intended to provide a comprehensive picture of the students' SRL development over time rather than a static snapshot at the semester beginning. This proposal can be considered in the context of the third wave of SRL assessment [42], involving both measurement and promotion. From a methodology point of view to the best of our knowledge, there is no other attempt to use spaced questionnaires for SRL promotion over an extended period.

The spaced approach can be very helpful to provide a more comprehensive view of SRL competences. As described in Section II and Table 2, SRL involves a variety of components

TABLE 9. SMSRLQ items.

1. I am confident I can manage my own learning (SASR)
2. I prefer course material that really challenges me so I can learn new things (MSLQ-1)
3. I come to most classes with questions in mind that I want answering (R-SPQ-2F)
4. I have high academic standards for myself (SASR)
5. I want to do well in the courses I study because it is important to show my ability to my family, friends, or others (MSLQ-30)
6. I know help is available if I need it (SASR)
7. Getting a good grade is the most satisfying thing for me right now (MSLQ-7)
8. When I study, I set goals for myself in order to direct my activities in each study period (MSLQ-78)
9. It is important for me to learn the course material (MSLQ-10)
10. I can motivate myself to learn when I need to (MAI)
11. I know how I will be graded (RLQ)
12. I have a regular place set aside for studying (MSLQ-65)
13. When I study, I practice saying the material to myself over and over (MSLQ-39)
14. I stop and go back over new information that is not clear (MAI)
15. I pace myself while learning in order to have enough time (MAI)
16. Understanding the subject matter of the courses is very important to me (MSLQ-27)
17. If I get confused taking notes in class, I make sure I sort it out afterwards (MSLQ-79)
18. If I try hard enough, then I will understand the course material (MSLQ-18)
19. I summarize what I've learned after I finish (MAI)
20. It's important to me to improve my skills this year (PALS)
21. I try to identify students in the class whom I can ask for help if necessary (MSLQ-75)
22. I'm certain I can master the skills being taught in different classes (MSLQ-29)
23. I use the available study aids like chapter outlines (SASR)
24. When reading for courses, I make up questions to help focus my reading (MSLQ-36)
25. The most satisfying thing for me is trying to understand the content as thoroughly as possible (MSLQ-22)
26. I try to work with other students from the class to complete the course assignments (MSLQ-45)
27. When I study, I write brief summaries of the main ideas from the readings and my class notes (MSLQ-67)
28. When studying, I try to determine which concepts I don't understand well (MSLQ-76)
29. Even if the work is hard, I can learn it (PALS)
30. When reading for the courses, I try to relate the material to what I already know (MSLQ-64)
31. I memorize key words to remind me of important concepts in the course (MSLQ-59)
32. If course readings are difficult to understand, I change the way I read the material (MSLQ-44)
33. I ask myself if I have considered all options after I solve a problem (MAI)
34. I make sure no one disturbs me when I study (SRSI-SR)
35. When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence (MSLQ-47)
36. I find that at times studying gives me a feeling of deep personal satisfaction (R-SPQ-2F)
37. I try to change the way I study in order to fit the course requirements and the instructor's teaching style (MSLQ-56)
38. When studying, I search for content-related videos on YouTube, Vimeo, … (SRLTU)
39. I'm certain I can understand the most difficult material presented in the readings for the courses (MSLQ-6)
40. I expect to do well this semester (MSLQ-21)
41. It is the first time I have done this type of tasks (SLSQ)
42. I try to relate ideas in different courses whenever possible (MSLQ-62)
43. Considering the difficulty of the courses, the teachers, and my skills, I think I will do well (MSLQ-31)
44. I spend a lot of my free time finding out more about interesting topics which have been discussed in different classes (R-SPQ-2F)
45. I usually study in a place where I can concentrate on my course work (MSLQ-35)
46. I repeat several times the important things to be learnt (SRKS-U)
47. If I study in appropriate ways, then I will be able to learn the course materials (MSLQ-2)
48. Even when course materials are dull and uninteresting, I manage to keep working until I finish (MSLQ-74)
49. I make a schedule to help me organize my study time (SRSI-SR)
50. I'm confident I can learn the basic concepts taught in the courses (MSLQ-12)
51. Before I study new course material thoroughly, I often skim it to see how it is organized (MSLQ-54)
52. When I can't understand the course material, I ask another student in the class for help (MSLQ-68)
53. I try to understand the course material by making connections between the readings and the concepts from the lectures (MSLQ-69)
54. I make good use of my study time (MSLQ-43)
55. It is my own fault if I don't learn the course material (MSLQ-9)
56. When I study, I go through the readings and my class notes and try to find the most important ideas (MSLQ-42)
57. When I become confused about something I'm reading for class, I go back and try to figure it out (MSLQ-41)
58. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying (MSLQ-61)
59. When studying, I often try to explain the material to a classmate or friend (MSLQ-34)
60. I prefer course material that arouses my curiosity, even if it is difficult to learn (MSLQ-16)
61. I have an uneasy, upset feeling when I take an exam (MSLQ-19) REVERSED
62. I believe that lecturers shouldn't expect students to spend significant amounts of time studying material everyone knows won't be examined (R-SPQ-2F) REVERSED
63. I would prefer to do class work that is familiar to me, rather than work I would have to learn how to do (PALS) REVERSED
64. I will do poorly because I have trouble doing assignments well (SLSQ) REVERSED
65. I wait to the last minute to start studying for upcoming tests (SRSI-SR) REVERSED
66. My aim is to avoid my teacher thinking I am a bad student (SLSQ)
67. I double-check my work to make sure what I am doing is right (SRLQ)
68. I am sure I understood the terminology used in task instructions (RLQ)
69. When studying, I often set aside time to discuss course material with a group of students from the class (MSLQ-50)
70. I find it hard to stick to a study schedule (MSLQ-52) REVERSED
71. During class time, I often miss important points because I'm thinking of other things (MSLQ-33) REVERSED
72. I will avoid participating in class if it means that other students will think I know a lot (PALS)
73. I try to apply ideas from course readings in other class activities such as lecture and discussion (MSLQ-81)
74. I ask myself questions about how well I am doing while I am learning something new (MAI)

TABLE 9. *(Continued.)* **SMSRLQ items.**

75. What I learn is relevant to me (SALES)
76. I am very interested in the content area of my courses (MSLQ-17)
77. If I don't understand the course material, it is because I didn't try hard enough (MSLQ-25)
78. Whenever I read or hear an assertion or conclusion in class, I think about possible alternatives (MSLQ-71)
79. When studying, I read my class notes and the course readings over and over again (MSLQ-46)
80. One of my goals is to master a lot of new skills this year (PALS)
81. I turn a learning task into smaller, easier steps (SLSQ)
82. I'm confident I can understand the most complex material presented by the instructors (MSLQ-15)
83. I keep track of how well I understand the instructor/professor (SASR)
84. I often find myself questioning things I hear or read in the courses to decide if I find them convincing (MSLQ-38)
85. When I take a test, I think about how poorly I am doing compared with other students (MSLQ-3) REVERSED
86. I change my learning strategies when I fail to understand (MAI)
87. I finish all of my studying before doing any recreational activity (SRSI-SR)
88. I share material with my classmates using Dropbox or similar tools (SRLTU)
89. It's important to me that I don't look stupid in class (PALS)
90. I attend classes regularly (MSLQ-73)
91. I ask myself questions to make sure I understand the material I have been studying (MSLQ-55)
92. What I learn encourages me to think (SALES)
93. I make simple charts, diagrams, or tables to help me organize course material (MSLQ-49)
94. I can't concentrate on a test/task when I get nervous (SASR) REVERSED
95. I interact outside the classroom with classmates using apps (WhatsApp, Line...) and we exchange information, solve doubts, etc. (SRLTU)
96. I think the course materials are useful for me to learn (MSLQ-23)
97. When I study the readings for courses, I outline the material to help me organize my thoughts (MSLQ-32)
98. I make sure I understand before I move on to the next part of a project (SRLQ)
99. I'm a member of groups on social networks that discuss, exchange information, etc., about content-related topics (SRLTU)
100. I think of several ways to solve a problem and choose the best one (MAI)
101. I periodically review to help me understand important relationships in the courses (MAI)
102. Even if I have trouble learning the course material, I try to do the work on my own, without help from anyone (MSLQ-40) REVERSED
103. I remind myself of the steps as I am working (SLSQ)
104. When I have the opportunity, I choose course assignments that I can learn from even if they don't guarantee a good grade (MSLQ-24)
105. I tell myself to keep trying hard when I get confused (SRSI-SR)
106. I'm confident I can do an excellent job on the assignments and tests in my courses. (MSLQ-20)
107. When I study, I pull together information from different sources, such as lectures, readings, and discussions (MSLQ-53)
108. My aim is to fully understand what I have to do (SLSQ)
109. When I take tests, I think of the consequences of failing (MSLQ-14) REVERSED
110. I make sure that I keep up with the weekly readings and assignments for the courses (MSLQ-70)
111. I work hard to do well in class even if I don't like what we are doing (MSLQ-48)

TABLE 9. *(Continued.)* **SMSRLQ items.**

112. I finish my work and assignments on time (SALES)
113. I share pictures on social media about course work (SRLTU)
114. I make lists of important items for the courses and memorize the lists (MSLQ-72)
115. What I learn can be used in my daily life (SALES)
116. I try to play around with ideas of my own related to what I am learning in the courses (MSLQ-66)
117. If I can, I want to get better grades than most of the other students (MSLQ-13)
118. I often find that I have been reading for the course but don't know what it was all about (MSLQ-57) REVERSED
119. I avoid asking questions in class about things I don't understand (SRSI-SR) REVERSED
120. I often find that I don't spend very much time on the courses because of other activities (MSLQ-77) REVERSED
121. I go beyond what is required to see how much I can learn (SASR)
122. I ask myself if I learned as much as I could have once I finish a task (MAI)
123. I like the subject matter of the courses I study (MSLQ-26)
124. When I study, I go over my class notes and make an outline of important concepts (MSLQ-63)
125. I ask the instructor to clarify concepts I don't understand well (MSLQ-58)
126. The most important thing for me right now is improving my overall grade point average, so my main concern is getting a good grade (MSLQ-11)
127. I feel nervous even when I am prepared for a test/task (SASR) REVERSED
128. Studying the course material will help me achieve my goals (SASR)
129. I treat the course material as a starting point and try to develop my own ideas about it (MSLQ-51)
130. When preparing for a presentation, I record myself (SRLTU)
131. I ask myself if there was an easier way to do things after I finish a task (MAI)
132. I think about what I really need to learn before I begin a task (MAI)
133. I find myself analyzing the usefulness of my learning strategies while I study (MAI)
134. I do my best so I can feel proud of myself (SLSQ)
135. What I learn is interesting (SALES)
136. I rarely find time to review my notes or readings before an exam (MSLQ-80) REVERSED
137. My aim is to pass courses while doing as little work as possible (R-SPQ-2F)
138. I often feel so lazy or bored when I study that I quit before I finish what I planned to do (MSLQ-37) REVERSED
139. I ask myself how well I accomplish my goals once I'm finished (MAI)
140. I ask my teacher about the topics that will be on upcoming tests (SRSI-SR)
141. I re-evaluate my assumptions when I get confused (MAI)
142. I spend too much time with friends when I should be studying (SASR) REVERSED
143. When course work is difficult, I either give up or only study the easy parts (MSLQ-60) REVERSED
144. When I take a test, I think about items on other parts of the test I can't answer (MSLQ-8) REVERSED

TABLE 9. *(Continued.)* **SMSRLQ items.**

145. I try to use learning strategies that have worked in the past (MAI)
146. I believe I will receive an excellent grade in my courses (MSLQ-5)
147. I look for content-related, self-evaluation exercises online and I use them to prepare for exams (SRLTU)
148. I feel my heart beating fast when I take an exam (MSLQ-28) REVERSED
149. I think I will be able to use what I learn in one course in other courses (MSLQ-4)
150. I ask myself if I have considered all options when solving a problem (MAI)

TABLE 10. **SMSRLQ items.**

1. This study kept me always alert and focused
2. Interaction was adequately maintained with the lecturer
3. I am satisfied with the quality of interaction between all involved parties in the study
4. I am satisfied with my participation in the study
5. The study encouraged me to evaluate the way in which I learn and study
6. My knowledge about my self-learning was improved compared to similar courses I studied before
7. I am satisfied with the level of effort this study required
8. The study instructions and guidelines were clearly communicated to me
9. Feedback on my progress during this study was given in a timely manner
10. Technical problems were not frequent and did not adversely affect my understanding of the study
11. Do you use Social networks in your daily life? If yes, what is your preferred social network to communicate with your colleagues and friends?
12. Do you prefer questionnaires via Facebook or via a traditional pen and paper questionnaire?
13. The technology used for this study was reliable
14. Facebook is compatible for use in a study like this
15. The use of Facebook facilitated my participation in this study
16. Do you prefer to be asked in a single session or throughout the whole semester? Which approach is more motivating and why?

and categories. In this way, considering all of them in a single session may be overwhelming for students. Another advantage of the spaced approach is that it raises the students' SRL awareness and keeps them alert and thinking about SRL behaviors for a long time.

The results shown in the paper demonstrate that the administration of questions on a spaced basis delivers differences in the results. This can be explained by changes in the student's competences over time, or because of changes in the honesty of the answers. In any case, these results should be considered in future studies. In addition, the provision of feedback over time is in line with improvements in the acquisition of competencies and the satisfaction of students.

However, this research is not free of limitations and the results and conclusions should be confirmed in further studies. The empirical study took place in a particular semester in a few academic institutions. Since it is hard to control the students' participation via Facebook, their participation was inconsistent over the elongated period. As participation decreased with time, we eliminated the responses of 136 participants: 61 from the experimental group and 75 from the control group. Therefore, there was an uneven distribution of students, according to gender and academic year, among the experimental and control groups. Consequently, results generalization should be with caution. The decreased participation rate over time could have significantly affected the Cronbach's alpha coefficient values of the SMSRLQ. To assess this novel approach and its reliability, we need more empirical studies with larger data samples in various higher education contexts. Another limitation is the use of quantitative data only. Quantitative SRL analysis may not produce the most accurate results. For example, a student using more SRL strategies may perform worse than another who uses fewer SRL strategies more efficiently [93]. Future work shall use both qualitative and quantitative data to enrich the results by capturing the students' different SRL dimensions. We can adopt a mixed-method approach, by using self-reported data with other measures (like Learning Analytics and Educational Data Mining) to triangulate data and obtain a more comprehensive understanding [44], [72], [94].

Finally, feedback provision was a tiring and time-consuming task for the lecturer. Therefore, there was a short delay in providing feedback to students. The faster the feedback delivery, the more influence it will have on the students' learning [95]. Future work shall include developing a conversational agent to automatize the processes of questions delivery, gathering responses, and feedback provision.

From a practical viewpoint, the findings invite higher education teachers and institutions to reflect about the importance of spaced repetition [96]. The achievement of real learning among students does not only involve punctual understanding, but also spaced reinforcement. The results obtained in this study are a new demonstration of this idea. In addition, asking different questions in class can cause serious planning problems because of the classroom time consumed. With spaced online questionnaires, students are free to answer questions at any time, leading to a different predisposition when answering. The main issue that remains to be solved is how to involve students to continue participating in the experience over time.

APPENDIX A: SMSRLQ ITEMS

See Table 9.

APPENDIX B: SATISFACTION QUESTIONNAIRE ITEMS

See Table 10.

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