The impact of Covid-19 on university computer science students' collaboration: A case study

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Abstract

When students develop their academic activities in collaborative contexts mediated by technology, they manifest their behaviors through the interactions that are exchanged between the members of the different learning groups. The analysis of these interactions is one of the variables that teachers consider when measuring student performance. With the appearance of Covid-19 and the impossibility of developing face-to-face activities, a drastic and unexpected change took place in educational scenarios all over the world. Particularly in Argentina, the technology-mediated collaborative activities that students developed in combination with face-to-face classes were later carried out exclusively online. This study allowed to evaluate changes in the behavior and the performance of Computer Science students at a public university in Argentina by comparing the pandemic and pre-pandemic periods. The analysis of the results obtained, discriminated by gender, allowed to recognize a certain improvement in the behavior and academic performance of the students during the pandemic period.

Keywords

Computer-Supported Collaborative Learning, Behavior, Academic performance, Content analysis, Pandemic

1. Introduction

In a Computer-Supported Collaborative Learning environment students are organized in groups to work together in collaborative activities proposed by the teacher, and they use computer as a communication, collaboration, and coordination channel [1]. Working together implies that students constitute a learning group; that is, a structure formed by people that interact in a shared time and space to achieve specific learning results through the interaction between its members [2]. The term interaction is inevitably linked to the term collaboration because people interact when they communicate, collaborate, and coordinate. There are several factors (knowledge level, emotional status, liked or disliked activities, liked or disliked tools, etcetera) that could influence in the behavior of students within a learning group as well as in the way students interact with each other. There is no doubt that Covid-19 pandemic changed all aspects of people's lives, and the impact of Covid-19 on education in being studied around the world.

During 2000 and 2021 the national government of Argentine Republic adopted several measures to protect people health against the spread of Covid-19 virus. In first place the government stablished a strict isolation (Social, Preventive, and Obligatory Isolation- SPOI), and secondly a careful distancing (Social, Preventive and Obligatory Distancing-SPOD). These measures affected severely the Argentine

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Educational System and produced a drastic change in educational scenarios. The usual face-to-face classes were replaced by fully, unexpected, and challenging virtual classes. This change showed that neither teachers nor students were prepared for virtual classes.

The aim of this work was to analyze conversations of students to discover if collaborative behavior had changed because of pandemic, and to find out the impact of behavior changes on academic performance. To achieve this aim, interactions of university students were collected and analyzed during two periods: 2018-2019 (pre-pandemic) and 2020-2021 (pandemic). Genre and grades of students during the two periods were considered. All participants were 4th and 5th year students of Bachelor's in information systems at National University of Santiago del Estero in Argentina. This paper is organized as follows. In section 2 the step by step of this study is described. Then, the obtained results are discussed in section 3. In section 4, some related works are presented. Finally, some conclusions and further works are stated in section 5.

2. Material and method

The 42 small learning group that participated on this study were constituted by students of the following subjects: Data Base II, Artificial Intelligence and Cryptography. Students were randomly assigned to the groups and each group had an average of 3 members. During pre-pandemic and pandemic periods students worked for two weeks on the same kind of activities and they communicate through the forum tool of COLLAB2 application to solve a problem allocated by the teacher. Pre-pandemic and pandemic problems had identical characteristics and difficult level. To complete activities students had to create a final product (report or graphic) and the final product was built through consensus of opinions posted on the forum that each group had in COLLAB. Figure 1 shows a snapshot of dialogue between members of a group of students that participated on this study.
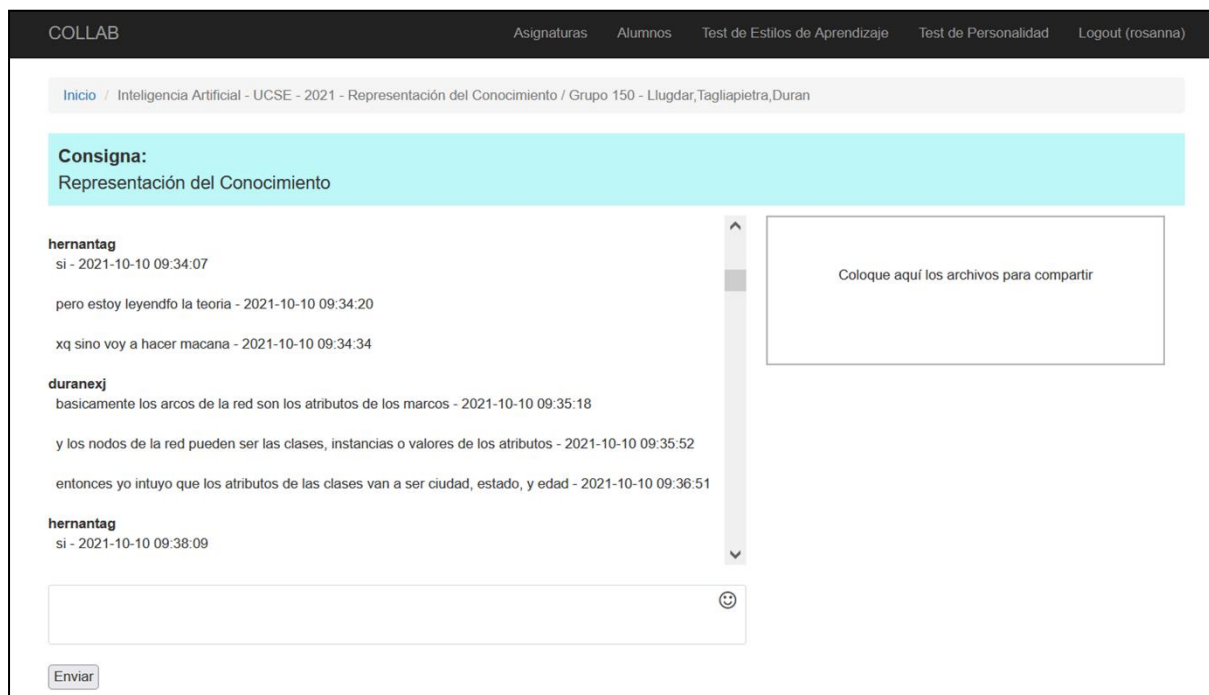

Figure 1: Portion of dialogue between students of a collaborative group.

As a result of collaborative activities between students, a total of 3.768 interactions were collected. 1.683 interactions took place during pre-pandemic and 2.085 during pandemic. Considering the gender of the author, interactions are distributed in the following way: 884 female interactions and 839 male

interactions in pre-pandemic, and 1.023 female interactions and 1.062 male interactions in pandemic. This way there are 4 subsets of data to be analyzed.

Pre-processing tasks were applied over the 4 subsets of data to improve the data quality. The first pre-processing task was stopwords removal, commonly used words (articles, prepositions, pronouns, conjunctions, etcetera) that does not add much meaning to a sentence were removed. The text mining software called GATE (developed by [3]) was used for stopwords removal and the result was registered on a spreadsheet. After stopwords removal each subset of data had 2.500 words in average. To the second pre-processing task the content of the 4 spreadsheet was analyzed by an online application3 to calculate the frequency of each word. Then, during the third pre-processing task morphological variations of a same word were identified and switched for a base mode. This pre-processing task changed the frequency of each word in the 4 spreadsheets. For example, in the spreadsheet of interactions posted by male students during pandemic there were 3 morphological variations of the Spanish word corresponding to professor: "profesor" (frequency 15), "profe" (frequency 18) and "profes" (frequency 11). These three morphological variations were replaced by the word "profesor", and its frequency was changed to 44. The last pre-processing task was concerned with removing words whose frequency was under 11. The lower limit of 11 was established after had analyzed the interactions and had discovered that words with a frequency under 11 did not provide significant information. At the end of pre-processing tasks there were: 92 different words used by female students and 159 different words used by male students during pre-pandemic, and 86 different words used by female students and 107 different words used by male students during pandemic. A fragment of the frequency table about preprocessed words for male students in pandemic period is showed in Figure 2.

FRECUENCY	WORDS
49	grupo
45	creer
44	rúbrica
44	profesor
41	drive
30	desarrollar
30	herramienta
29	realizar
29	sistema
28	alumno
26	agente
26	propuesta
24	wiki
23	coincidir
23	presentación
22	clase
22	feedback
22	poner
21	decir
21	ver
20	tema

Figure 2: Part of the preprocessed words frequency table for male students in pandemic period.

Once subsets of data were pre-processed, content analysis was applied over the content of 4 spreadsheets. The content analysis process followed the steps of the methodology suggested by Krippendorff [4]. Content analysis is a research technique that can be applied over texts in order to make replicable and valid inferences from texts to the contexts of their use. These inferences provide texts with a meaning. To guarantee that the results of content analysis can be replicated it is necessary

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3 (https://www.nubedepalabras.es/)

to ensure that no noise or extraneous influence has entered the process and polluted the data. Reliability calculation is required to be sure if noise has polluted the data [4]. Reliability data are usually obtained under test-test conditions: two or more analyst works independent of each other, yet they apply the same set of analysis categories to the same units of analysis (input data). Agreements and disagreements between analyst can be measure by the index α. The α reliability index indicates the degree to which a process of content analysis can be replicated by different analysts working under varying conditions, at different locations, or using different but functionally equivalent measuring instruments [4].

In this research reliability data were calculated under test-test conditions since two teachers, experienced in e-learning and group dynamics, tagged each word of dataset (analysis unit) with the conceptual content and collaborative skill that they considered the word was linked to. The term conceptual content is understood as all word related to specific knowledge of each subject, for example the word "Agent" is typical of Artificial Intelligence or the word "cryptosystem" that is related with cryptography. Regarding to collaborative skills, the two analysts considered the following categories proposed by Soller [5]: active learning, creative conflict, and conversation. When a student can disagree, to offer alternatives or to propose exceptions, the student is manifesting creative conflict skill; when a student is able to ask for information, opinions or clarifications, the student is manifesting active learning skill; when a student apologizes, shows appreciation, coordinates group process, or finishes participation on an appropriate way, the student is manifesting conversation skill.

The two-analysts or experts worked independent of each other and applied the same categories to the 4 subsets of words. The agreement level between analysts was very high as reliability index reached the value of 0.99. Despite α=0.99 surpasses the 0.80 recommended by Krippendorff [4] as minimum value for accepting the results of content analysis as reliable, there were disagreements when analysts classified some words. The two-analyst reviewed at the same time the words in conflict and resolved all disagreements. That way an alpha index α=1 was reached, and the final data set was made up of 394 words. The Figure 3 presents a section of the content analysis showing the categories assigned by experts.

FREQUENCY	WORDS	EXPERT 1	EXPERT 2
49	grupo	Concepto	Concepto
45	creer	Habilidad	Habilidad
44	rúbrica	Concepto	Concepto
44	profesor	Concepto	Concepto
41	drive	Concepto	Concepto
30	herramienta	Concepto	Concepto
30	desarrollar	Habilidad	Habilidad
29	sistema	Concepto	Concepto
29	realizar	Habilidad	Habilidad
28	alumno	Concepto	Concepto
26	agente	Concepto	Concepto
26	propuesta	Concepto	Concepto
24	wiki	Concepto	Concepto
23	presentación	Concepto	Concepto
23	coincidir	Habilidad	Habilidad
22	clase	Concepto	Concepto
22	feedback	Concepto	Concepto
22	poner	Habilidad	Habilidad
21	decir	Habilidad	Habilidad
21	ver	Habilidad	Habilidad
20	tema	Concepto	Concepto

Figure 3: Part of the content analysis on the preprocessed words for male students in pandemic period.

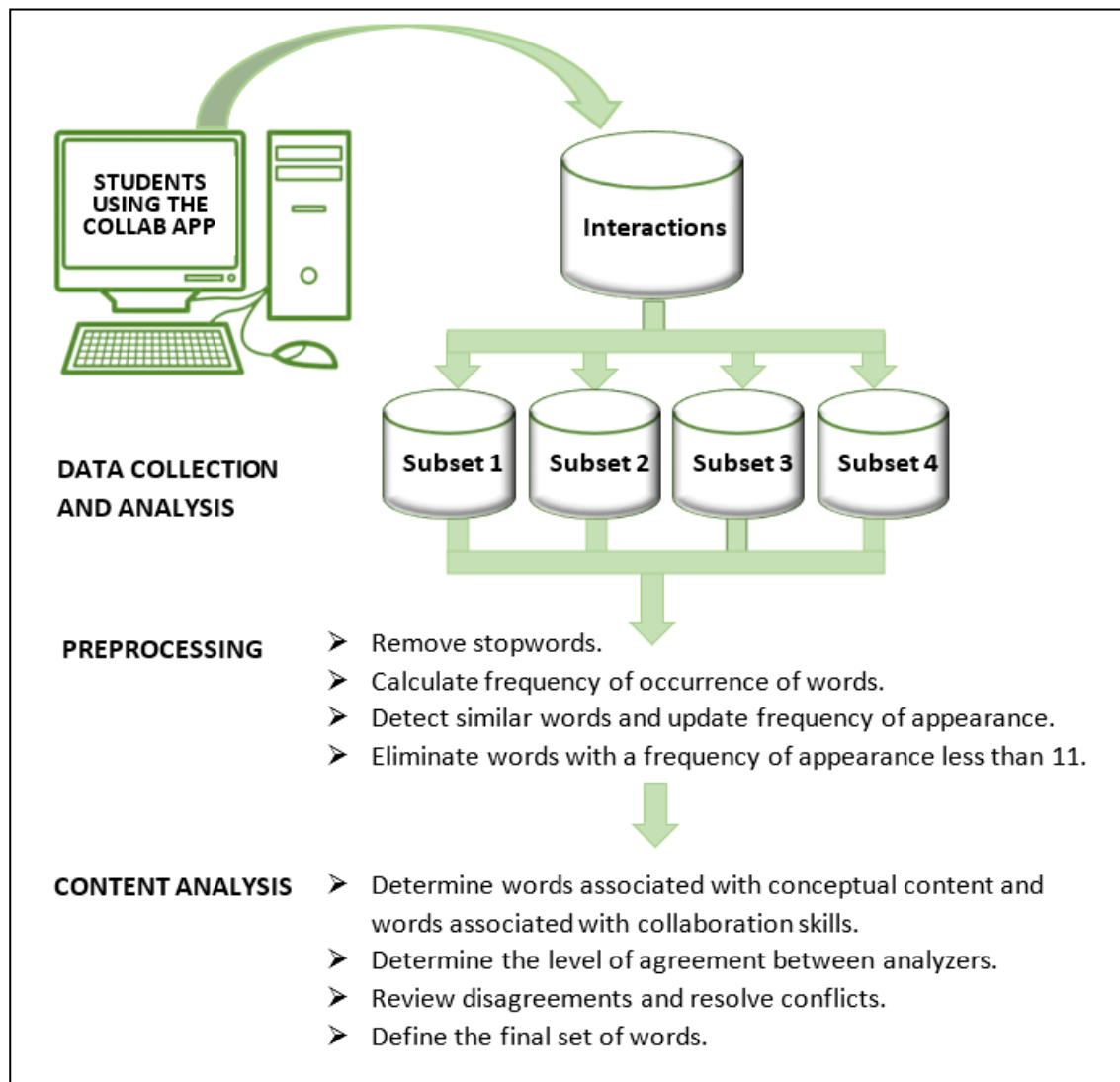Figure 4 summarizes in a graphic the steps followed from the collection of interactions to their analysis.

Figure 4: Sequence of activities to analyze group interactions

3. Results y discussion

Finally, 237 words out of 394 belonged to male students and 157 to female students. For male students 31% of the 100 words posted during pandemic were related to conceptual content and 69% related to collaborative skills. Regarding to pre-pandemic, the 137 words posted by male students were distributed on the following way: 27% conceptual content and 73% collaborative skills. Figure 5 shows the distribution of words during pre-pandemic and pandemic periods.

Female students generated a set of 157 words, 79 during pandemic and 78 during pre-pandemic. The 37% out of words published in pandemic were associated with conceptual content and the remaining 63% was tagged as collaborative skills. In pre-pandemic the situation was different as 28% of words indicated conceptual content and 72% manifested collaborative skills. Figure 6 shows the distribution of interactions of female students in pandemic and pre-pandemic.
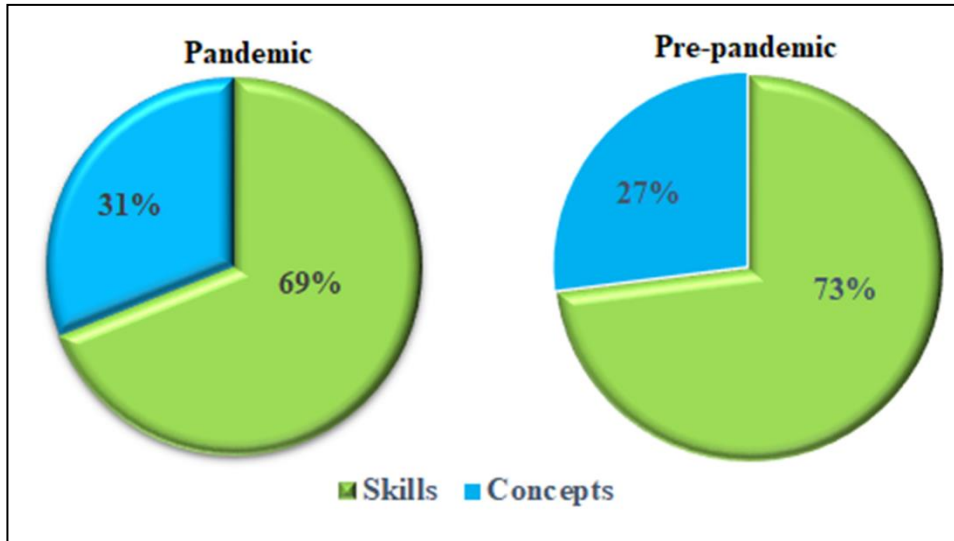
Figure 5: Percentages of concepts and skills identified in interactions of male students
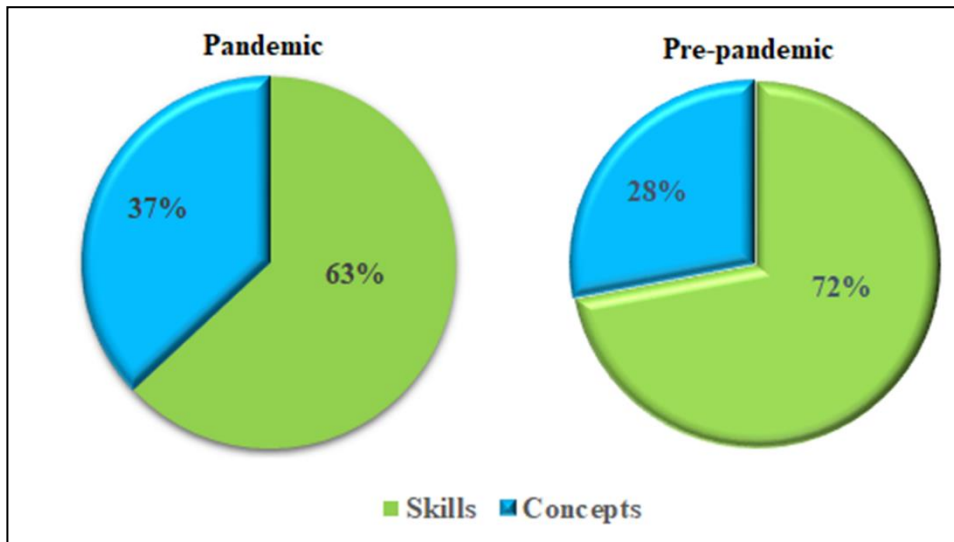

Figure 6: Percentages of concepts and skills identified in interactions of female students

Interesting discoveries can be made when considering the grades that teachers assigned. In pre-pandemic as well as pandemic teachers evaluated groups through the evaluation scale of "excellent", "very good", "good", "fair" and "poor".

As it is showed in Figure 7, the percentage of male students graded as "excellent" during pandemic (37%) far exceed the amount of male student graded as "excellent" during pre-pandemic (13%). On the other hand, the number of male students with "very good" grade was 16% higher in pre-pandemic than in pandemic. Regarding to "good" grade, there was no significant difference between two periods, 16% in pandemic and 13% in pre-pandemic. The number of students with "fair" grade was noticeably lower during pandemic (7%) than the number recorded during pre-pandemic (18%). No "poor" grades were recorded in either period. Considering that a satisfactory academic performance could be represented by "excellent" and "very good" grades, could be stated that 77% of male students had a satisfactory performance during pandemic and 69 % during pre-pandemic. These numbers show a certain positive difference in favor of the pandemic period. If "good" and "fair" grades are considered as evidence of deficient academic performance, it could be stated that deficient academic performance was mainly

observed in pre-pandemic period. Unsatisfactory academic performance was not recorded in any periods since there were no "poor" grades.
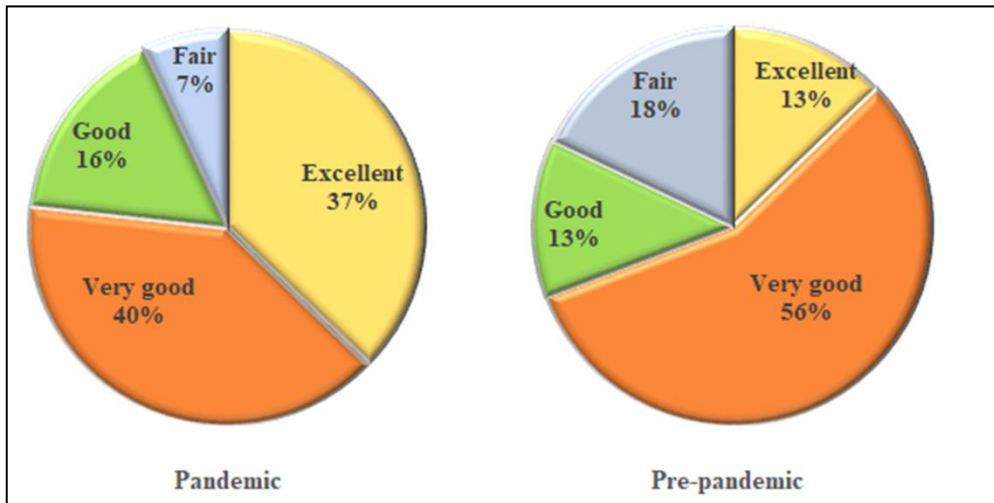

Figure 7: Grades assigned to female students and their percentages

The performance of female students can be observed in Figure 8. The number of "excellent" grades changed considerably from a period to the other as 52% of female student reached "excellent" during pandemic and only 44% in pre-pandemic. Considering the "very good" grade there was no significant difference between two periods, 26% in pandemic and 28% in pre-pandemic. Students that were graded as "good" represented 22% during pre-pandemic and this number decreased to 13% in pandemic; while the number of "fair" grades in pandemic was 4 point higher than the number of "fair" grades recorded in pre-pandemic. There were no students with "poor" grade in either period. If "excellent" and "very good" grades define satisfactory academic performance, Figure 8 shows that in pandemic 77% of female students had satisfactory performance while in pre-pandemic the satisfactory performance represented 72%. These numbers demonstrate a certain positive difference in favor of the pandemic period. Considering that "good" and "fair" grades define deficient academic performance, 23% of female students were rated as deficient performance in pandemic and 28% in pre-pandemic. This confirm the positive difference in favor of the pandemic period that was detected when analyzing satisfactory performance. No unsatisfactory performances were recorded because there were no students with "poor" grades.
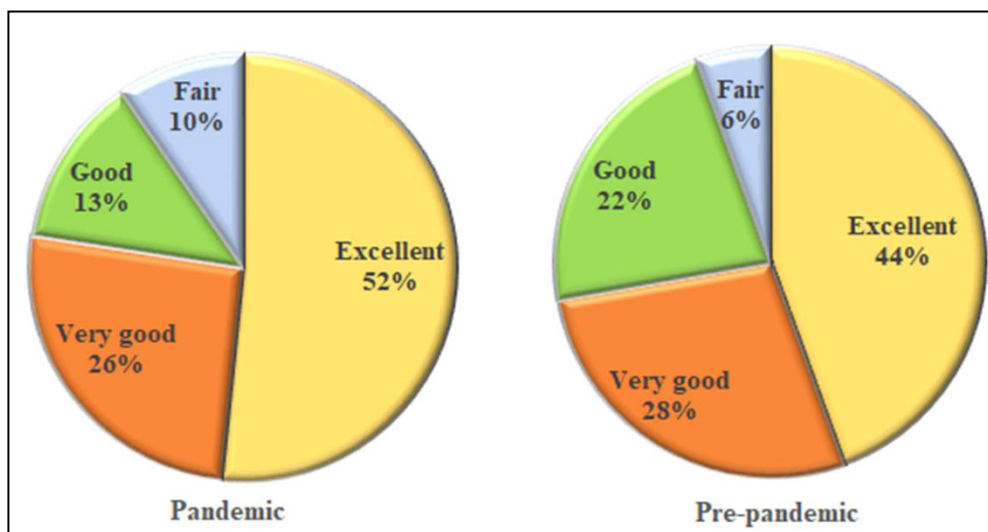

Figure 8: Grades assigned to female students and their percentages

4. Related works

Professors from different universities have modified their classes with curricular innovations because of COVID-19 pandemic and have evaluated their impacts. This section presents some of these related works describing such curricular innovations.

Area-Moreira et al. (2020) describe an experience at Universidad de La Laguna (Spain) where a blended learning classes were designed for a distance modality. Students had to choose one of two learning itinerates: the first itinerary was based on group and project learning, and the second itinerary was individual and based on learning by topics. The two itineraries included the same topics and skills to be achieved. In both itineraries students had a virtual classroom and remote classes throughout Google Met. Students could ask questions by e-mail or forums. At the end of the experience students answered a survey. Considering the results of survey and the performance of students, Area-Moreira et al. (2020) evaluate their innovation as successful.

Castro et al. (2020) worked with students of Immunology, and they incorporated videos (recorded classes), assignments to complete in the virtual classroom, remote synchronous meeting (Zoom platform), problem-based learning, gamification and flipped learning. The authors pointed out that videos and some assignment caused tiredness, lack of attention and mistakes on students since they were very extensive. However, the authors highlight that most of the activities were positive, motivating, and encouraged students to use specific technical vocabulary.

Professors of mathematic at the Engineering Faculty of Universidad Nacional de La Plata (Argentina) worked with Google Classroom as virtual classroom, Zoom and Webex platforms for remote meeting, Jamboard and Microsoft Whiteboard as virtual blackboard, and the open software called GeoGebra for solving assignments (Del Río et al., 2020). In spite of evaluating the experience with a survey, the authors do not explain results or measure the impact on students learning.

Moreno-Correa (2020) describes the innovations made in following subjects at the Faculty of Health Sciences of the Pontificia Universidad Javeriana Cali (Colombia): Infections and Immunity of the Medicine degree, and Immunology and Infections of the Nursing degree. The author used active learning throughout flipped classroom. Students had to deliver activity guides to be revised by teachers and all activities were recorded in a virtual classroom in Blackboard. Moreno-Correa states that a survey to gather the opinions of the students would be conduct, yet he does not provide the results of processing the survey and he does not analyze the impact on students learning.

Llorens-Largo et al. (2021) implemented project-based learning in a subject of the Multimedia Engineering at the Universidad de Alicante (Spain). The first part of the subject was developed face-to-face, but in the second part the virtual modality was adopted because of pandemic. In the virtual modality the authors used videos to explain the theoretical content, videoconferences to answer questions of students, and video-streaming for students to present their work. Authors conduct an opinion survey for each modality of classes (virtual and face-to-face) and students expressed their satisfaction with both modalities. Llorens-Largo et al. states that the performance of the students was similar in both modalities.

Lacave and Molina (2021) designed a cross-sectional pilot study to explore, from both social and technological points of view, how students carried out their group programming activities during the pandemic period. The authors indicated that the students adopted a programming model based on work division or distributed peer programming, and very few made use of synchronous distributed collaboration tool. However, no significant differences are detected in the students' needs between pre-pandemic and pandemic period.

5. Conclusions

This paper described a comparative study of interactions and academic performance of Computer Science university students along two periods: pre-pandemic (2018 and 2019) and pandemic (2020 and 2021). Results were discriminated by gender: male students and female students. The study considered the content of interactions recorded while students used COLLAB as a communication tool to complete

collaborative activities. Pre-processing tasks and the content analysis technique were applied on set of interactions collected in pre-pandemic and pandemic. That way the percentage of conceptual content and collaborative skills identified in group interactions was defined. The results pointed out that there were no significant changes in the behavior of male students. However, female students showed a greater willingness to focus dialogue on interpersonal relationships instead of conceptual content.

The grades assigned to the students and the academic performance of both genre (male and female) was analyzed to compare pre-pandemic and pandemic. The analysis showed an improvement of academic performance during pandemic, and this improvement was noticeable in male students.

When analyzing the relationship between behavior of learning groups (conceptual content and collaborative skills) and academic performance, it seems that pandemic had a positive effect on dynamic of learning groups regardless of the gender of group members. A possible explanation of this positive effect can be found on the features of students that participated on this research: university students of Computer Sciences are used to utilize technology for doing their academic activities and it is possible that the drastic transition to virtual classes far from being conflictive, was beneficial. Furthermore, at the end of classes all students stated that virtuality and isolation due to pandemic led them to allocate more time to academic activities. The increase on the time spent on academic activities is probably one of the causes of the improvement in performance during pandemic.

The findings of this study are original and contrast with those obtained by other researchers, as can be seen in the section on related works. On the other hand, it is worth noting that no studies have been found that focus on assessing the impact of the pandemic on students' collaborative interactions, analyzing their skills, concepts, and academic performance.

In conclusion, this research provides relevant information on the impact of COVID-19 pandemic on teaching and learning processes when these processes are supported by computer and based on collaborative activities. However, results should be careful considered because they might not directly apply to other academic disciplines. It is well known that features, preferences, and skills of students change from one discipline to other. In near future the impact of COVID-19 pandemic on teaching process and collaborative learning process will be evaluated, yet this time the research will focus on students of Computer Sciences of other universities. In the medium term, an attempt will be made to analyze the interactions considering variables such as emotional states of the students, preferences regarding activities, and preferences regarding tools.

6. Acknowledgements

7. References

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