Improving Soft Skills Through an Interdisciplinary Approach in a Realistic Context Between Education and CS Students in an HCI Course

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Abstract*—*Contribution: **Prior studies on pedagogical methodologies to acquire soft skills have shown that developing collaborative tasks produces positive impact in students' abilities. In this article, a pedagogical approach based on interdisciplinary practice and realistic problems is proposed to improve students' teamwork skills.**

Background: **Traditionally, soft skill acquisition has received scarce attention in high education curricula. Consequently, students finish their studies without having developed important competencies, such as communication, conflict resolution and teamwork skills.**

Intended Outcomes: **Students who follow a realistic interdisciplinary approach improve both their soft and hard skills compared to students who follow a traditional collaborative pedagogical methodology. Through the approach proposed, students progress in completing tasks, participating in the team, collaborating in the organization, accepting agreements and taking into account the others' points of view.**

Application Design: **The experience involved students from two different disciplines, prospective computer science engineers and preservice teachers. They worked together to design an educational application that required prospective engineers to apply Human–Computer Interaction fundamentals. A quasi-experimental study was performed using either knowledge tests or self-assessment pre-post-tests, both subsequently analyzed using quantitative methods.**

Findings: **1) the prospective CS engineers who followed the interdisciplinary realistic practice approach achieved better learning outcomes than those who did not; 2) the educational context affects teamwork skill development; and 3) students improved their ability to work and participate in the team after the experience.**

***Index Terms*—Experiential learning, interdisciplinary, professional practice, self assessment, teamwork skills.**

Manuscript received 7 December 2021; revised 30 September 2022 and 23 March 2023; accepted 10 April 2023. This work was supported in part by the Government of the Region of Madrid and "Fondos Estructurales" of the European Union under Grant S2018/TCS-4307, and in part by the Rey Juan Carlos University under Project M2614. *(Corresponding author: Maximiliano Paredes-Velasco.)*

This work involved human subjects or animals in its research. The author(s) confirm(s) that all human/animal subject research procedures and protocols are exempt from review board approval.

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Digital Object Identifier 10.1109/TE.2023.3269691

I. Introduction

THE KNOWLEDGE about a discipline (also known as hard skills) has been traditionally prioritized over other important aspects like soft skills. Nowadays, however, the latter are being more valued by employers [1], [2] and even some part of the academia, e.g., teamwork, communication, or conflict resolution skills [3]. Training in soft skills helps students to learn how to share the control of tasks and projects and how to solve practical problems, always in connection with hard skills [4]. Many approaches are being used to teach soft skills, e.g., [5]: methodologies, such as problem-based, project-based or game-based learning; learning platforms, such as MOOCs, personalized learning environments, or collaborative environments.

Interdisciplinary contexts are an interesting perspective for the development of students whose future professional tasks include dealing with people outside of their discipline. These students need to train in how to apply their hard skills within these contexts as well as how to use their soft skills therein. Interdisciplinary contexts are often present in the professional world but are difficult to integrate into educational programs [3]. The health field is an example where interdisciplinary contexts are present and soft skills are also highly important [3], [6].

The integration of realistic contexts with interdisciplinary approaches has been previously addressed [7]. The use of both approaches together with other related techniques have shown interesting results, e.g., in terms of students' satisfaction [6]. In addition, these experiences allow to train in skills that are not usually dealt in classroom [4] such us developing creative and critical thinking [8] or organizing the thinking process [1]. Other experiences have produced improvements in the learning process and the performance of interdisciplinary teams. Klipfel et al. [6] have detected improvements in the performance and communication of multidisciplinary teams in the healthcare. Similar effects have been achieved within other fields such as computer games development, where teamwork skills and employability have been increased [2]. In fact, improving students' employability is an interesting aspect of these approaches, mostly because soft skills are highly demanded by companies [1]. Other authors highlight the advantage of having students participate in activities closely related to their future professional life [4], [9].

However, these pedagogical approaches have some limitations. On the one hand, many of the experiences could be classified as anecdotal ones and students could feel frustration and anxiety during the project [4]. On the other hand, teachers' workload is significantly increased due to the need for them to prepare and run simulations [6] and to provide support to students [2], [4].

Despite these limitations, the results of the previous works point out that the study of interdisciplinary activities within realistic contexts could produce interesting results. Urquiza-Fuentes and Paredes-Velasco [7] showed how these activities improved students' motivation. Hall and Weaver [3] intuited that an interdisciplinary approach could promote the acquisition of teamwork, communication, and conflict resolution skills. In addition, students' self-assessment of soft skill acquisition, through realistic activities is highly positive, as is the case, e.g., of teamwork skills [2], [6]. Thus, the improvements in soft skill acquisition could improve effectiveness of the use of hard skills [6]. However, more studies are needed to deepen the process of soft skill acquisition within the university scope [1].

Therefore, the main aim of this work is to study the impact on hard skills and teamwork skill acquisition of interdisciplinary practices and collaboration between Computer Science students (hereinafter "prospective engineers") and Education students (hereinafter "preservice teachers") within realistic contexts in university education.

II. Theoretical Framework

A. Realistic Projects and Problem-Based Learning

The educational use of real experiences is not a new idea. Aristotle already proposed that experience is an important source of knowledge. However, this idea is still the foundation of many innovative learning experiences and new research. The study of the role of students' experiences in their learning process has led to important learning theories such as Kolb's experiential learning theory (ELT) [10]. This theory states that the transformation process from experience to knowledge follows a cyclic process made up of four phases which require students to be engaged with the learning process. Thus, ELT is also related to some forms of active learning like collaborative learning or team-based learning.

Realistic practices are broadly used as educational tools in some knowledge areas. They allow students to use their acquired knowledge in realistic contexts as a colophon of their education. A paradigmatic example is Teacher Education. It was detected that traditional programs seemed to fail in preparing prospective teachers for the real facts of the classroom. Korthagen et al. [11] showed that 71% of the graduates taught with realistic teaching practices achieved significant better results than the rest of the graduates. In addition, the value of realistic experiences is highlighted by augmenting the ELT model with aspects that consider the nonreflective learning extracted from these experiences [11].

Nowadays, teaching practices and programs are broadly included in all degrees of early childhood, primary, or secondary education. Health Sciences or Law degree programs, where working with other people is a constant in the daily professional life, are other fields where this kind of practices has been longer integrated in the curriculum. Other fields consider realistic projects but in a more anecdotal way, e.g., Accounting [12] or Computer Science [7].

Most of the previously mentioned works focus the learning process on hard skills, but realistic activities can also be used as educational tools to develop soft skills. Thus, some approaches try to reach the realistic feature by means of simulations in different areas like Computer Science [13], Business [14] or Nursing [15]. Furthermore, there are some examples that implement more realistic approaches to improve student's competency in soft skills related to university programs in Computer Science or Management [12].

Problem-based learning (PBL) is closely related to realistic learning experiences. PBL is considered a very successful method, as it engages students into realistic practices, and it does so at a high level of cognitive activity. In the PBL method, the objectives are to get students to solve problems they will meet in their professional careers, and students' assessment is based on how well they solve the proposed problems [16]. In fact, early uses of PBL were applied in medical education using "patient problems as a context for students to learn" [17]. Thus, the integration of real problems is being used to develop either learning skills [18] or professional skills [19], like communication [20] or teamwork ones [21]. Here, educational technologies have contributed with more realistic contexts using augmented reality [22] or virtual reality [23]. Positive experiences have been recorded also with e-learning frameworks [24], [25], [26], but these need to be carefully designed as they could blur some of the desired effects of the PBL methodology [27].

PBL is integrating innovative aspects that can affect how students work in groups. One example is that of the Agile principles [28], whose use has shown interesting effects on teamwork skills [29] even outside computer science degree programs [30]. Another example is the application of a multidisciplinary approach, grouping students from different programs to develop professional skills [31] and teamwork skills among them [32].

B. Interdisciplinary Teamwork Skill

Teamwork skill is considered by many authors to be a key competency; therefore, it is already included in the learning objectives of some university programs [33]. It is an interpersonal skill with three different ways of collaboration between disciplines: 1) multidisciplinary; 2) interdisciplinary; and 3) transdisciplinary.

Multidisciplinarity means a process that provides juxtaposition of disciplines in an additional way, but without integrating them [34]. In a multidisciplinary collaboration, individuals work independently on different aspects of the same project, in a parallel or sequential manner, but without exceeding their limits of knowledge [35]. Furthermore, the objective set is different for individuals from the various disciplines, e.g., student interactions within realistic context in the educational field [7]. Also in the case of interdisciplinary teamwork, individuals from different disciplines work on the same project, but they analyze, synthesize, and coordinate their work in such a way to establish a new level in the discourse and promote the integration of different fields of knowledge [34]. Interdisciplinarity strives to create new disciplines, a common goal is pursued, and a common methodology is used. Finally, in transdisciplinary, individuals from different disciplines work on a common problem by bringing together the theories, concepts, and approaches of their own disciplines [35]. Arthur et al. [36] went a step further, referring to transdisciplinarity as the moment when different points of view are recognized and conclusions are reinterpreted in terms of the other persons. The difference between interdisciplinary and transdisciplinary lies in the fact that in the first case, people from different disciplines manage to work together using a common methodology, while in the second case, they are able to reinterpret the conclusions of the other individuals. In relation to gender, the roles assumed by engineering students in groups are often assigned according to gender stereotypes [37]. In fact, Stein et al. [38] stated that, although they make similar efforts, men tend to write code and redesign, while women perform synthesis, presentation preparation, report writing and documentation tasks.

There are also differences according to the age of the participants in group work. Older students interact in a positive way with younger team members, while the latter do not always appreciate the leadership and organization of the project undertaken by others [39]. Also, older students feel more pressure because they take on responsibility for practical tasks of the group [40].

In summary, realistic practices are often used in education, law and health sciences degree programs. However, outside of these areas, realistic practices are used in a mostly anecdotal way. In CS education, simplified real problems are often used instead of realistic problems and contexts. The approach presented in this work does not simplify the real problem because students will have to face the full development process of a user interface. Furthermore, the context is made more realistic thanks to the interdisciplinary approach. Instead of involving other CS students as users, like [7], this work involves education students as the users. This is a radically different knowledge area, since there are no common concepts or vocabulary shared between CS and education students on Human–Computer Interaction.

III. Description of the Study

The main research question addressed was whether the interdisciplinary realistic project methodology impacts positively on students' teamwork skill and learning outcomes, stating the following hypothesis.

- H1: The interdisciplinary realistic project approach improves Human–Computer Interaction learning outcomes.
- H2: The interdisciplinary realistic project approach improves students' self-perception of teamwork skill.
- H3: Students' educational context (degree and academic year) affects their teamwork skill.
- H4: Students' personal profile (age and gender) affects their teamwork skill.

In order to validate these hypotheses, an experience was developed where prospective engineers had to develop an interactive educational application collaborating with preservice teachers.

A. Educational Context and Subjects

The proposed work was carried out in a public university involving, in an interdisciplinary way, students from several degree programs pertaining to different branches of knowledge from two different schools located in two different cities. All participants had previously completed courses on subjects requiring them to acquire teamwork skills. On the one hand, there were the prospective engineers who participated in an experience-based course: they were attending a Human–Computer Interaction course as part of their third university year in the first semester. In this course, students learn user-centered design techniques and the development of interactive applications, focusing on the usability of the user interface. The contents of the course are organized into three main blocks: 1) specification of usability requirements; 2) design of user interfaces; and 3) evaluation of usability. Prospective engineers must apply these contents in a continuous practice during the whole semester that involves the participation of hypothetical users, applying both technical activities and tasks with a high component of social interaction, such as interviews, surveys, brainstorming, etc.

On the other hand, there were the preservice teachers from two degree programs both belonging to the branch of knowledge of Social Sciences. These students belonged to different programs, from the first to the fourth year, although most of them were in third year, and all of them were taking courses in didactics of mathematics. In these courses the students were trained in learning and teaching the first notions of mathematics.

As it will be described in the next section, the students had to design an educational interactive tool focused on a concrete aspect of mathematics. Thus, within the interdisciplinary teams, the prospective engineers contributed with their interface design and development skills, while preservice teachers contributed with their knowledge about didactic and pedagogical contents as well as activities needed to learn mathematics.

B. Participants and Procedure

This study was conducted in two academic years: 1) 2018/2019 and 2) 2019/2020, with a total of four instructors and 164 students, 89 of whom were prospective engineers enrolled in a Computer Science degree program, whereas 74 were preservice teachers enrolled in Primary Education and Early Childhood Education degree programs. The students were 19–24 years old. The research work was designed with two groups, an experimental group and a control group. The experimental group included 35 prospective engineers and 74 preservice teachers enrolled in their corresponding programs for the academic year 2019/2020. The control group was made of 54 prospective engineers enrolled in the HCI course for the academic year 2018/2019. Note that prospective engineers, both control and experimental groups, did not have previous HCI knowledge.

The treatment applied to the experimental group, i.e., the interdisciplinary realistic project methodology, was divided into four phases for a period of 12 and half weeks.

Phase 1 (Presentation): The students were divided into two classrooms. In one classroom, the instructor introduced the treatment to the preservice teachers, explaining the objective, which was to develop an educational tool to learn mathematics, aimed at both students and teachers of first educational stages. Afterward, the instructor explained that students had to play the role of teachers in the process of developing the educational tool. Similarly, other instructor presented the same objective to prospective engineers in a separate classroom, explaining that they had the role of developers and computer experts. This phase took 15 min.

Phase 2 (Pretest Assessment): The instructor presented a hypothetical situation where preservice teachers and prospective engineers had to work together. He asked the students to evaluate their own teamwork ability in that situation. To do this, the participants filled out a pretest to gather data about the teamwork skill. This phase took 15 min similar to phase 1.

Phase 3 (Development): All the students were gathered in the same classroom and groups were formed consisting of three prospective engineers and seven preservice teachers. In this phase, students had to develop the learning tool taking into account the roles explained in phase 1. The phase was divided into three stages.

1) *Requirements:* Prospective engineers interviewed and surveyed preservice teachers to determine the requirements for the prototype.
2) *Design:* Prospective engineers presented prototypes in order to capture feedback from preservice teachers and used it to improve their prototypes. To do this, prospective engineers filmed short videos, supported by the ClipIt educational tool, showing their prototypes, and preservice teachers commented on them. This stage was cyclic, and students only met sporadically for it.
3) *Evaluation:* Once the tool was concluded, preservice teachers evaluated its usability, with prospective engineers applying empirical techniques, such as focus groups, user feedback, thinking aloud, etc.

This phase lasted 12.5 weeks and students were free to meet at their discretion, although professors established the need for three face-to-face meetings, one for each stage.

Phase 4 (Post-Test Assessment): Participants were asked to fill out post-tests which involved the same variables measured in the pretest in order to evaluate teamwork skill of students after the treatment. Besides, an HCI knowledge test was completed by prospective engineers. Table I shows a summary of main phases to replicate the experience with the experimental group.

These stages represent several teamwork experiences for students through which they will develop their teamwork skills. Thus, each stage involves students in an ELT cycle that is also connected with the next one, since the active experimentation of one stage/cycle is associated with the concrete experience of the next stage/cycle.

TABLE I
STEPS TO REPLICATE THE EXPERIENCE

Week	Session*	Phase	Description
1	#1. F2F	1, 2 & 3	Presentation, Teamwork pre-test and group formation & requirements capture
1-4	Free remote	3	Requirements capture
4	#2. F2F	3	Design
4-9	Free remote	3	Design
9-11	Free remote	3	Evaluation
11	#3. F2F	3	Evaluation
11-13	Free remote	3	Evaluation
13	#4. F2F	4	Teamwork post-test & HCI exam

*F2F: Face to Face

The treatment applied to the control group consisted in a more traditional methodology based on a collaborative learning, nonrealistic approach. The students had to develop a prototype similar to the experimental group's prototype. However, on this occasion, usability requirements were determined by the teacher and each group consisted of three CS students. This treatment was divided into two phases and lasted 12 weeks as well.

1) *Phase 1 (Development):* Prospective engineers developed a prototype throughout three stages.
   a) *Requirements and Design:* A requirement document was delivered to prospective engineers and they had to develop an initial prototype without taking into account usability requirements.
   b) *Usability Designing:* The students improved the initial prototype obtained from the previous stage, considering usability principles and guides.
   c) *Evaluation:* Each group of students evaluated their own prototype applying Nielsen heuristics.
2) *Phase 2 (Knowledge Assessment):* A nominal HCI knowledge test was required on completion of experimental group treatment.

Fig. 1 shows a block diagram describing phases of the experience and treatment applied to both the experimental and the control group.

C. Technological Infrastructure

Students in the experimental group followed a teamwork approach together with a peer-review; the latter was used for commenting videos about prototypes. Thus, the first approach was to use the Moodle environment of the institution involved in the study, which provides suitable tools, such as a forum (https://docs.moodle.org/400/en/Forum_activity) and a workshop (https://docs.moodle.org/400/en/Workshop_activity). These are powerful tools, but this institution does not allow to mix students from different degree programs in the Moodle environment. Therefore, an alternative tool had to be used, choosing the ClipIt learning environment [41]. ClipIt is an open-source software (https://github.com/juxtalearn/clipit) that, among other features, allows group collaboration, and video-based learning facilities. Within ClipIt, students are

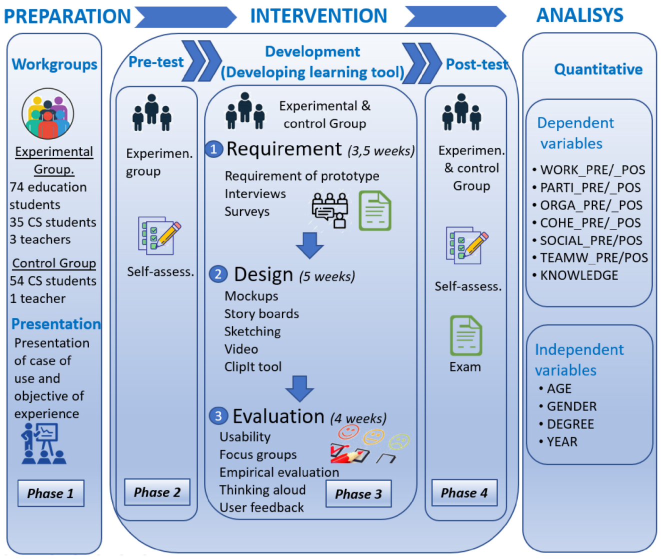

Fig. 1. Phases and process of experience.

distributed in groups by default. ClipIt provides two communication spaces based on discussion forums, and two types of repositories of materials: 1) intragroup and 2) intergroup. The former can be used as a private space for each group where members can share opinions as well as materials, e.g., documents, videos, etc. The latter can be used to discuss and share information with other different groups.

ClipIt natively supports a video-based learning approach. Thus, activities are organized in different steps toward the production of a video explaining a concept or presenting a tool. The first step consists in intragroup discussions with the aim of producing a script for the video. This script is stored in the intragroup communication space. The second step consists in producing of the video. The final step is publishing the video for it to be evaluated by the members of other groups. All these steps can be divided in different tasks so that students' work can be monitored, thus, providing a feedback to both, teacher and students on the degree of completion of each task and step. In this experience, only the two first steps were used, because the focus of the study was the teamwork approach rather than the global peer evaluation methodology implemented in the third step, although a peer evaluation approach was used among the members of each group before publishing the video.

The ClipIt learning environment was used in the second stage of the third phase of the treatment applied to the experimental group: "Design." The objective of this stage was to design the user interface of the educational tool, with a video describing this interface as the final output. Therefore, the intragroup video production facilities were used during this stage, i.e., the group home page in the ClipIt environment where group members can see their progress. In addition, they can see a list of the members, a timeline detailing all the activities performed by the group, and links to other sections, such as materials provided by the teacher, tasks, discussion, and materials produced and published by the group.

D. Variables and Instruments

Two main aspects were evaluated in this work: 1) teamwork soft skill and 2) HCI knowledge acquisition. Next, variables and instruments used to measure both aspects are detailed.

1) Measuring Teamwork Soft Skill Acquisition: The project "TUNING Educational Structures in Europe" [42] redesigned degree programs in Europe and determined learning outcomes in terms of competencies. The competency-based learning assessment model proposed by [43], which is within TUNING publications and based on this project, has three levels of mastery to assess the teamwork skill: 1) actively participating and collaborating in team tasks and promoting confidence, cordiality, and focus on shared work; 2) contributing to the consolidation and development of the team, fostering communication, balanced distribution of work, good team atmosphere, and cohesion; and 3) directing groups, ensuring member integration and high-performance orientation. This research is focused on the first level [43], participating and collaborating in team tasks, which determines five indicators of teamwork competency. These indicators are considered as subskills to valuate five teamwork's dimensions in current study.

1) *Work:* Completing assigned tasks within the deadline as group member.
2) *Participation:* Participating actively in team meetings, sharing information, knowledge, and experiences.
3) *Organization:* Collaborating in defining, organizing, and distributing group tasks.
4) *Cohesion:* Focusing on and being committed to agreement and shared objectives.
5) *Social Value of Activity:* Taking into account the points of view of others and giving constructive feedback.

Thus, teamwork related dependent variables were based on these indicators [43], together with another one, named "teamwork," that represents a global view the previous five indicators.

As it has been said in Section III-B, this study is based on a pre-post-test design. Therefore, each indicator was associated with two variables measuring it before (pretest) and after (post-test) the treatment applied to the experimental group. The names of the variables were formed by adding the "_PRE" (pretest) and "_POS" (post-test) suffixes to the name (or its abbreviation) of the indicator. Table II shows the mapping between the indicators (2nd column) and the variables (3rd and 4th columns).

In order to measure these variables, a self-evaluation questionnaire has been developed. Among teamwork skills, self-evaluation and peer review are used to establish the responsibility, identify the competencies and spot some of the learning needs [44]. In addition, the evaluation of the individual competency in the groups must not depend only on the teacher. Thus, self-perception manages to catch the information about questions and events that otherwise could not be obtained [45]. Therefore, previously mentioned dependent variables were evaluated based on students' self-perception.

Thus, the instrument is a questionnaire (see the Appendix) that measures the six pairs of variables. Each question has five possible answers (from "a" to "e.") The instrument has

TABLE II
DEPENDENT VARIABLES DESCRIPTION

Instrument*	Indicator & Description	Name Before	Name After
TWS Item 1	Work. Perform assigned tasks within the group (Work).	WORK _PRE	WORK _POS
TWS Item 2	Participation. Actively participate in the group's meeting and collaborative space.	PARTI _PRE	PARTI _POS
TWS Item 3	Organization. Collaborate in definition, organization and distribution of group tasks.	ORGA _PRE	ORGA _POS
TWS Item 4	Cohesion. Orienting and committing to common agreements and objectives.	COHE _PRE	COHE _POS
TWS Item 5	Social value of activity. Take into account the point of view of others and feedback constructively.	SOCIAL _PRE	SOCIAL _POS
TWS Item 1-5	Work collaboratively and efficiently with team's members, whose value is the mean of previous variables.	TEAMW _PRE	TEAMW _POS
Hard skill test	HCI exam score	–	KNOWLEDGE

**TWS=Teamwork skill instrument*

been adapted from the rubric provided in [43]. Table II also shows the mapping among questionnaire items, indicators, and dependent variables. Each one of the first five pairs of variables (X_PRE & X_POS) were valued using an ordinal scale (from 1 to 5) where answer "a" of the questionnaire was mapped to 1, and answer "e" of the questionnaire was mapped to 5. Note that the sixth row of the table corresponds to the global teamwork perspective. Therefore, these two variables are not mapped to any item, but computed as the mean of the other five corresponding variables.

2) Measuring the HCI Knowledge Acquisition: This aspect focuses on HCI hard skills, and, therefore, a new dependent variable was created named KNOWLEDGE. Hard skills pretest was not performed since prospective engineers did not have HCI knowledge before the experience. The HCI hard skills assessed through questionnaires were design usability requirement, design low-fidelity and high-fidelity prototyping, application of usability guides and standards, and UI evaluation with Nielsen Heuristic and empirical methods (thinking aloud, focus group, questionnaires, interviews, etc.) The instruments used to measure this variable were the ones developed for the HCI course assessment. They consisted of reports and exams. Student teams were required to deliver three reports describing the prototype and development process during the treatment, one for each stage of development, i.e., requirements, design, and evaluation (see Section III-B). At the end of the treatment, students completed an exam to assess their HCI knowledge individually. Students' final mark was determined applying the following weighting: 20% for each report and 40% for the exam. This final mark was the value of the KNOWLEDGE variable.

3) Independent Variables: Finally, independent variables are those factors that might produce a change in students' teamwork skill. Evidently, the list of those factors can be very long, so the list is limited to the main ones: personal and academic profile, considering age, gender, degree program and highest academic year of the subjects in which the student is enrolled in the year in which this experience was carried out; and pedagogical methodology, which is collaborative learning based on a realistic project for the experimental group and a traditional approach for the control group. Consequently, the following independent variables are defined: AGE, GENDER, DEGREE, and YEAR.

TABLE III
MEANS COMPARISON WITH WILCOXON TEST

Desc. statistics (Mean, Standard Deviation) (N=99)			_PRE vs. _POS
Variable	_PRE (M,SD)	_POS (M,SD)	W Significance Test
WORK	**(4.06, .740)**	**(4.24, .671)**	**.003**
PARTI	**(3.62, .752)**	**(3.85, .676)**	**.013**
ORGA	(3.86, .821)	(3.90, .839)	.787
COHE	(3.92, .665)	(4.05, .612)	.058
SOCIAL	(3.81, .765)	(3.94, .753)	.144
TEAMW	**(3.85, .526)**	**(3.99, .480)**	**.001**

IV. RESULTS

In this section, the analysis of HCI learning outcomes and students' self-perception regarding the teamwork skill acquisition are presented.[1] But first, in order to assess to assess teamwork competence the reliability [46] of the scale based on the five indicators of [43] is summarized. Statistical calculations show that the Cronbach alpha value was 0.764, which is an acceptable level. Therefore, it can be stated that these indicators are a valid instrument to assess the teamwork skills.

A. Analyzing Preservice Teachers and Prospective Engineers Together

The quantitative and correlation analyses follow. They are performed on the data collected with pretest and post-test assessments regarding teamwork skill acquisition for prospective engineers and preservice teachers. Contrasts of hypotheses in statistics analysis of results are validated significantly at 95% confidence level. Apart from a general point of view, the teamwork skill has also been studied from other perspectives: students' educational context, students' personal profile and the realistic interdisciplinary approach.

1) Analyzing Students' Teamwork Skill: The analysis of the hypothesis involves contrasting the student's teamwork ability before and after the treatment. Table III shows descriptive statistic of students' teamwork skill together with the significance difference analysis between pretest (_PRE) and post-test (_POS) measurements. Wilcoxon test was applied to contrast means differences since the Kolmogorov–Smirnov test (using the Lilliefors significance corrections) determined that all variables followed a no-normal distribution. The results show significant differences for WORK, PARTI, and TEAMW (values marked in bold in Table III, column W Significance Test).

2) Students' Educational Context Regarding Teamwork Skill: Two analyses were carried out in order to consider possible differences between students of different degree programs and academic years. Again, means of variables before and after the treatment are contrasted, but in this case, the samples are grouped by students' educational context (DEGREE

[1]Dataset available at https://doi.org/10.21950/E0D3QP (accessed 4/20/2023).

TABLE IV
MEANS COMPARISON GROUPED BY DEGREE AND YEAR

Variable	ECE (N=29)	PE (N=45)	CS (N=25)	Kruskal-Wallis (Sig.) Differences by DEGREE	Kruskal-Wallis (Sig.) Differences by YEAR
WORK_PRE	4.03	4.20	3.84	.155	.725
PARTI_PRE	3.52	3.78	3.44	.080	.771
ORGA_PRE	3.69	3.96	3.88	.372	.384
COHE_PRE	3.72	4.04	3.92	.120	.768
SOCIAL_PRE	3.76	3.84	3.80	.916	.118
TEAMW_PRE	3.74	3.96	3.78	.111	.684
WORK_POS	4.14	4.40	4.08	.128	**.044**
PARTI_POS	3.66	3.98	3.84	.108	.306
ORGA_POS	3.83	3.96	3.88	.758	.416
COHE_POS	4.14	4.00	4.04	.645	.811
SOCIAL_POS	3.93	4.09	3.68	.082	.641
TEAMW_POS	3.93	4.08	3.90	.357	.642

ECE = Early Childhood Education Degree; PE = Primary Education Degree; CS = Computer Science Degree

TABLE V
CORRELATIONAL ANALYSIS

Variable	TEAMW_PRE (Coeffi., Sig.)	Variable	TEAMW_POS (Coeffi. Sig.)
WORK_PRE	(.648, p<.001)	WORK_POS	(.585, p<.001)
PARTI _PRE	(.732, p<.001)	PARTI _POS	(.642, p<.001)
ORGA _PRE	(.741, p<.001)	ORGA _POS	(.791, p<.001)
COHE _PRE	(.652, p<.001)	COHE _POS	(.605, p<.001)
SOCIAL_PRE	(.714, p<.001)	SOCIAL_POS	(.700, p<.001)

TABLE VI
COMPARING TEAMWORK SKILL OF HCI STUDENTS BEFORE AND AFTER TREATMENT

_PRE vs. _POS	WORK	PARTI	ORGA	COHE	SOCIAL	TEAMW
Asint. Sig.	.109	.090	.405	.405	1.000	.100*

*t-Student

TABLE VII
KNOWLEDGE EXPERIMENTAL VERSUS CONTROL GROUP

Group	N	Mean	Standard Deviation	Min.	Max.	Mann-Whitney
Control	54	6.13	2.56	2.00	9.90	**.044**
Experimental	35	7.41	1.72	3.00	9.47	

and YEAR independent variables). Therefore, the Kruskal-Wallis test for nonparametric independent samples was carried out. Table IV displays the results of the test grouped by the academic year and degree program in which students were enrolled (Computer Science, Primary Education, and Early Childhood Education), and shows no significant differences in terms of degree program. However, the Kruskal-Wallis test shows that WORK_POS variable was different regarding the YEAR (Sig. = 0.044). The Kruskal-Wallis adjusted by Bonferroni's correction test revealed that WORK_POS was significantly different (Sig. = 0.049) between academic years 1 (M = 3.71, SD = 0.488) and 4 (M = 4.63, SD = 0.916). Prospective engineers of the experimental group participating in the experience were 35, but 10 of them were eliminated from this analysis because their questionnaires were invalided (personal code of pretest and posttest do not match).

3) Students' Personal Profile Regarding Teamwork Skill: Students' age and gender may be factors affecting their teamwork skill. In order to determine whether these factors are decisive, a contrast test of AGE and GENDER variables was developed. Mann–Whitney test with Bonferroni correction were applied grouping the sample by AGE and GENDER. The results show that there are no differences in teamwork skill regarding students' age and gender.

4) Correlational Analysis of the Teamwork Subskills: As it has been mentioned previously in Section III, teamwork skill is formed by several components or dimensions named indicators. Such dimensions might be related in a realistic project approach. Therefore, a linear correlation analysis of every variable with all the others was carried out. Particularly, the focus was on correlations between teamwork skill and subskills, before and after the treatment. Nonparametric Spearman test's coefficients shown in Table V represent significant correlations with at least a 95% confidence level, whose values show strong and medium positive correlations between all variables. Besides, other less significant correlations were found between SOCIAL_POS and PARTI_POS (0.375), ORGA_POS (0.282), and COHE_POS (0.372).

B. Analyzing Prospective Engineers

This section focuses on HCI students analyzing the influence of the treatment on teamwork skill and learning outcomes.

1) Results of Teamwork Self Assessment: Within the experimental group, HCI students' teamwork skill was analyzed independently of the rest of participants. Shapiro–Wilk test showed that all variables followed no-normal distribution except TEAMW_PRE and TEAMW_POS. Therefore, in order to validate the hypothesis whether means are different before and after the treatment, the t-Student test was applied to TEAMW variable and the Wilcoxon test was applied to the rest. Results showed in Table VI indicate that no differences were detected (p>0.05).

2) HCI Learning Outcomes: The KNOWLEDGE variable was analyzed in order to determine whether the realistic project approach influences in knowledge gained by prospective engineers. To do this, the KNOWLEDGE means of experimental and control group were compared. The Kolmogorov-Smirnov (using the Lilliefors significance corrections) and Shapiro–Wilk test determined that KNOWLEDGE followed a no-normal distribution. Table VII shows that the experimental group significantly outperformed the control group' since Mann–Whitney test determined that means are significantly different.

Additional studies were carried out to analyze correlations between KNOWLEDGE and teamwork skill variables within the experimental group. Table VIII shows the significant correlations detected applying Spearman test with at least 95% confidence level. The results indicate that KNOWLEDGE is significantly correlated with AGE and COHE_POS.

TABLE VIII
LEARNING CORRELATIONAL ANALYSIS

Variables analyzed	AGE (Coefficient, Sig.)	COHE_POS (Coefficient, Sig.)
KNOWLEDGE	(-.573, .003)	(.473, .017)

V. DISCUSSION

Realistic experience through interdisciplinarity have been put into practice for studies associated with Nursing [15] or Business [14], but its use within Computer Science is mostly anecdotal [13]. From a general point of view, the approach has positively impacted either students' learning outcomes or some aspects of teamwork skill acquisition. These achievements associated with realistic software have already been highlighted by Hart [1], Vogler et al. [4], and Buffardi et al. [9], among students from different fields of knowledge (including engineering). Based on these results, it can be affirmed that there exist benefits for prospective engineers and preservice teachers. These benefits were achieved thanks to students' social interaction through interviews, surveys, brainstorming, etc. The social skills trained during the treatment are related to their participation, organization, and cohesion in a realistic project environment. These results follow the conclusions obtained by Klipfel et al. [6] who highlighted that the use of simulations improves teamwork and communication skills. The environment for developing this experience was ClipIt. This online social learning platform encourages student-driven reflection and focuses, especially, on social interaction and collaboration [41].

A. H1—The Effect on HCI Technical Knowledge

Hypothesis H1 focuses on learning technical contents, analyzing the level of HCI knowledge acquired during the experience. The results of the current study show that students who took the approach outperformed those that followed a more traditional approach. Therefore, hypothesis H1 is assumed supporting that interdisciplinary realistic projects improve HCI hard skill acquisition.

Seman et al. [30] applied the PBL methodology to Electrical Engineering students to evaluate the technical knowledge formation process, and concluded that the passing rate raised after the application of said methodology. Lee et al. [47] compared PBL to traditional approach in two courses, Programming Fundamentals and Laboratory of Programming. They found out that the students in the PBL approach passed the course at a rate of 47.37% while only 7.27% of the students following the traditional approach passed. However, the differences detected in these studies were not significant. This research complements these studies and demonstrates that acquisition of technical knowledge can be significantly improved. Thus, this work is in line with [26], whose results confirm the existence of statistical differences in final marks between PBL and a traditional approach.

Finally, another relevant finding of present study is the correlation detected between hard and soft skill acquisition. Considering that level of commitment and sharing objectives was measured (cohesion subskill), it seems that students who committed the most to the agreements and shared objectives in their teams were the ones who learned the most [positive correlation between COHE_POS and KNOWLEDGE (see Table VI)]. The authors consider that improving cohesion subskill has a positive impact on hard skills where reaching agreements and being committed to common objectives are essential, such as prototype design, UI empirical evaluation design, and requirements questionnaires design. Therefore, within an interdisciplinary realistic project context, HCI technical knowledge could be related to social cohesion skills. As far as authors know, nowadays there are not studies in HCI related to this finding.

B. H2—The Effect on Teamwork Skill Acquisition

Based on the results reported in Table I, all the variables seem to have increased their values after the treatment. The significant differences detected show that the students' ability to work in a team (TEAMW) was higher after the treatment based on an interdisciplinary realistic project approach. To be more concrete, the improved dimensions were completing assigned tasks (WORK) and participating (PARTI). Consequently, hypothesis "H2: The interdisciplinary realistic project approach improves students' self-perception of teamwork skill" is assumed.

This study confirms some of the findings pointed out by previous research. Sancho-Thomas [24] found out that a simulated environment based on PBL, where students collaborate through a role-based game, improves soft skills to work on a project. This research goes beyond, since the H2 hypothesis confirms that the interdisciplinary realistic environment based on problem solving, where students collaborate without any team role assignment, improves self-perception of soft skills. This self-perception in soft skill acquisition can be due to several reasons. Hart [1] stated that the mode of project delivery is not important and adding an interdisciplinary element to project work improves the perceived gains in soft skills. The nature of interdisciplinary projects supports important aspects for soft skills learning [4]. Therefore, it seems that the interdisciplinary approach developed in this study may have improved the students' soft skills.

An additional factor which may have an influence is the technological infrastructure, which has played a significant role in the study. The experimental group was formed by students from two different degree programs (computer science and primary education) of two different schools located at two different cities. Therefore, it needed a way to facilitate group collaboration outside the sessions where the students met each other in person. This was the role of the ClipIt learning environment. From the perspective of the tools available, forums and workshops from Moodle are quite similar to ClipIt. However, ClipIt facilitated the control tasks performed by the instructors during the work and it has been essential for students' collaboration tasks. Consequently, the technological infrastructure was essential in the development of students' teamwork skill.

Another important aspect regarding soft skills improvement is the learning methodology developed by instructors. The use of a real-word problems approach in collaborative learning contexts encourages student' active participation and integration of diverse view points in the team promoting some soft capabilities such as teamwork [2]. The results of current study show that all variables of teamwork were increased after students finished their software prototypes, and two of them were raised significantly which were developed by real problem solving sessions. Consequently, this work agrees with [2] and consider that approaches based on real problem resolution is an appropriate resource for developing the teamwork skill.

In summary, the authors consider that real-word PBL combined with interdisciplinary and collaborative activities enhance teamwork skill acquisition, particularly the task completion and active participation abilities. In addition, other interesting aspects of team work such as organization, cohesion, and social interaction were slightly improved.

C. H3—The Effect of the Educational Context

The H3 hypothesis was focused on the educational context influence. This hypothesis must be discussed differently for the two variables under consideration (DEGREE and YEAR). On the one hand, the hypothesis regarding the study programs followed by the students (degree program) is rejected, because there are no significant differences between them. This contrasts with the literature reviewed, where [4] found that student's perception about some soft skills developed during learning activities varied according to the student's degree program or a certain discipline, particularly in skills related to communication and teamwork/collaboration, among others. On the other hand, the results of the analysis show that students' skill about performing assigned tasks in group were different depending on the academic year where they are enrolled. The finding found is aligned with results of other studies on interdisciplinary and PBL. In this way, the results of [4] are complemented. Therefore, the H3 hypothesis cannot be totally assumed but it is worth noting the importance of the student's academic year on teamwork skill acquisition.

D. H4—The Effect of the Personal Profile

Hypothesis H4 is focused on the personal profile where the students' age and gender is considered. Although correlation between age and HCI knowledge has been found (Table VIII), the findings of the literature reviewed regarding teamwork skill [37], [38], [39], [40] cannot be confirmed considering the results obtained in this study. This could be due to the difference in the way of evaluating the teamwork skill acquisition. Previous studies measured the amount of tasks performed by each student (gender) and the leadership roles assumed (age), while it has been used a self-assessment approach. It remains as a future perspective to address how the self-assessment of teamwork skills is related to the tasks performed and leadership role assumed within a team.

E. Interesting Correlations Among Teamwork Dimensions

The study presented in this article analyzes importance and relevance of subskills regarding the main skill teamwork. All subskills showed important correlation with teamwork before the treatment. However, two subskills maintained a high level of correlation after the treatment: 1) social subskill, which focuses on taking into account the points of view of others and giving constructive feedback and 2) organization subskill, which is centered on collaboration in defining, organizing, and distributing work tasks in the group. The authors consider that this finding is very interesting, although this belongs to the psychological scope rather than the educational one and requires further research.

Besides, some interesting correlations have been found after the treatment, although they have medium level significance. Particularly, the correlation related to taking into account other points of view is noted. Vogler et al. [4] found that several students indicated a need for negotiations (between client and contractor) in context of interdisciplinary communication, although they did not identify which participation and collaboration elements were related to negotiations. This research expands results in [4] since the correlation study shown in this article states that taking into account other points of view, which is a basic aspect in negotiations, correlates with participating, organizing, and agreeing. Therefore, the more the students in a team are involved in participating, organizing, and agreeing, the greater their sensitivity to other points of view is, and consequently, the better is the negotiation result they will achieve.

F. Limitations of the Study

Regarding validity of the study, the following aspects have been taken into account: the control and treatment groups were formed with different subjects, participants did not have knowledge about the subject before the experience, and contents and tasks were the same in both groups' students, varying only the applied learning methodology.

However, some risks or limitations can be identified. First, the sample was formed come from only one university. Besides, the control and experiment groups were not formed randomly, but students enrolled in different academic years. Therefore, there is no certainty that the sample is representative of the population.

Second, the control group was formed to validate learning outcomes, but there was no control group to validate teamwork skill acquisition. Therefore, the finding regarding soft skill could be limited.

Finally, a statistic study has been carried out, where an inferential analysis has been performed. Type 1 errors (incorrect rejection of the null hypothesis) and type 2 errors (not rejecting a false null hypothesis) might be present in this analysis [48].

VI. Conclusion

This article presents an interdisciplinary experience of learning based on realistic contexts where preservice teachers and prospective engineers had to work together in order to design an educational tool for primary and early childhood education. An experimental group of students followed this interdisciplinary approach, whereas a control group of students followed a more traditional methodology based on collaborative, noninterdisciplinary learning. Students' teamwork skill self-evaluation was carried out through on pre- and post-tests, while students' learning outcomes were measured through knowledge tests.

The extant literature shows that realistic experiences through interdisciplinarity have been carried out in several knowledge branches. However, this is the first study about teamwork skills in which an experience was developed with prospective engineers and preservice teachers in an interdisciplinary way. Therefore, it is highlighted the possibility of developing an experience based on interdisciplinary work in areas that are not very similar to each other.

Based on the results, it can be confirmed that the interdisciplinary realistic approach improved significantly HCI learning outcomes of the experimental group. Besides, the prospective engineers and preservice teachers increased their ability to work in teams. Although all the three participating degree programs experienced this improvement, differences were found in the ability to perform the task in groups between students who were in the first year and those in the fourth (and last) year, with the latter developing this competence more than the former. Nevertheless, there is no evidence that gender affect students opinion on their ability to work in a team. In addition, the ability of students to perform tasks and participate in the group increases as their capacity to organize the work grows. Also, the students' ability to participate, organize, and accept agreements is as important as their ability to consider other points of view and their willingness to work in a group.

Finally, although this was not the main aim of this work, an interesting contribution comes from the reliability analysis of the teamwork skills' indicators model [43] as an acceptable scale to assess the teamwork skill. As far as authors know, there is currently no published work regarding the first level of mastery of the teamwork assessment model described in [43]. In fact, one of the future works envisaged will be to increase the sample size in order to achieve a more significant validation of this instrument.

Appendix
Questionnaire for the Assessment of Teamwork Skill

Note: Adaptation for preserve teachers in square brackets.

Self-Assessment of the Ability to Work in a Multidisciplinary Group: The questionnaire assesses your teamwork skill in a multidisciplinary working group. The answers are treated anonymously and have no impact on the grades obtained in the subject. As the experience is totally anonymous, you must enter a code (which only you will know). The code will be formed by the last three digits of your ID + letter of your ID + the last three digits of your phone number. For example, if my ID finishes in 123R and my mobile finishes in 456, my code is 123R456.

The scale consists of giving yourself a work scenario and rating how you think you would behave in that scenario. Read the description of the work scenario and rate the subsequent items.

Imagine you are an HCI engineer (teacher) in a TIC company (school), and you want to design and implement a computer platform for teachers and students. You will be part of a team of teachers, head of school, Web programmer, and network administrator, in which you must work side by side quite frequently for three months as an HCI expert (teacher) to build the computer platform. Imagine yourself in this multidisciplinary work situation and evaluate the following aspects.

1) Perform the tasks assigned to me within the group and within the required deadlines.
   a) I will not complete the assigned tasks.
   b) I will partially comply and/or will do so with delays.
   c) I will comply with the established deadlines.
   d) I will meet the deadlines and will also be an important contribution to the team.
   e) In addition to meeting the deadlines, I will guide and facilitate the work of the rest of the team members.
2) Participate actively in team meetings, sharing information, knowledge and experiences.
   a) I will often be absent from group and my presence will be irrelevant.
   b) I will take little part, mostly at the request of others.
   c) In general, I will be active and participative in group meetings.
   d) With my interventions I will encourage participation and improve the quality of the team's results.
   e) My contributions are fundamental for the group process and for the quality of results.
3) Collaborate in defining, organizing, and distributing group tasks.
   a) I will manifest resistance to the organization of work within the team.
   b) I will limit myself to accept the organization of work proposed by other members of the team.
   c) I will participate in the planning, organization, and distribution of teamwork.
   d) I will be organized and will distribute work with effectiveness.
   e) I will foster organization of work by taking best advantage of team member talents and Know-how.
4) Focus on and being committed to agreement and shared objectives.
   a) I will only pursue own objectives.
   b) I will have difficulty in integrating personal and team objectives.
   c) I will accept as own the objectives of the group.
   d) I will promote a clear definition of objectives and the group's integration round them.
   e) I will motivate and marshals' group round more demanding objectives. Groups where will participate noteworthy for performance and quality.

5) Consider (take into account) the points of view of others and provide constructive feedback.
   a) I will not listen to classmates and systematically disparages them, wanting to impose own opinions.
   b) I will listen little and will not worry about the opinion of others. My contributions will be redundant and not very suggestive.
   c) I will accept the opinions of others and I will be able to give ow point of view constructively.
   d) I will promote constructive dialogue and will inspire quality participation from other group members.
   e) I will integrate others 'opinions into a higher perspective, maintaining atmosphere of collaboration and support.

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