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Design, Validity and Effect of an Intra-Curricular Program for Facilitating Self-Regulation of Learning Competences in University Students with the Support of the 4Planning App

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Abstract: Background: Smartphone applications have the potential to support university students for the benefit of learning in higher education. Objective: To design and evaluate the effect of an intra-curricular program using a mobile application on self-regulated learning strategies in university students. Method: The 4Planning mobile application was designed following a systematic literature review, expert judgement and application. The instrument to assess the effect of the intervention was the SRL Readiness Practices Scale, with a one-factor structure (CFI = 0.98; TLI = 0.97; RMSEA = 0.05) with reliability of α = 0.89. The design was quasi-experimental with pre- and post-test measures and experimental and control groups. The sample consisted of 473 first-year university students (37.02% male) from seven Chilean universities with a mean age of 19.35 (SD = 2.49). Statistical analysis was an ANOVA performed in R software version 4.0.3. Results: Statistically significant differences were identified in the levels of self-regulated learning between the experimental group compared to the control group. Conclusion: The development of the 4Planning app proved to be effective in promoting the development of self-regulated learning strategies in university students.

Keywords: mobile app; program; university students; self-regulation of learning; smartphone

1. Introduction

1.1. Fostering Self-Regulation to Overcome Academic Failure in University Students

The transition from secondary to tertiary education is a critical stage, as this process of separation, transition and incorporation into a new social and academic world leads students to experience academic difficulties [1,2] and dropout rates, especially in the first year of the university experience, are a major concern [2].

A key competence for higher academic education and future professional life is self-regulation of learning (hereafter SRL) [3,4]. It is nothing new that SRL is a fundamental attribute for successful study and learning processes as it has been discussed for several decades [5], and is still strongly considered in research on university adjustment [6,7], achievement of academic demands [8] and, consequently, dropout prevention [9]. Several theoretical reviews and meta-analyses have shown that SRL strategies (cognitive, metacognitive, resource management and motivational strategies) influence students' academic performance, achievement, conceptual understanding and motivation, in traditional face-to-face [10–12], online [13,14] and blended learning environments [15]. That is, the

empirical evidence is strong that SRL strategies have a "large" effect size (d = 0.86) on academic performance [10] and thus significantly predict academic performance in university students [16].

SRL is defined as an active, critical, reflective process in which the learner directs his or her performance, contributing to the individual's full development, and with a sense of self-determined learning [17,18]. All university students should develop SRL to adapt to the demands of the level of education they are in and the future world of work into which they will have to enter. The different theoretically and empirically supported models of SRL [18–22] agree that SRL is cyclical and develops in different phases and sub-processes. Broadly speaking, they consider three phases: readiness, performance and evaluation [13,17].

A common misconception, but widely held in university communities, is that university students are perfectly able to cope successfully with their studies just because they have completed secondary education [23]. However, most students are not adequately prepared for what is required of them, as they are not self-regulated learners [24,25]. This lack of SRL coping strategies is a major factor in the academic failure of first-year students in higher education [23,26]. Specifically, they find it difficult to manage time properly and to plan and organize tasks [27–29]. The increasingly evident study difficulties observed and reported by university teachers coincide with those reported by students themselves, and are caused by a considerable deficit in learners' SRL strategies [3,30]. Subsequently, students exhibit maladaptive and counterproductive behaviors such as procrastination and disengagement with the university career [3].

Developing lifelong learners is not as simple as teaching some tried and true disciplinary content. It is about achieving models of self-empowerment support for students as they go through a transformative journey from a novice learner to an intrinsically motivated lifelong learner [31]. The learners in this process will gain insights about themselves as they become intimate with their ability to push themselves to the maximum, practice self-control and critically evaluate the path they need to take to achieve maximum results. They will also need to overcome personal challenges such as unforeseen events or setbacks, distractions and the desire to procrastinate [3].

It is recommended that universities develop forms of retention based on the development of SRL because of its proven impact on academic performance. This will enable new generations of students to be encouraged to meet the demands of the university and thus improve institutional retention rates [32].

1.2. SRL Interventions in Higher Education: Intra-Curricular (Discipline-Dependent) vs. Extra-Curricular (Discipline-Independent) Approach

Previous research has shown that students who receive training in self-regulated learning strategies achieve better academic performance and it has been identified as a key variable in preventing academic failure [33].

Programs developed in a university context for the promotion of SRL have been classified into discipline-independent (extra-curricular) and discipline-dependent (intra-curricular) programs [12,14]. Extra-curricular programs are interventions outside the curricula of the disciplinary subjects of the degree programs. They include: (a) extra-curricular training courses, or (b) one-off interventions, summer courses or leveling programs between two study cycles, oriented on the logic of filling gaps, focused on enhancing isolated strategic aspects. Intra-curricular programs, on the other hand, consider the promotion of SRL through curricular activities, in which teachers encourage self-regulation in the context of strategies and beliefs related to their disciplinary areas [32].

Currently, the focus has shifted to intra-curricular SRL development programs because of their greater effectiveness in promoting SRL, as well as their coherence with competency-based curricula that have been promoted by international bodies such as the European-influenced Bologna Process [34]. These curricula promote a greater capacity for SRL, which guarantees academic and lifelong success [35]. Extra-curricular programs lose strength, as they are used in spaces created outside the curriculum and by external agents. On

the contrary, training in self-regulation strategies, carried out by teachers themselves in contexts, tasks and content specific to the curriculum, increases the likelihood of transfer of learning [32,36].

Intra-curricular programs can consider both direct and indirect ways of promoting SRL [34]. Direct promotion involves teachers' explicit or implicit instruction of students' self-regulation competences. We speak of explicit instruction when a teacher demonstrates a certain procedure, explaining that it is a learning strategy and the benefits of using it, i.e., students are informed of the meaning and importance of a specific self-regulation procedure. On the other hand, implicit instruction corresponds to the promotion of competences through modeling, not to mention that this behavior can be an effective learning strategy [37]. Indirect promotion involves the organization of a supportive learning environment that fosters the development of self-regulation, the main objective of the activity being a disciplinary one. This environment comprises not only the characteristics of the students and teachers themselves, but also the characteristics of the task, teaching methods and verbal messages from teachers to their students [38].

1.3. Smartphones as Ubiquitous Supports for Self-Regulation of Learning

The controversy regarding the benefits and disadvantages of mobile phone use is also observed at the educational level. In students, it has been shown that excessive smartphone use has been associated with poor sleep quality [39], and also that the more students use their mobile phones, the more it affects their academic performance [40,41]. However, one study shows that the size of the negative effect of smartphone use on academic performance has been overestimated in studies that controlled only for observed student characteristics [42].

One study found that when university students use smartphones for social and non-academic activities, they were seen more as a distraction in the classroom than as an aid to learning [43]. Students' non-academic and multitasking use of smartphones harmed students' learning and, as a result, reduced their academic performance. However, it also functioned as a learning aid, which was essential for students, allowing them to find information quickly and save time. The use of smartphones could be an excellent resource if the smartphone is capitalized upon to achieve the benefits associated with its use and can enhance their learning, which can lead to success in their academic life. Another study revealed that university students who use their smartphones for entertainment, social networking sites and game-related use showed smartphone addiction; however, study-related use has a positive effect on academic performance, while game-related use has a negative effect [44].

In line with the above, it is evident that previous studies have indicated that higher mobile phone use is associated with lower academic performance [45], while others suggest that smartphones have the potential to serve as study and learning aids. Ultimately, how the student uses (or does not use) a smartphone will go a long way in determining the impact on learning, so interventions that change students' mobile phone use behavior towards effective strategies while studying will lead to better academic outcomes [46].

Currently, almost all students have mobile phones and most use smartphones based on Android operating systems. Unfortunately, smartphones are mainly used as a means of communication and entertainment and few use them for educational purposes. By using smartphones, students could actively learn without direct guidance from their teachers [47].

Smartphones have brought massive changes to people's lives, allowing, in the case of students, easy access to information, diverse social communications and learning possibilities [45]. Portable educational technologies, such as simulators, provide students with the opportunity to learn independently [48]. As we have highlighted above, given that students use and carry their smartphones every day, and their behaviors are reflected in their smartphone use, it is important to explore ways to support self-regulation through smartphones [45]. New media offer fundamentally promising possibilities for sustainably implementing SRL interventions in the field.

The gap in research is observed in the scarce evidence on the development of smartphone apps for the promotion of SRL and testing their effectiveness with experimental designs. To identify existing targeted research on the evaluation of smartphone interventions to promote SRL, and in the context of this study, a brief systematic review was conducted following the PRISMA method [49]. A search algorithm based on previous systematic reviews on smartphones was designed to select words recommended or used by previous research [50–54]. The search was conducted in Web of Science and Scopus databases with the following keywords: "smartphone*" OR "smart-phone*" OR "smart phone*" OR "iPhone" OR "android" OR "blackberry" OR "black berry" OR "windows mobile" OR "windows phone" AND "self-regulated learning" OR "self-regulated learning" OR "self-regulation" OR "self-regulation" OR "self-regulated" OR "self-regulated" OR "SRL". It was not limited by year. In the Scopus database using the above algorithm, the first research appeared in 2012, while in Web of Science, it appeared in 2015. In phase 1, 98 studies were identified, phase 2 with duplicates was completed with 88 unique studies, phase 3 involving title and abstract review selected 17 studies, then in phase 4 the inclusion criteria were applied (empirical research, in university students, interventions that included the use of smartphones in the topic of SRL), and the final sample was 7 studies (see Table 1).

Table 1. Interventions to promote SRL in university students with smartphone use.

Ref	SRL Approach to Promotion	Objective	Sample	Limitations	Main Results
[55]	Extra-curricular (by means of reminder mails students monitored their academic goals)	Testing the efficacy of a brief intervention designed to increase smartphone use and the study of behaviors that support learning.	Total: 289 university students Country: USA	The focus was on a specific aspect of SRL and resource management, and therefore limited consideration of motivational aspects.	Students were introduced to SRL strategies for career planning. The brief intervention resulted in modest gains in SRL but did not influence achievement.
[47]	Intracuricular (evaluated classroom-assisted instruction)	Develop Android-based computer-assisted instruction and evaluate its effectiveness.	First-year undergraduates in a mathematics education program. Country: Indonesia	Not explicitly stated.	The Android-based computer assisted instruction (CAI) is valid for use as a learning resource, flexible and supportive of students' self-regulated learning.
[45]	Extra-curricular (the platform assesses behavior in general and not in a specific class)	To investigate the effectiveness of a self-regulation strategy in time management leveraged by smartphone capabilities using a theoretical framework of self-regulation.	Total: 295 university students Country: Korea	Results are not generalizable as the study was conducted for only three weeks, which may not have a strong influence on altering behavior and the diversity of the population was limited.	The students: (1) were not exactly aware of their smartphone usage; (2) need a system that helps them track their smartphone usage and manage their time through feedback interfaces; (3) smartphone usage did not differ much even during the trial period.
[56]	Intra-curricular (all students were from the same course)	To apply the SRL approach with the use of technologies in the context of a university course to reduce academic procrastination.	Total: 89 university students Country: Germany	Small sample, lack of behavioral measures, use of self-reports, design does not allow conclusions on long-term effects of interventions.	The individualized, rationale-based intervention allowed IG students to reduce procrastination while increasing their workload and using study time effectively compared to CG.
[48]	Extra-curricular (students were recruited)	Pairing self-regulated learning (SRL) with direct instruction.	Total: 34 university students Country: Canada	Small sample size, knowledge test has weak evidence of validity, participants did not capitalize on the content, study was conducted during the week before the final examination period.	Both curriculum sequences led to improved knowledge scores without statistically significant knowledge differences. When given minimal guidance, students engaged minimally in discovery learning.

Table 1. *Cont.*

Ref	SRL Approach to Promotion	Objective	Sample	Limitations	Main Results
[34]	Extracurricular (discipline-independent online training via smartphone)	Evaluate the effects of online SRL training for mobile devices.	Total: 73 university students Country: Australia	No long-term effects of the interventions were investigated, there was no performance evaluation, the sample was not representative, and the MSLQ only measures perceptions of strategy use and not behaviors.	The results showed that participants in the combined condition (diary training) improved more than other conditions. Specifically, SRL knowledge, metacognitive strategies, cognitive strategies and resource management strategies improved.
[57]	Intra-curricular (promoting the knowledge and application of SRL strategies for the writing of the bachelor's thesis)	The study aimed to develop, test and explanatorily evaluate an SRL intervention.	Total: 118 university students Country: Austria	The sample shows selection bias and high dropout rates during the study, implying analysis restrictions. For the self-report type of measurement, there may be response distortion due to the direction of social attractors.	Contrary to expectations, a pre–post comparison showed a decrease in self-reported knowledge of metacognitive SRL strategies. No significant changes were found for their use. In the case of students who used the app regularly, there was an increase in motivation to write the bachelor's thesis, which was shown in all groups. However, there is a significant increase in an unfavorable attribution style for success and failure.

Note: None of the studies were carried out in Latin America.

This justifies the need for more effective designs of SRL promotion in the first years of the university experience to become powerful interventions. It reinforces the idea that SRL skills should be taught explicitly to all students, rather than expecting them to develop the skills organically over time while students are enrolled in university courses [30].

1.4. Present Research

The current study aimed to design and evaluate the effect of an intra-curricular program with the use of a mobile application on self-regulation strategies for learning in university students. The hypothesis established is that those students who are exposed to the 4Planning app program (experimental group) have a higher frequency of SRL strategies use than those who are not (control group).

2. Materials and Methods

This study was developed with a quantitative approach using a quasi-experimental design with a control and experimental group and pre- and post-test measures [58].

2.1. Participants

A total of 473 first-year university students from seven Chilean universities participated in the study. Of the total number of students, 174 were male (37.2%) and 296 were female (62.98%). The mean age was 19.35 (SD = 2.49). Three hundred and thirty-two (70.19%) students were in the experimental group and 138 (29.17%) in the control group. The inclusion criteria required that the students were enrolled in their first major at the university, and that they were in the first or second semester of their program. To participate in the control group, students had to complete all the program sessions (4Planning) (see Table 2).

Table 2. Distribution of participants by OCDE area.

Group	OCDE Area				
	Agricultural Sciences	Medical and Health Sciences	Social Sciences	Engineering and Technology	Total Group
Control	19	42	64	13	138
Experimental	25	86	157	64	332
				Total sample	470

2.2. Instruments

2.2.1. Scale on SRL Practices

For the evaluation of the effect of the intervention program, the Lobos, Bruna and Sáez (2019) [59] scale on SRL practices was used. This scale was constructed to assess the frequency of students' use of SRL strategies after the 4Planning training program, corresponding mainly to the first phase of the SRL model, i.e., study readiness. It consists of 11 items: (1) I identified what my study purposes are (what I study for), (2) I defined achievable goals, (3) I evaluated how I distribute my time in the different activities I do, (4) I made a weekly schedule that includes all my activities, (5) I made to-do lists, (6) I updated my to-do lists daily, (7) I prioritized academic tasks according to importance and urgency, (8) I plan periods for after-school study, (9) I planned a time slot for a good night's sleep, (10) I planned activities for good quality individual study, (11) I planned good group study processes. These items were answered on a Likert-type scale with 7 response options (1 = never to 7 = always). In psychometric terms, a single-factor model with the optimal fit was identified when its psychometric properties were studied in university students (N = 716; CFI = 0.98; TLI = 0.97; RMSEA = 0.05) [59]. In this research, reliability of $\alpha = 0.89$ was identified with the results of the pre-test application.

2.2.2. Intervention Program: 4Planning

The intervention program to promote SRL strategies for university students using a mobile application is called 4Planning. The mobile application consists of 9 sessions that work on topics such as purposes, goals, time planning, organization of individual study, organization of group study and productive use of time in class, which promote SRL strategies based on Zimmerman's model [60]. The program was designed by the researchers and based on experiences from previous interventions [32,37]. The app has Android and iOS versions.

2.3. Procedure

2.3.1. Intervention Program Design: 4Planning

Nine academics and researchers from seven universities in Chile participated in the design of the training program. Members of this group began with the development of a systematic review of scientific literature on SRL and intra- and extra-curricular training programs [12]. Based on this review, the 7 SRL strategies considered in the program and consistent with Zimmerman's model (2000) were defined. Activities were then designed to develop each of them in the app. The participation of an academic from each of the 7 universities with experience in SRL and intervention programs was requested to carry out a validity study of the app sessions, focusing on the contents, method and the activities of the program. Subsequently, a team of experts in technological integration was hired, who, through a user-centered design (UCD) method, developed the resources (videos, infographics and activities) for the app according to the guidelines obtained from the expert judgement and joint work with the project's team of researchers.

The UCD methodology involved permanent iterations between the team of researchers and the team of experts in technological integration. The challenge was to develop software and hardware solutions that would allow the app to have the functionalities to carry out the activities requested for the training. In addition, we are working on two components proposed by the technology integration team that are fundamental for the success of the

app: (a) consideration of gamification elements in the app through the emulation of the motivation that users experience when they interact in a game. This will be done by transforming tasks into rewarded challenges, (b) implementation of a more irreverent, a non-academic youth communication tone, of the type used in memes (media resource frequently consumed by young people).

Once a preliminary version of the app was available, testing sessions were coordinated with university students, who experimented with the different resources and gave feedback as users on design and software improvements. With a second version of the app, an application was coordinated with the participating universities, selecting seven universities as they were more representative of the group of participating universities (diversity of students in terms of socio-demographic characteristics). Based on the improvements generated in this stage, the final version of the program was developed.

2.3.2. Implementation of the Training Program

Initially, a meeting was arranged with the course directors of each participating university to obtain authorizations and select courses for the research. At this meeting, the course directors informed about the courses with critical indicators of university dropout during the first academic year (subjects with high failure rates), so that both their teachers and students would be invited to take part in the study. After that, teachers of the indicated subjects were contacted via email for a first interview, where the aims were explained to them, characteristics and scope of the project and they were shown the mobile application and its sessions and given the support material: the 4Planning user manual and training support book called Facilitation of Self-regulation of Learning in the University Classroom [61]. All the participants of the control group followed the same program implementation protocol. Those who agreed to participate voluntarily were included in the research. Participation was achieved for the subjects suggested by the directors. The participating students were previously enrolled in the different courses, so it was not possible to organize the participants randomly. Convenience sampling was used. The application of the pre-test scale was carried out in the classrooms in person, and the teacher was accompanied to monitor the moments during the academic semester when the app sessions were applied, considering the academic program and its respective syllabus (teachers' lesson plans). Before the end of the academic semester and after verifying the completion of the application of the sessions in the app, the post-test application was carried out in the classrooms with the students present at that time.

Both teachers and students were asked to give their permission to participate in the research by signing an informed consent form, and the study data were stored under strict security regulations and protected by concealing the identification data of the participants.

2.4. Data Analysis

2.4.1. Content Validity of the Training Program

An inter-judge analysis was carried out with six experts to validate the content, method and activities of the program. Their selection was based on two criteria: experience in self-regulation research and experience in developing interventions. Additionally, they were required to have a doctoral degree and to have experience in university teaching. The results obtained led to modifications to the program which were incorporated.

2.4.2. Impact of the Training Program

All procedures described above were performed using R version 4.0.5 and RStudio IDE version 1.3.959.

Central tendency statistics of the scores obtained by the experimental and control groups were analyzed, and well as mixed ANOVA. First of all, the compliance with the following assumptions of the data was assessed [62]:

1. Presence of significant atypical values in none of the design's cells: the "identify outliers" function of the rstatix package was used, confirming the existence of one outlier in the control group, which was eliminated.
2. Normal distribution of the data: due to the size of each group, the Kolmogorov–Smirnov test, with the modification of Lilliefors [63], was used. The result was significant only for the experimental group in the post-test ($p = 0.012$). In the other groups (control pre-test and post-test, and experimental pre-test) the result was non-significant, thereby the normality of the data distribution can be assumed in these cases.
3. Variance homogeneity: the assumption of the variance homogeneity of the factor between subjects (control–experimental) was verified using the Levene test. The test was executed each time. The result was non-significant ($p > 0.05$), therefore the variance homogeneity was confirmed for each group in the pre-test and post-test. The homogeneity of the covariance of the factor between groups (control–experimental) can be assessed using Box's M test, with the R package rstatic. The results of the Box test, of similarity of the covariance matrixes, indicated homogeneity of the covariances ($p > 0.05$).
4. Sphericity assumption: the variance of the differences between groups within subjects must be the same. The sphericity assumption is verified automatically during the calculus of the ANOVA test, using the R ANOVA test () function of the rstatix package. The Mauchly test was used internally to assess this assumption.

When using the function get_ANOVA_table () to extract the ANOVA table, the Greenhouse–Geisser sphericity correction is applied automatically to the factors that could breach the sphericity assumption. The effect size was assessed by means of the eta square [64]

3. Results

3.1. Design and Validity Study of the Intervention Program

From the process of the literature review, expert judgement, and application, it was possible to design the final version of the 4Planning program with the use of a mobile application, consisting of nine sessions (see Table 3), which address SRL strategies based on Zimmerman's model, promoting goal setting, time planning, organization of individuals, group study and behaviors for the productive use of time in class.

Table 3. 4Planning sessions and learning outcomes.

N	Name of the Session	Learning Outcomes
1	Purposes of study	Reflects on his/her purposes of study (what he/she is studying for, what is the point of studying).
2	Goals	Defines two goals for the subject, with respect to the purposes indicated in session 1.
3	Daily schedule for the week	Evaluates the distribution of time and makes a weekly timetable.
4	To-do list for the subject	Makes a list of things to do in the subject.
5	Development and prioritization of academic tasks	Updates daily to-do list.
6	Organization and balance of activities	Develops a to-do list according to importance and urgency.
7	Planning and preparing my individual study for assessments	Prioritizes to-do list items according to importance and urgency.
8	I plan and prepare my group study	Plan and prepare the group study.
9	I take advantage of learning in class	I fulfill basic behaviors for learning in class.
	Digital closure	I evaluate what I have learned.

Each session includes a motivational video (https://bit.ly/366Ecfj accessed on 8 June 2021), knowledge infographics on the topic of the session, interaction activity(ies) in the app associated with the specific SRL strategy being promoted, an action commitment (activity outside the virtual environment) to be carried out by the students and an activity where the student can evaluate the usefulness of the experience of the session. Additionally, the app provides feedback messages that indicate what needs to be improved for future performance in each of the strategies promoted by addressing strategies from phases 2 and 3 of Zimmerman's model. An example of a session can be seen in Figure 1.

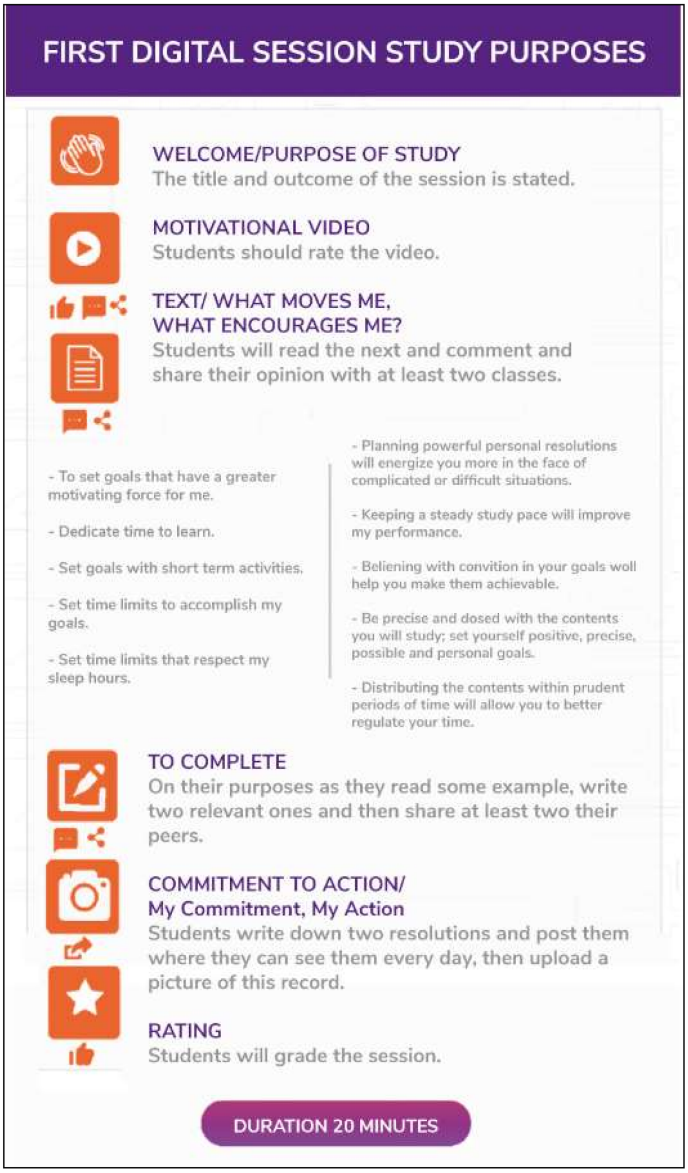

Figure 1. Example of a mock-up of the first session of the app.

The pedagogical sequence includes didactic strategies of (a) gamification, through the obtaining of scores, badges and messages of recognition, (b) transmedia narrative, which is deployed through multiple media and (c) communicative tone adapted to the user, in this case, university students. Performance data and progress with the application are reported to the teacher on a desktop interface dashboard (see Figure 2).

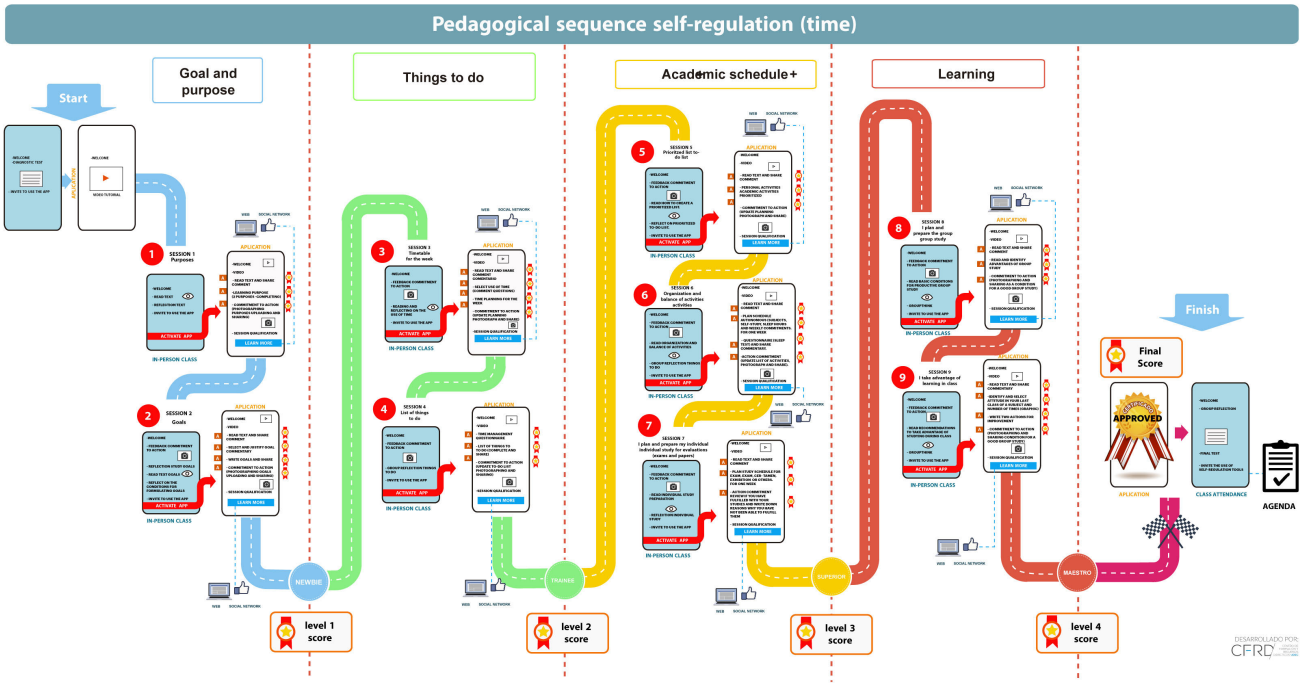

Figure 2. 4Planning pedagogical sequence.

The application is designed for a face-to-face higher education context, with an intra-curricular component that depends on the teacher linking the sessions of the mobile app with activities of their subject and motivating the use of the app in the classroom with the data reported by the dashboard (see Figure 3).

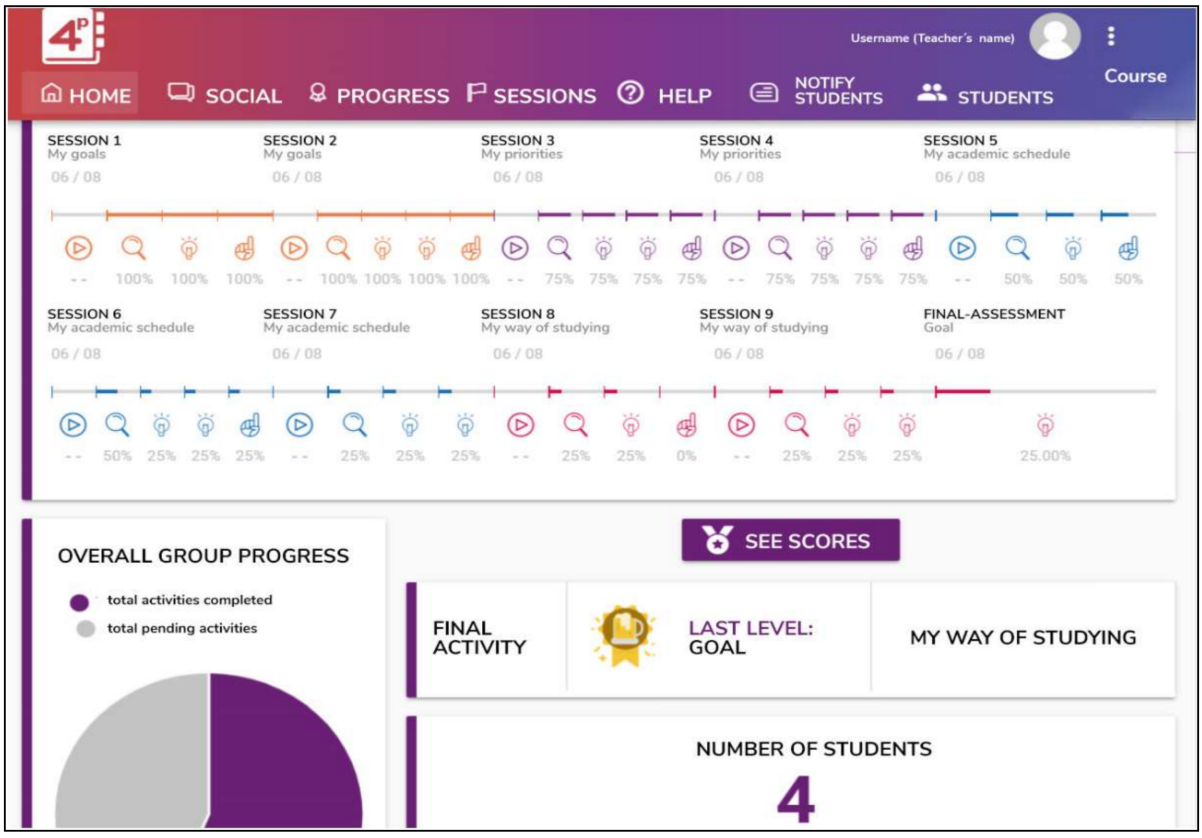

Figure 3. Teacher dashboard image on desktop interface.

The program includes: (a) a manual for teachers, which documents the features of the 4Planning software (V 0.26), to provide a written and graphic support guide to the use of the application, (b) two video tutorials, one aimed at teachers that shows how to use the desktop interface platform that provides graphic information on the student's progress in the app and another which teaches students how to download the application to their mobile phones and shows them the main components of the sessions and how to interact with the training resources and learning and (c) a book called "Facilitating Self-Regulation of Learning in the University Classroom" [61] which provides an empirical theoretical basis of the importance of self-regulation of learning, its scope, strategies, recommendations for teachers and practical examples complementary to the use of the application.

3.2. Effect of 4Planning on SRL Strategies

To evaluate the effect of exposure to an intra-curricular program for facilitating self-regulation of learning skills in university students with the support of the 4Planning app, a quasi-experimental study was carried out in first-year students. The results obtained before the application of the training program supported using the 4Planning app and after the completion of the training are presented below.

Table 4 describes measures of central tendency before and after applying the intervention program to analyze the effects on the comparison groups. In this case, before the application of the program for the students belonging to the experimental group and the control, the average score was within the category of "4 = indifferent" on the use of the self-regulation learning strategies described in the questionnaire. Non-statistically significant differences between the groups are identified (t (468)1.29457, $p = 0.195$).

Table 4. Results of ANOVA measures before and after the intervention with the support of the 4Planning app.

Measurement Time	Experimental (n = 332)		Control (n = 138)		ANOVA			
	M	SD	M	SD	Effect	*F* Ratio	df	η^2_G
Pre-test	4.52	1.04	4.66	1.05	G	0.17	1467	0.00
Post-test	4.94	1.01	4.69	1.12	T	35.86 ***	1467	0.01
					G × T	27.36 ***	1467	0.01

Note: n = 470, ANOVA = analysis of variance; treatment = training group; control = control group; G = group; T = time. *** $p < 0.001$.

For the scores obtained after the application of the intra-curricular program, an increase was identified in the average of the responses of the students in the experimental group, with scores close to the category "5 = quite a lot" on the use of the self-regulation strategies described in the measurement instrument. In the case of the students belonging to the control group, practically the same scores were identified as those reported by this group of students in the first measurement. To analyze the effect of the intra-curricular training program with the support of the 4Planning app for the promotion of students' self-regulation strategies, it was decided to perform an ANOVA analysis (see Table 4).

The results through the post hoc test on the measures obtained with the questionnaire of willingness to study for the self-regulation of learning, with between-subjects factors (control and experimental), showed significant differences only in the post-test, F (1.467) = 5.129; $p < 0.05$, $\eta^2_G = 0.01$. Then, within-subjects factors (before and after treatment) indicated the presence of statistically significant differences in the levels of self-regulation of learning between the scores found in the experimental group concerning the control, after the application of the intervention, F (1.331) = 137,099; $p < 0.001$, $\eta^2_G = 0.042$. In this case, there is a higher score in the students belonging to the experimental group on the use of self-regulation learning strategies.

4. Discussion

This paper shows the development of a mobile application that is effective in promoting the development of self-regulated learning skills in university students. Although there are other interventions that achieve this goal [10–12], this one is particularly innovative, as it involves the use of smartphones by students, with a youth culture communication tone, with the use of gamification and the possibility of carrying out activities associated with a challenging subject that usually has high failure rates [65,66], as the subjects of algebra and calculus traditionally are, which is motivating for students.

The quasi-experimental measurement was able to identify changes in the use of self-regulation practices of the participating students and, although the effect size is small, this positive change in the increase in self-regulated learning occurred in a short time.

Undoubtedly, the use of smartphones has increased exponentially in the last 20 years, being more frequent for social interaction and entertainment activities [47], which is why they have traditionally been seen as an "enemy" to learning, especially in the classroom, as they are a barrier to attention and concentration [44]. Contrary to this idea, this study takes a positive view of the use of smartphones as a vehicle to achieve better quality learning, which achieves the autonomous development of self-regulation skills and willingness to study, through a tool that is intuitive to use, with a design centered on the user, their needs and preferences. On the other hand, although there are interventions that have used this type of technology (as shown in Table 1), there are no experiences in Latin America that take into account the local culture, rescuing the global findings.

The designed program is versatile in that it can be used autonomously by the students, in their extra-classroom time, strengthening the learning achieved in the classroom. Additionally, all sessions can be linked to a particular subject, through intentional actions of the teacher in the classroom. This allows the intervention to have an intra-curricular, domain-specific component, achieving a perception of greater utility for students [12,34]. Another of its advantages is that it seeks to develop skills in goal setting and study purposes, study organization and time management, among others, which, although they are worked on in the context of a critical subject in the curriculum, are transferable to other subjects, to the world of work and, most importantly, to life, in coherence with the skills needed for the 21st century and with the lifelong learning model, understanding that learning occurs throughout the life cycle and in contexts broader than the academic one [31].

The fact that it is a smartphone-based activity opens up the possibility of continuing to use it, both in Chile and in other countries, given the growing need for institutions to incorporate technologies into their academic processes. This has become especially relevant in the context of the health crisis caused by the COVID-19 pandemic, in which classes have had to move from being face-to-face to being remote on different platforms and devices [41,67,68]. How to create the institutional conditions and provide digital competencies to the human capital that participates in remote teaching and learning processes, in order to promote high-quality education (with synchronous and asynchronous interactions), has been a priority concern for all levels of the education system, especially at the university level and with a view to post-pandemic higher education [69].

Most higher education institutions seek, within their educational models, to promote this type of interaction, given that it allows the development of skills that contribute to better job performance, considering the level of technological advances and the globalization of information that exists today [70]. In this way, using a smartphone and its applications as a didactic tool is a good and efficient decision.

Currently, after the design of the program, the validation of the designed measurement instrument and the preliminary analyses obtained in the test, there is a promise of further research with this proposal. However, it is important to interpret the results considering the limitations of quasi-experimental studies, which are developed in natural environments which prevent the random assignation of the participants to the different types of treatments [58], preventing, for instance, the analysis of the effect of the program

on students' SRL according to the type of course, major or knowledge area, elements that could not be analyzed in this work.

Future studies could include longitudinal research to assess the sustainability over time of the learning and skills obtained through the use of the 4Planning app in subsequent courses. It would be interesting to monitor and measure its impact on students' academic performance or other academic variables. Other research could also be designed considering the design-based research methodology, which has been employed in educational interventions that use technologies and have demonstrated benefits in student learning outcomes [71]. In this case, design-based research is characterized by being in real educational contexts in which the design and measurement of interventions consider the use of mixed methods. It involves the participation of researchers and education professionals, with the objective of enhancing the impact of these proposals in educational practice [71,72]. Another possible line of research would be to evaluate the effect of its implementation in other disciplinary areas, especially in pedagogy, achieving the transfer of these skills from the future teachers to the students of tomorrow.

5. Conclusions

This study aimed to develop and evaluate the impact of a mobile application software solution to increase the use of SRL strategies in university students. To this end, the 4Planning app was designed and a quasi-experimental design application was conducted with students from two engineering majors to identify the effects on students' self-regulated learning and the functionality of the tool. The study showed that the use of the 4Planning mobile app generates benefits in the increase in SRL strategies in university students, providing a technological tool, with theoretical–empirical support, with a youthful, versatile, communicative tone and an intra-curricular component in its approach, which is designed for higher education and to be useful and easy to use. It is aimed at students who wish to increase their SRL strategies or teachers who intentionally seek to support their students in the development of self-regulated learning skills in the development of their courses.

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