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# UNCOLAB: A COMPUTATIONAL TOOL FOR COLLABORATIVE LEARNING OF COMPUTER PROGRAMMING

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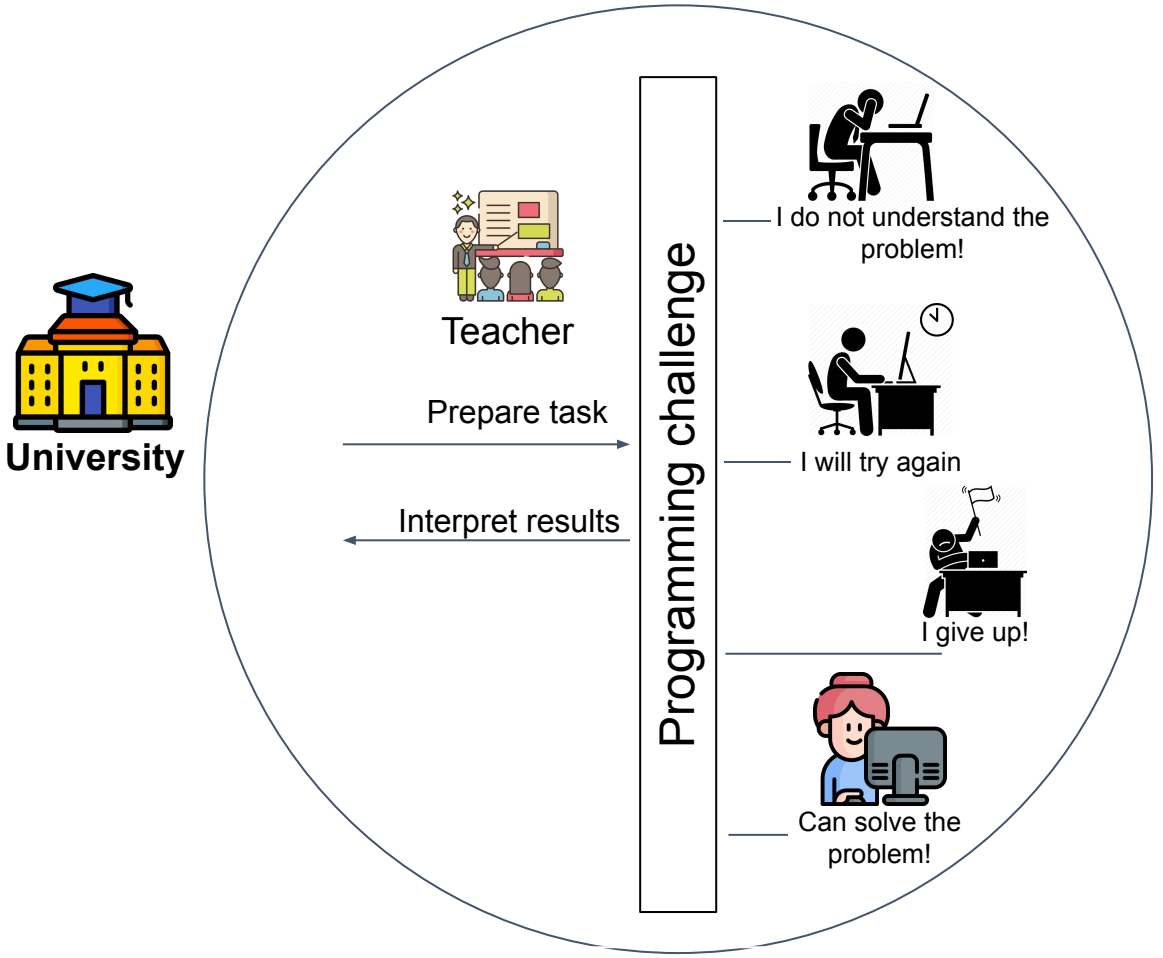
## Introduction

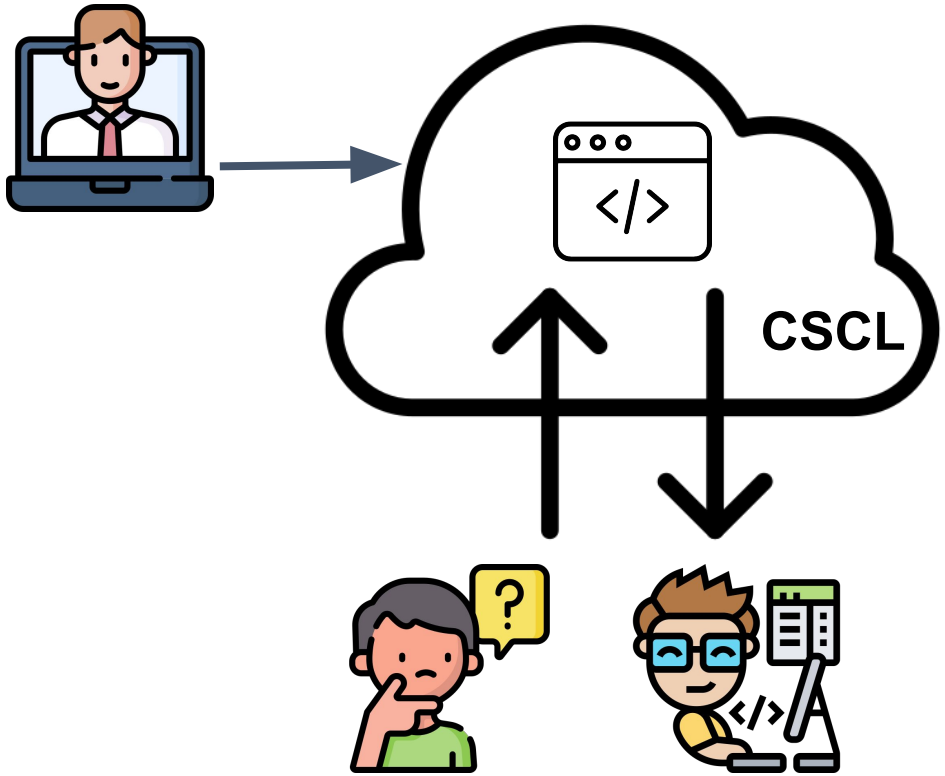



**Introductory computer programming courses**

**loss of motivation**

(Ala-Mutka, Kirsti, 2005)

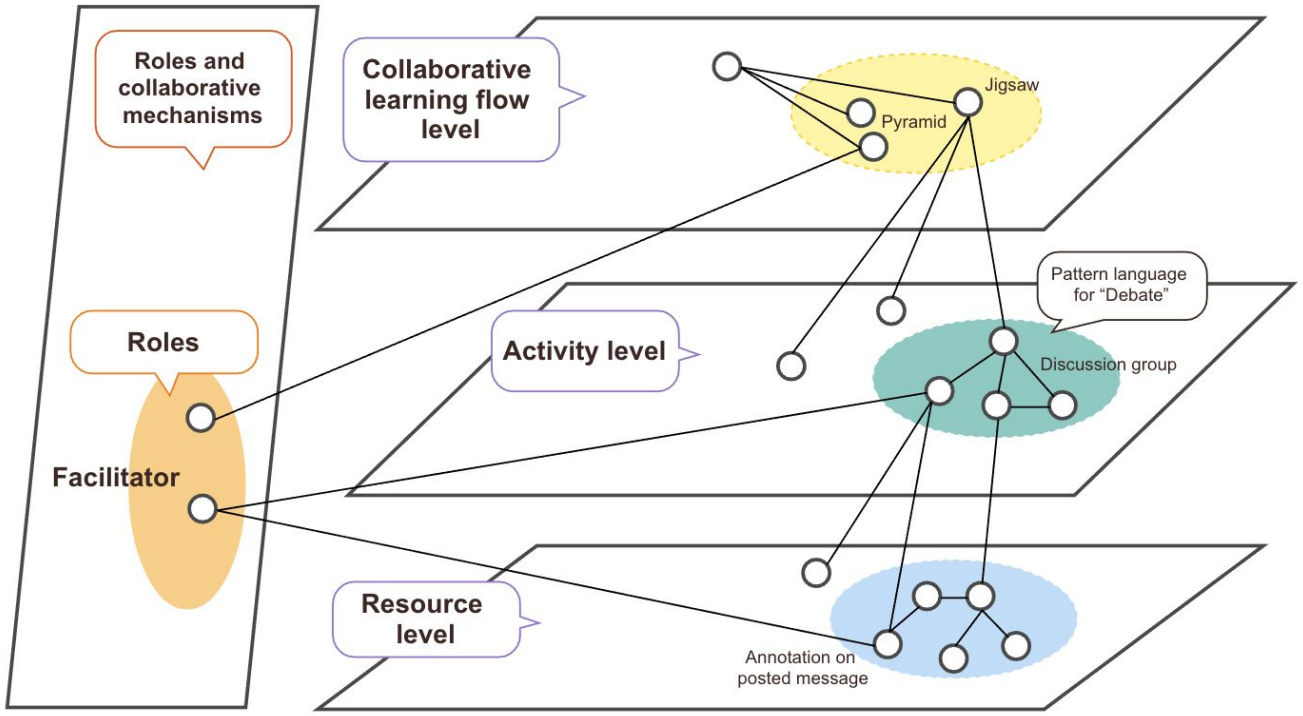
## Computer Supported Collaborative Learning (CSCL)




### Benefits:

- **Higher educational efficiency and motivation.**
  (Serrano Cámara et al., 2016)
- **Foster in critical thinking skills.**
  (Jussi Laakso et al., 2018)
  (Hwang et al., 2017)
- **Facilitation in the process of assigning tasks to students.**
  (Ouafae Debdi et at., 2015)
- **Better formation of learning groups.**
  (Sao De Faria et al.,2006)

## CSCL SCRIPTS




(Hernández et al, 2009)

### Benefits:

- **Establishing a sequence of activities to be performed by a group of students.**
- **Defines how the collaborative work will be structured.**
- **Facilities the assignment of roles within each activity.**
- **Better formation of learning groups.**

## Problem identified and research question

**More experimentation with CSCL scripts to measure their effectiveness, especially in group assignment and how they affect collaboration among students.**

(Sao De Faria et al.,2006; Ouafae Debdi et at., 2015;Serrano Cámara et al., 2016; Hwang et al., 2017)

**What are the effects on the resolution of computer programming problems from the use of a collaborative computational tool that facilitates formative peer assessment?**

## Instructional design of the collaborative environment

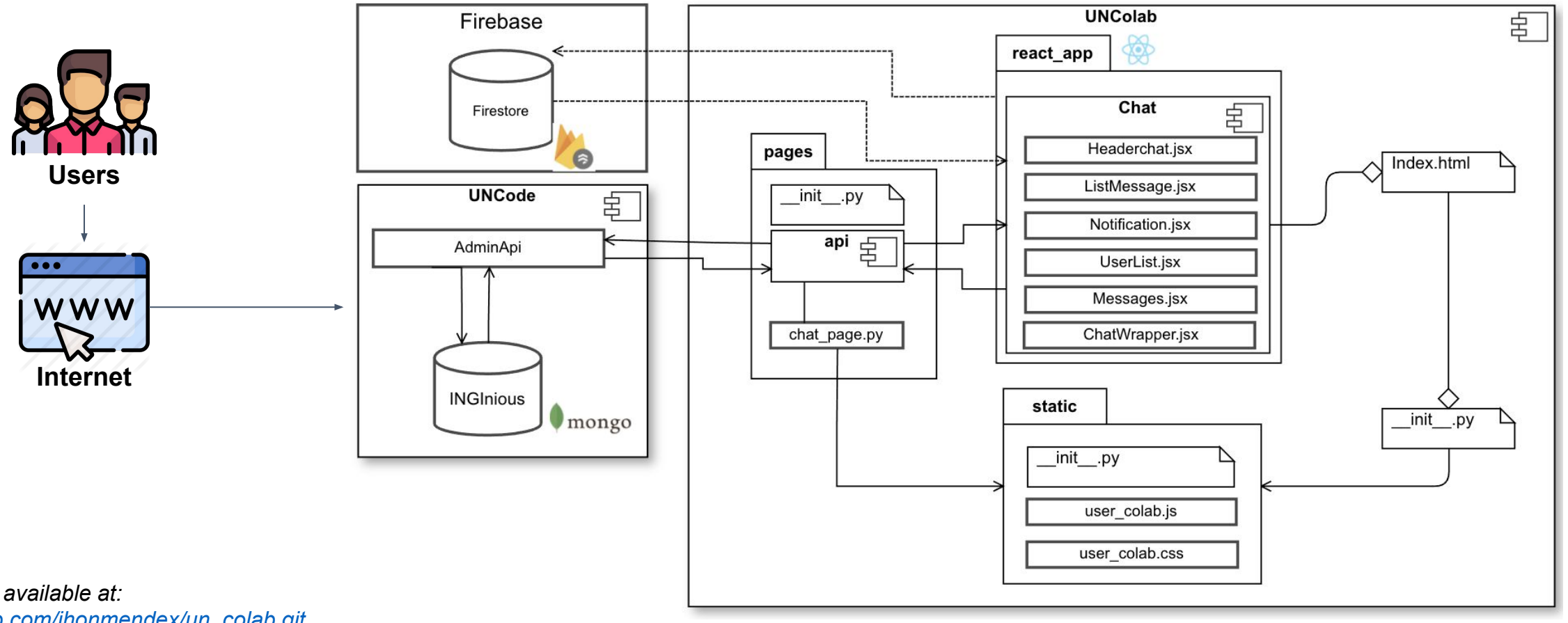
**Collaborative Learning Techniques (CLTs)**

- Think-pair-share (TPS) } **Collaborative learning flow level**
- Introductory activity } **Activity Level**
- Group discussion
- Programmers and novices } **Role Level**

| Functionality | Resource level |
|---|---|
| Approaching the task | UNCode |
| Task resolution | UNCode |
| Student grouping | UNCode, **UNColab** |
| Collaboration between students | **UNColab** |
| Collaboration assessment | **UNColab**, Google Forms |

*UNCode is a platform educational which supports programming courses.* https://uncode.unal.edu.co/
(Restrepo-Calle et al,2018)

## Development of the collaborative environment: architecture



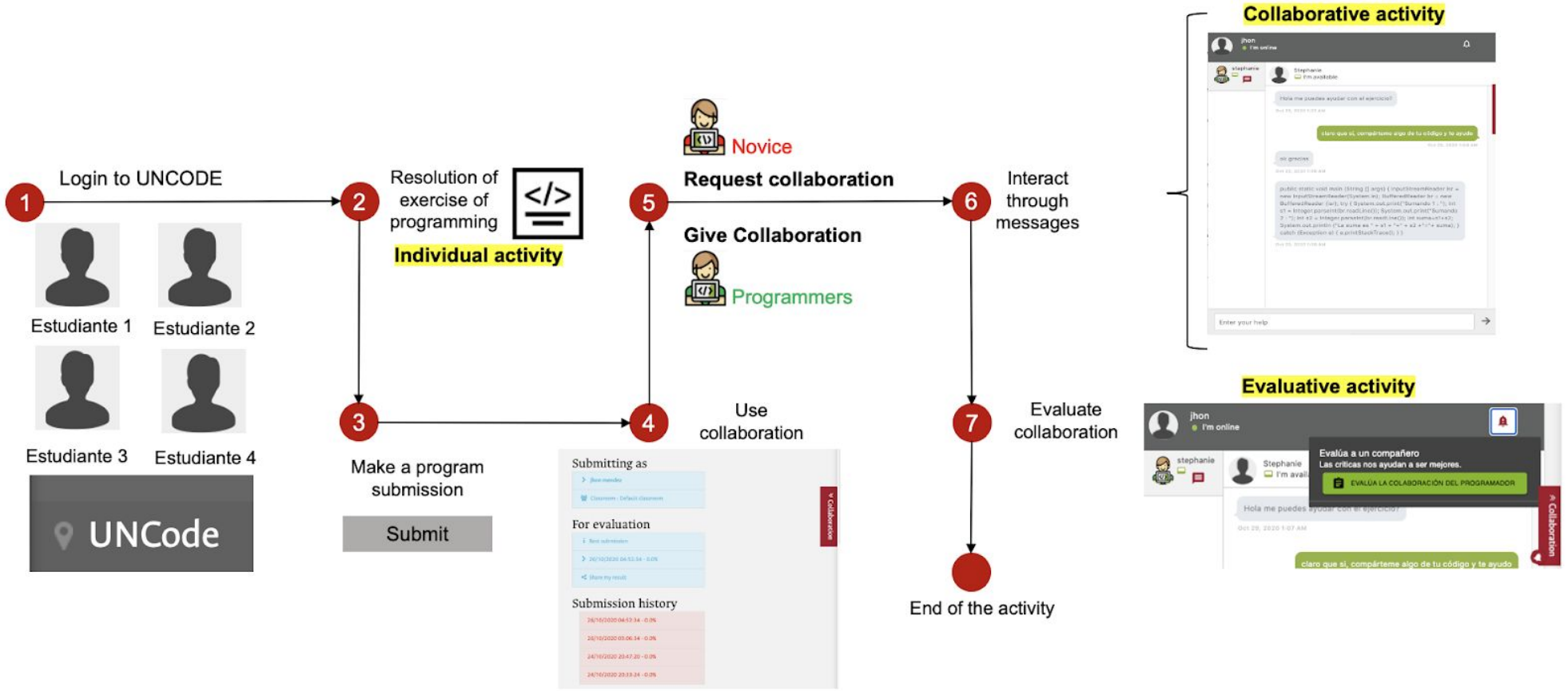

*source code available at:*
*https://github.com/jhonmendex/un_colab.git*

## Development of the collaborative environment: characteristics

- Formation of groups.
- Role assignment.
- Notification of task status.
- Synchronous and asynchronous communication.
- Collaboration evaluation


*Screenshot UNColab*

## Educational intervention



## Educational intervention

| Topic | Intervention #1 | Intervention #2 |
|---|---|---|
| | Control structures and functions | Arrays |
| Distribution of activities | • 20 minutes of individual activity<br>• 25 minutes collaborative activity<br>• 15 minutes of evaluative activity | • 20 minutes of individual activity<br>• 25 minutes collaborative activity<br>• 15 minutes of evaluative activity<br>• 15 minutes to fill out a perception survey |
| Aspects of collaboration | • To request collaboration, a student must have at least two attempts to solve the assignment.<br>• Once the student uses the collaboration option the system will notify if it is classified as "Programmer" or "Novice", according to his/her success rate in the exercise.<br>• The system will notify a partner when the collaboration assessment should be done.<br>• A "programmer" can help several "novices".<br>• A "novice" can receive collaboration from various "Programmers".<br>• The activity ends once the evaluative activity and the perception survey are completed. | |

## Participants and data collection

**Participants:** 27 first semester students of Computer Programming at the Universidad Nacional de Colombia.

### Quantitative data:

- **Number of "programmers":** number of students who solved the problem in the first two attempts.
- **Number of "novices":** number of students who did not solve the problem in the first two attempts.
- **Number of role changes:** students who eventually converted from "novice" to "programmer".
- **Number of collaborations:** number of groups that were formed to collaborate.
- **Number of messages:** number of messages made per collaboration.

## Participants and data collection

### Qualitative data

**Evaluation of the collaboration**

**Collaboration assessment survey for "Programmers"**

| # | Question | Answer option |
|---|---|---|
| Q1 | I consider that the collaboration given to my partner was useful to help him/her to improve his/her proposed solution to the programming problem. | ***Likert scale***<br>1.Strongly disagree<br>2.Disagree<br>3.Somehow disagree<br>4.Somehow agree<br>5.Agree<br>6.Strongly agree |
| Q2 | I consider that the collaboration given to my partner helped him/her to identify some errors in his/her proposed solution. | |
| Q3 | I consider that the collaboration given to my partner helped him/her to correct some errors in his/her proposed solution. | |
| Q4 | I believe that the collaboration provided allowed me to strengthen my knowledge about the topic of the problem. | |
| Q5 | What opinion do you have about the collaboration offered to your partner? | Open-ended answer |

**Collaboration assessment survey for "Novices"**

| # | Question | Answer option |
|---|---|---|
| Q1 | I consider that the collaboration received allowed me to improve my proposed solution to the programming problem. | ***Likert scale***<br>1.Strongly disagree<br>2.Disagree<br>3.Somehow disagree<br>4.Somehow agree<br>5.Agree<br>6.Strongly agree |
| Q2 | I consider that the collaboration received helped me to identify some errors in my proposed solution. | |
| Q3 | I consider that the collaboration received helped me to correct some errors in my proposed solution. | |
| Q4 | I consider that the collaboration received gave me more confidence to try to solve the programming problem. | |
| Q5 | What is your opinion about the collaboration received? | Open-ended answer |

## Participants and data collection

### Qualitative data

**UNColab students perception survey**

| # | Question | Answer option |
|---|---|---|
| Q1 | I consider that the UNColab tool was useful for solving programming problems in a collaborative way. | ***Likert scale***<br>1.Strongly disagree<br>2.Disagree<br>3.Somehow disagree<br>4.Somehow agree<br>5.Agree<br>6.Strongly agree |
| Q2 | I consider that the UNColab tool facilitated the communication with my classmates to solve the programming problem in a collaborative way. | |
| Q3 | I consider that the UNColab tool encouraged my participation in solving the programming problem in a collaborative way. | |
| Q4 | In general, what do you think of the collaboration tool UNColab? | Open-ended answer |

## Quantitative data UNColab

### Intervention #1:

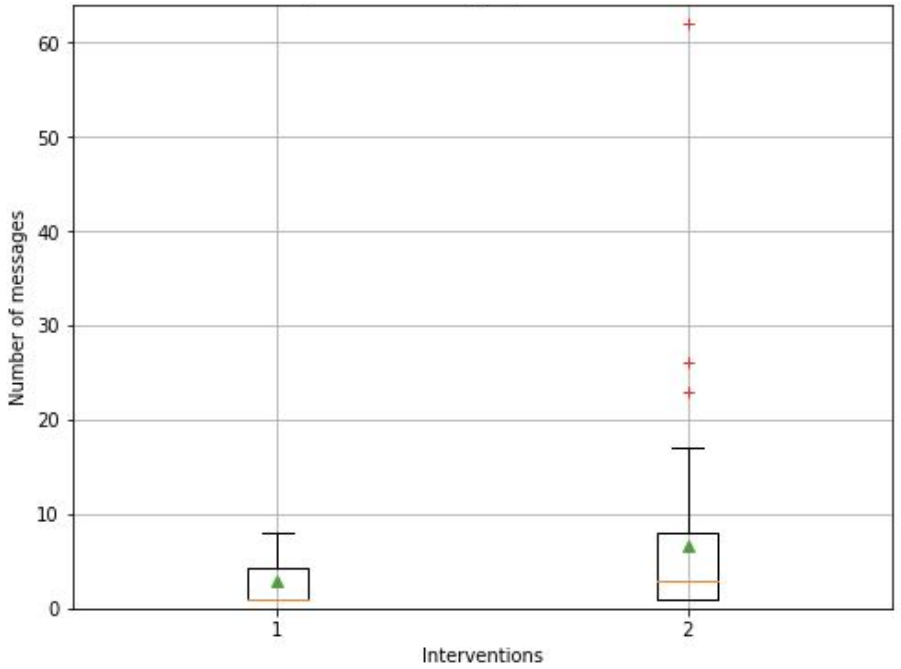
- 13 students managed to solve the exercise in the first attempts without requesting collaboration; the tool classified them as **"Programmers"** and 14 students as **"Novices".**
- Once the collaborative activity started, 6 students managed to change their role from **"Novice"** to **"Programmer".**

### Intervention #2:

- 12 students managed to solve the exercise in the first attempts without requesting collaboration; the tool classified them as **"Programmers"** and 15 as **"Novices"**
- once the collaborative activity began, only 2 students were able to change their role from **"Novice"** to **"Programmer"**.

## Quantitative data UNColab

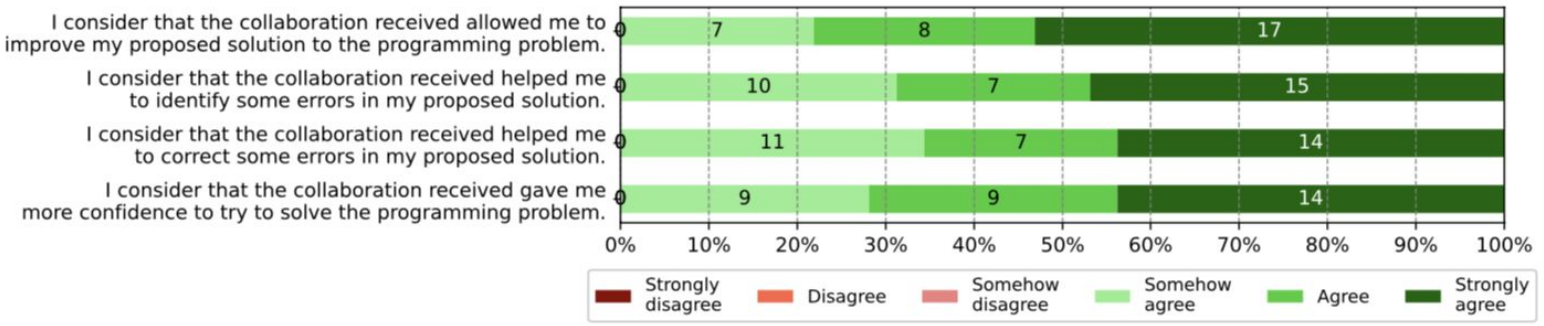
### Collaborations



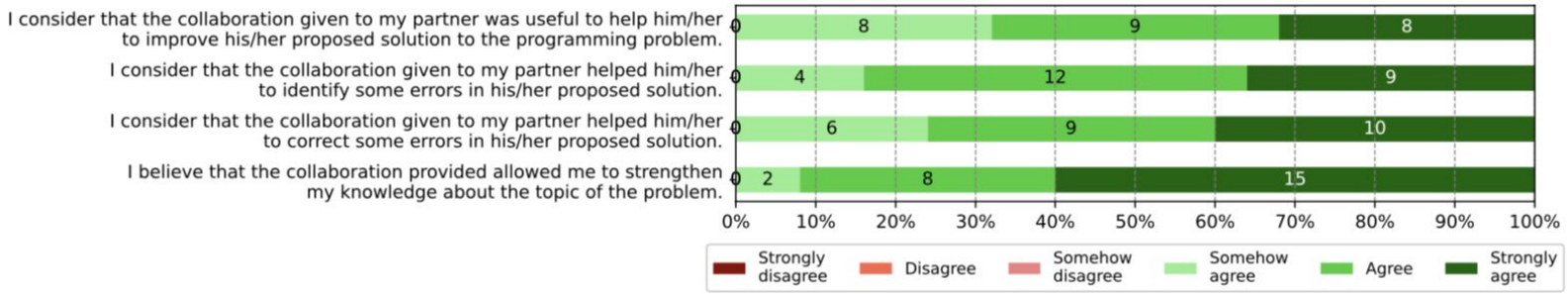

*Box Plots of messages per collaboration and intervention*

- **Intervention #1**
  - Average of messages: **3.0**
  - Standard deviation: **2.9**
- **Intervention #2**
  - Average of messages: **6.6**
  - Standard deviation: **11.0**

## Collaboration assessment



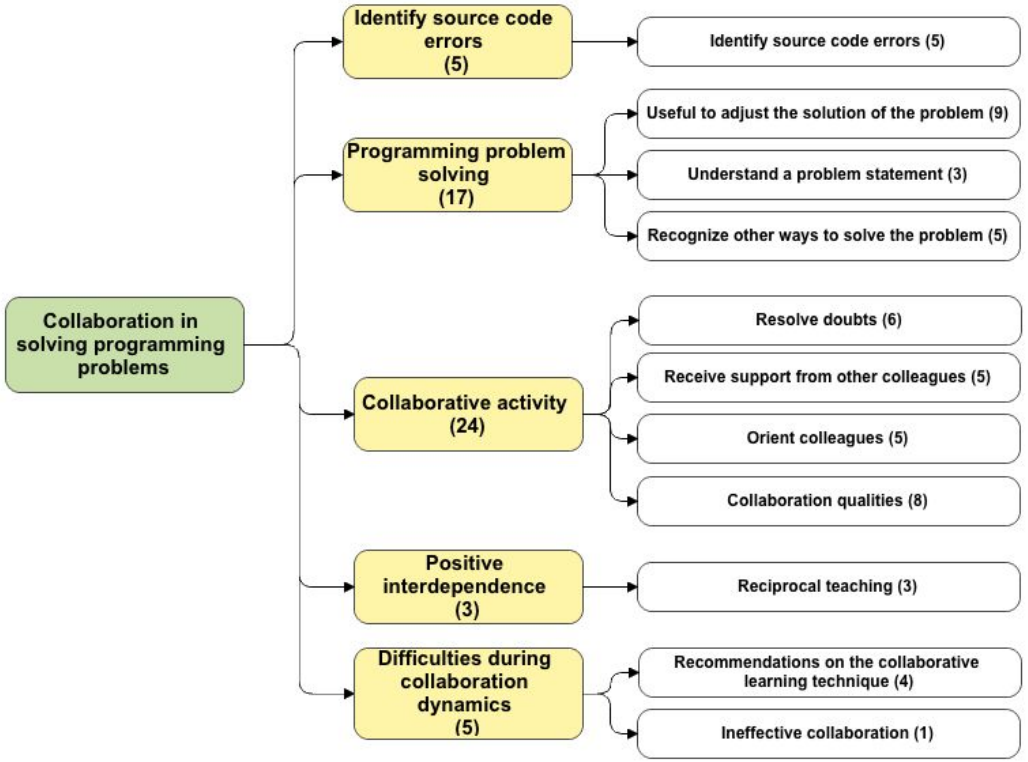

*Collaboration evaluation results from "Programmers"*




*Collaboration evaluation results from "Novices"*

*The 100% of the students perceived with some level of agreement that the collaboration given or received had been useful to improve the solutions of the programming problems, to identify and correct errors in the solution, to consolidate the knowledge in the evaluated topic and to improve the confidence when solving the problem.*

## Perceptions from the students' assessment of collaboration




*Perceptions from the students' assessment of collaboration*

*"Identification source code errors" allowed grouping comments related to the benefit students see in receiving help from a peer to identify errors in the source code directly.*

*"Programming problem solving" gathered comments associated with the usefulness of collaboration in understanding or finalizing an exercise.*

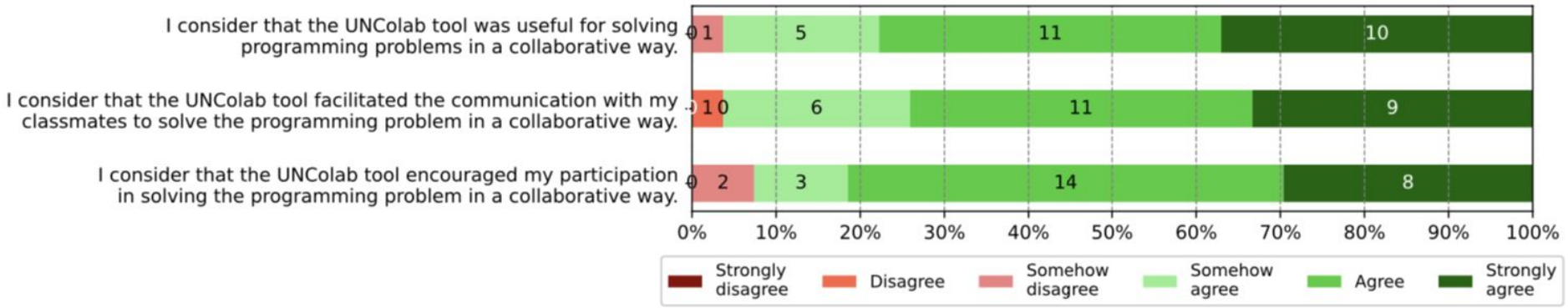
*"Collaborative activity" focused on capturing perceptions about the main features and advantages of collaboration that students identified.*

*"Positive interdependence" refers to perceptions involving reciprocal teaching; that is, students who stated that they learned something mutually through collaboration.*

*"Difficulties during the collaborative dynamic" captured some comments related to inconveniences during the dynamic established for the study.*

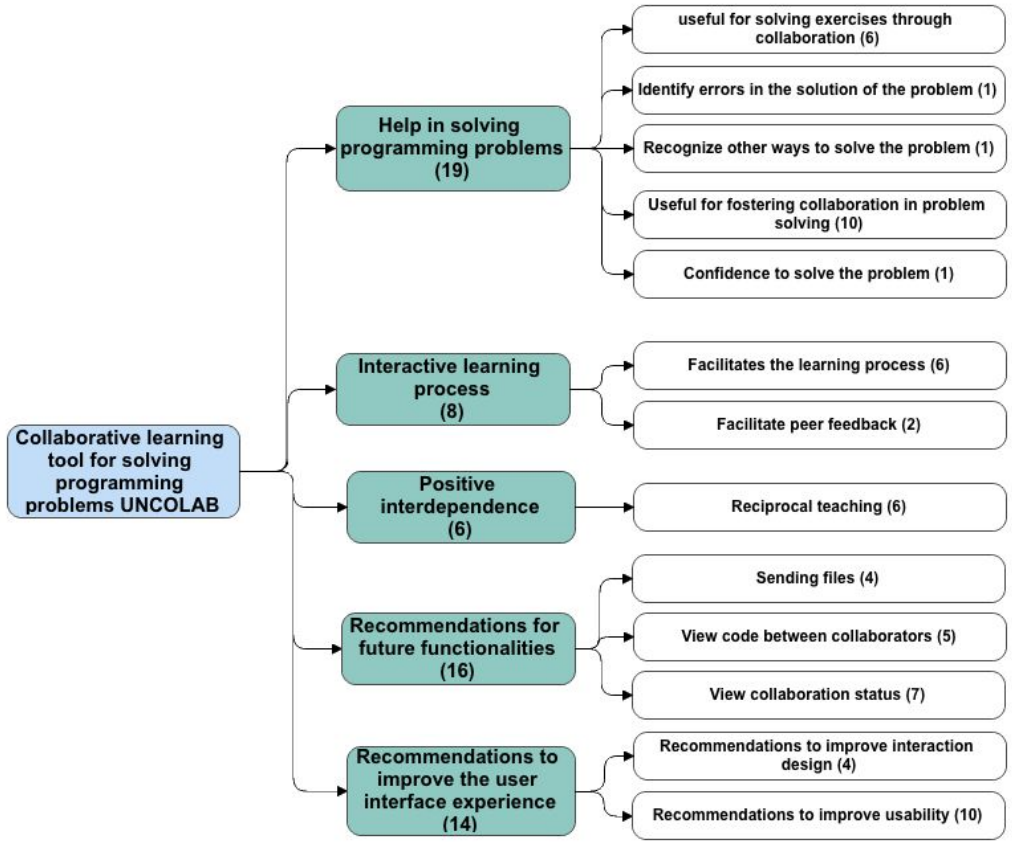
## Students' perceptions when using UNColab

More than the 92% of the students agreed with some level of agreement on the usefulness of the tool to solve problems collaboratively, the ease of communication between classmates for this purpose, and the utility of UNColab to encourage participation in collaborative problem solving.




*Students' perception with respect to the UNColab tool*

## Students' perceptions when using UNColab




*Student perceptions of UNColab*

"Help in solving programming problems" relates the opinions about the usefulness of the tool as a facilitating element when requesting help.

"Interactive learning process", comments were collected regarding the recognition of the tool as an aid in the learning process.

"Positive interdependence" gathers responses where a recognition of UNColab as a mediating element for reciprocal teaching is evident.

"Recommendations for future functionalities" captures opinions about ideas for new functionalities that students expressed that could improve the tool during collaboration.

"Recommendations to improve the user interface experience" relates aspects that can be improved to make the tool easier to use and have a better interaction.

## Discussion

- To answer the research question posed about the effects on programming problem solving when using UNColab, the results obtained at a quantitative and qualitative level were considered.
  - During the collaborative activity, UNColab facilitated the formation of 12 collaboration groups or pairs for the first educational intervention and 39 for the second; Likewise, it allowed the exchange of messages between these pairs during the time available to collaborate, achieving that at least each participant was able to establish communication with a peer and that in the second intervention some students made greater use of UNColab to establish constant communication with a collaborator at the time of solving the exercise.
  - The qualitative data related to the assessments of collaboration for both student roles ("Programmer" and "Novice") allowed identifying and corroborating aspects related to the advantages of implementing collaborative activities within the classroom, such as those expressed in (Vinagre Laranjeira,2016) who mentions the integration of students, reciprocal teaching and discussion of ideas as elements found when implementing CSCL tools.
  - The results of the interventions showed that 44% of the participants believe that a collaborative activity can help in the resolution of doubts and concepts related to a collaborator's orientation. The 31% of the participants state that collaboration is beneficial for the successful completion of a computer programming exercise. A 6% report opinions related to reciprocal teaching; which corroborates one of the advantages of the collaborative learning theory.

## Conclusions

- We have presented UNColab: a tool which supports the resolution of programming problems through collaboration among students.
- The experience of using UNColab in a computer programming course at the Universidad Nacional de Colombia was reported.
- The students' perceptions show that the use of this type of tools favors the teaching-learning of computer programming.

## Future work

- It is proposed as future work to carry out an analysis of the quality of the interactions carried out by the students and their influence on the resolution of programming exercises.
- Improve and add new UNColab functionalities, according to the suggestions given by the students.

# Thank you for your attention!

**In case of any questions, please contact the authors**

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