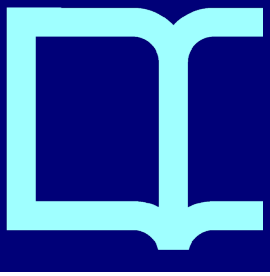

# Game Learning Analytics of Instant Messaging and Online Discussion Forums in Higher Education


## Abstract

Purpose: With the growth of digital education, students increasingly interact in a variety of ways. The potential effects of these interactions on their learning process are not fully understood and the outcomes may depend on the tool used. This study explores the communication patterns and learning effectiveness developed by students using two basic synchronous and asynchronous communication tools in e-learning environments, specifically business simulation games.

Design/methodology/approach: We conduct a quasi-experiment research with 478 online business students, 267 of whom used online discussion forums and 211 interacted via an instant messaging app. The application of learning analytics and text mining on natural language processing allows us to explore the student communication patterns with each of tools and their effectiveness in terms of learning.

Findings: Our results confirm the complementarity of the communication tools, asynchronous tools being especially the suitable for task-related communication and synchronous ones for speeding up and facilitating student social interactions.

Originality: The main value of this research lies in the use of data analytics and text mining to access and analyse the content of student interactions to assess the learning process in greater depth, comparing synchronous and asynchronous learning modes, considering that little is known about the impact of online synchronous interaction or instant messaging, and even less about the different features, content, and performance that emerge when these two learner interaction modalities are compared.


**Keywords**: online messaging apps; online discussion forums; game learning analytics; data mining; higher education

## 1. Introduction

Digital education, understood as current online educational practices, is projected to surpass 243 billion U.S. dollars worldwide by 2022 (The Statistics Portal, 2017). It has growing support from educational institutions, teachers and students, who show their willingness to support digital education models and embrace digital learning technologies. As a result, e-learning and hybrid blended models have become essential in the learning pedagogical design (Jones et al., 2007).

In the current situation, dominated by the health outbreak provoked by COVID-19, the measures adopted to face this challenge have disrupted education. Governments worldwide have encouraged workers in different economic sectors to stay at home and develop, if possible, telecommuting solutions to avoid community spread of the virus and the collapse of the healthcare systems (Schade *et al.*, 2021). Schools at all educational levels and higher education institutions have experienced different measures that imply total and partial closures (Grooms and Childs, 2021), in an attempt to contain the pandemic, affecting millions of learners enrolled from pre-primary to upper-secondary education, as well in tertiary education programs (Chen *et al.*, 2021). Given this threat, distance learning solutions have been emphasized to minimize the educational disruption and to facilitate the continuity of learning (Dincher and Wagner, 2021; Oloyede *et al.*, 2021).

Digital education, rooted in the use of the Internet and web-based technologies, offers a toolbox that complements traditional educational methods, where students are mostly passive learners (Dufresne *et al.*, 1996), and facilitates new roles, ways of functioning, and outcomes, motivated by a more interactive student-based teaching-learning process (Author *et al.*, 2019, 2018). Communication platforms emerge as a fundamental resource that promotes not only teacher-student and student-student learning interactions, but also teacher-student content interactions (Cheng and Chau, 2016).

Promoting such interactions carries educational benefits as it shifts the focus towards students, who may enrich their learning through applying a constructivist approach, take responsibility for their own knowledge construction, and collaborate with their peers (Lonn and Teasley, 2009).

Interactivity, however, also implies challenges. Firstly, there is some scepticism regarding its unequivocal effectiveness in improving learning (Author *et al.*, 2019; Lonn and Teasley, 2009). Only few studies have addressed this field and their findings have differed. Some studies claim a positive association of interactivity with learning results while, in others, the association is negative (Kent *et al.*, 2016). There are also scholars who find little difference, either in terms of quality or quantity, in the learning results (Picciano, 2002).

Secondly, interactivity has hitherto been treated from an excessively quantitative view (Schellens *et al.*, 2007), which offers only a partial view that needs to be complemented with additional information on the quality and contents of student interactivity (Author and Author, 2018; Lonn *et al*., 2011). Data analytics and text mining help in accessing the content of student interactions in the course of the learning process, and analysis of the data collected allows us to assess the process in greater depth (Alonso-Fernández *et al.*, 2019a; Alonso-Fernández *et al.*, 2019b).

Finally, although much previous research has analysed synchronous and asynchronous learning modes, there is still a need for evidence when it comes to comparing the two in terms of i) communication patterns (Kubasko *et al.*, 2008), ii) their contribution to students' knowledge and learning performance (Lim, 2008), and iii) the content of the learners' interaction itself. Although online asynchronous interaction has been quite widely researched (Lim, 2008), little is known about the impact of online synchronous interaction or instant messaging, and even less about the different features, content, and performance that emerge when these two learner interaction modalities are compared.

These major challenges motivate the main objective of the present study, which consists in analysing the communication patterns and learning effectiveness related to the use of two basic synchronous (instant messaging app) and asynchronous communication (online discussion forums) tools, in digital educational environments, specifically in a business simulation game.

The analysis of the different features of the communication patterns that characterise synchronous and asynchronous communication tools, as well as the content profile detected in student communications when using both of them, will provide evidence-based recommendations for improving communication in online education, and a better understanding of its impact on learning outcomes.

## 2. Literature Review

### *2.1. Learning outcomes of learner interactivity*

The social constructivist learning theory highlights the role of social interactions in promoting knowledge construction (Karahan and Roehrig, 2015; Kent *et al.*, 2016). This theoretical framework presents learning not just as a cognitive individual process, but as a social and cultural process developed through human relationships and activities, so what is learned is influenced by the social practices and interactions of learners (Kent *et al*., 2016). The relevance of the social component in the learning process emerges as much as interaction impacts include engagement, teamwork, analysis, coordination, negotiation, problem-solving, and reflection, all of them relevant ingredients for sharing and constructing knowledge and skills (Boticki *et al.*, 2015; Kent *et al.*, 2016).

The study of the effects of learner interactivity at an educational level has attracted the attention of previous research, but there is no clear consensus on its impact on student learning results (Adeyinka and Abdulmumin 2011; Wei *et al*., 2015). Some studies have highlighted a positive link between learner interactivity and results, highlighting that when this interaction is impeded the educational achievements are limited (Hodkinson and Poropat, 2014). These include Wei *et al*. (2015) who pointed out that students with frequent access to an online platform and with more interactions showed improved learning. This positive association could be explained by the exchange of ideas that human beings need and enjoy, the creation of an environment where learners test their attitudes, choices and reactions against peers and tutors (Jones et al., 2007), and the creation of learning communities with positive effects on learning outcomes (Chaparro-Peláez *et al.*, 2013). Boticki et al. (2015) also found that the quantity and quality of student interactions were related to better exam results. Likewise, Yueh *et al.* (2014) noted that both instructors and learners agreed on improved interaction leading to a better sense of a learning community, a reduction of isolation, and an improved performance. These results are similar to those of Wang and Walker (2013), who remarked that collaboration increases engagement, which is correlated with greater learning achievements. Pee (2019) also pointed out that the sharing of solutions in the interaction of students enhances cognitive learning. Interactions, especially between international students, have been proved important to the development of global competence, essential in globalised workplaces (Zou and Yu, 2019).

Other studies, however, have opposing findings. For example, in their study on online discussion posts, Song and McNary (2011) found multiple topics in student conversations and no correlation between the number of posts and overall student marks. This result was provoked by finding that the posts' content was frequently unrelated to the specific learning objectives of the course. Picciano (2002), also found an inconsistency between the posting on discussion boards and performance related to the courses' goals, although the reasons behind these findings were not explored. More recent studies emphasise this lack of connection between learner interactivity and either the students' perception of their learning (Chaparro-Peláez *et al.*, 2013) or competences such as commitment and teamwork (Iglesias-Pradas *et al.*, 2015). These findings may be justified in various ways, such students sometimes preferring more individual, self-directed learning styles, or their perception of interaction as an inherent element of how they learn (which reduces its relevance as a predictor of perceived learning).

These studies also highlighted the excessive relevance given to quantitative measures in describing the characteristics and functioning of interactivity, especially since the proliferation of online learning environments, learning management systems, and web-based distance education, has facilitated the integration of learning analytics to

better understand the learning process of students (Koç, 2017). The most-used metrics were number of logins, posting frequency, number of read messages, and messages lengths (although other metrics also exist). This quantitative approach measures learning performance mainly by course marks.

The inconsistent findings and gaps encourage a continued exploration of the impact of learner interactions on their learning which should also include qualitative measures of interaction and learning achievement.

### *2.2. The effects on learning of synchronous and asynchronous communication tools*

Interaction in online learning revolves around a variety of communication modes (Madden *et al.*, 2017) but, basically, these can be classified into synchronous and asynchronous (dos Santos and Cechinel, 2019).

Previous research on both types of interaction at an educational level has been focused on better understanding their characteristics and roles (dos Santos and Cechinel, 2019). Scholars have generally considered the two types as complementary (deNoyelles and Raider-Roth, 2016; Muniz-Solari and Coats, 2009), because both support collaboration. Mostly, they are considered together, without remarking on the differences between them and their different purposes (Meyer, 2015; Wang and Walker, 2013; Yueh *et al.*, 2014). A few studies, however, do contrast their differences and suitability.

Some of these studies have emphasised the different characteristics and features of communication patterns in synchronous versus asynchronous mode. For example, the study conducted by Alario-Hoyos *et al.* (2018) analysed learning interaction tools when running MOOCs in terms of time spent and accesses, and found that in the case of synchronous modes the use of the tool is concentrated in shorter periods of time but the accesses to the tool were higher. Similarly, Sere *et al.* (2011) pointed out that a higher percentage of social interactions occurs in synchronous rather than asynchronous modes, while students spend more time in task-oriented interaction in asynchronous discussions.

Analyses of the preference for one specific form of communication over the other, sometimes explained by the user type, are also found in the literature. For example, dos Santos and Cechinel (2019) noted that, although both forms received good ratings assessments, students and supervisors preferred asynchronous forms of communication. Hampton *et al.* (2017) studied the preferences of students and teachers in online nursing courses by considering different modes of synchronous and asynchronous tools (videos, narrated PowerPoint presentations, Adobe Connect education sessions, article readings, e-mails, wikis, simulations/games and case studies). They found that the most engaging method depended on the students' generation (Baby Boomer, Generation X or Millennial). Smithson *et al.* (2012) demonstrated in their study on mental health system that synchronous formats of participation encouraged the users more, while professionals showed a preference for asynchronous formats.

Although the characteristics and features of interaction, as well as user satisfaction and preference are important, they do not directly predict outcome success in terms of learning (Nowak *et al.*, 2009). Most previous analyses of learning outcomes of synchronous and asynchronous interactions are of the latter (Kim *et al.*, 2018; Lim, 2008). Few studies have analysed synchronous modes or have conducted comparison studies between them. There are only some exceptions, which are basically focused on comparing the impact of synchronous and asynchronous communication tools on cognitive and knowledge construction, considering the learners level of experience (dos Santos and Cechinel, 2019), their attitudes towards the use of the Internet and web-based learning

(Korkmaz, 2013), or their characteristics and competences, for example in the use of language (Korkmaz, 2013). In addition, the exploration of the learning outcomes would benefit from the use of data analytics, mostly neglected by previous research, to analyse the contents of learners' communication and not only be focused on quantitative indicators of their communication.

The scarce research justifies the need of more evidence to reach a better knowledge of the contribution of both types of interactivity in terms of learning results. The theoretical foundation of this study relies on the social constructivist learning theory, which has been shown as a valuable approach to understand the effects of social relationships on learning outcomes, emphasising that relevant learning occurs through the interactions of social and educational experiences (Koç, 2017). The social construction of learning underlines that the learning results are largely influenced by the participation in different communities, that could be identified by their communication mode. It means that the different ways of interactivity may determine what is learned, given the social practices, the different patterns and contents that communities, using different communication modes, may develop (Cole, 1996).

Based on these assumptions, this research aims at responding three questions:

RQ1: What are the learning results of students using synchronous and asynchronous communication?

RQ2: What are their communication patterns using these tools?

RQ3: What is the content profile of their communication when using these tools and its relationship with learning?

## 3. Methodology

### *3.1. Data collection*

The participants of our research were students of the Universitat Oberta de Catalunya, an online higher education institution of Spain, who were studying business and management courses at bachelor level. Data from seven academic years were retrieved (2011–2012 to 2017–2018 inclusive). The selected students were participants in the non-compulsory course "Business Simulation and Practice". This was a 4 month-long course that required the participation of students in a business simulation game.

The game chosen was Cesim Global Challenge (www.cesim.com), a strategy and international business management simulation, where student/player teams have to manage a simulated international telecommunication enterprise. Participants, organised into teams of an average of five students, manage a global technology company that operates in three regions with varied customer preferences, growth rates, and economic conditions. The teams have to compete, planning and implementing demand-supply strategies for the three markets and two production areas, making decisions on different functional departments, that include research and development, international taxation, corporate social responsibility, human resources, logistics, and finance. The game is organised into rounds that simulate economic periods, so after each one, the players will have updated information to assess the financial and economic implications of the strategic and operational decisions made by all the teams. This information constitutes a valuable feedback that players need to analyse, together with the market conditions provided each round, to make the decisions for the next round or economic period. The game provides an experiential learning scenario based on global businesses and the operations of management-related functional areas, while developing generic

competences in decision-making, teamwork, communication, and problem solving, relevant to foster entrepreneurial capacity (Thanasi-Boçe, 2020).

The game consisted of eight rounds, one a week, and was played completely online, without face-to-face interactions among players, which promoted the use of different interactivity modes.

For the purpose of this study, a quasi-experiment research was conducted, where the teachers offered only one communication mode to each course, and students chose voluntarily whether or not to participate using it. These communication tools were either asynchronous, through the online discussion forum provided by the game; or synchronous, using an instant messaging app. Specifically, the teachers decided to use Telegram, which is a free cloud-based instant messaging service whose the client-side code is open-source software. Telegram allows creation of a Telegram Bot access and record the communication within the teams using this tool. The students were informed about this, and whether or not to participate in the experiment, using the instant messaging app, the online discussion forums, or none of them, knowing that no personal data would be used and that all the information retrieved would be treated anonymously and only for academic research purposes.

The participation ratio of the students was very high, especially in the courses where the interaction mode proposed was the instant messaging app, which exceeded 94%, and reached 81.9% in the courses where the communication mode was the online discussion forum. The Mann-Whitney U test confirmed that there were no significant differences in the grade levels of students who decide to take part or not in the experiment ($U = 6.876$, p value = .562), as well as in the main financial indicator of the game, the total cumulative shareholders' return ($\chi 2 = 11.367$, p value = .854).

From a total population of 551 students, the final sample was composed of 478 (267 using online discussion forums and 211 using the instant messaging app); distributed among 106 teams (63 using online discussion forums and 43 using the instant messaging app); and playing in 13 different competitions (9 in the case of the online discussion forums and 4 in the case of the instant messaging app). Teams were composed of an average of 4.24 members in the case of the courses using online discussion forums (ranging from 2 to 6 students), and an average of 4.9 members in the courses where the instant messaging app was used (ranging from 4 to 6 students). Likewise, 213 students were female (44.56% of the sample, 117 in the online discussion forums courses and 96 in the instant messaging app courses) and 265 were males (55.44% of the sample, 149 in the online discussion forums courses and 116 in the instant messaging app courses). The average age of students was 31.40 years in the online discussion forums courses and 30.8 in the instant messaging app courses.

### *3.2. Measurement of variables*

Learning outcomes and results were measured through quantitative indicators in a first phase, which included their grades or marks (Marks) in the course that integrates the business simulation game, as it has been frequently reported by previous research (Boticki et al., 2015; Kent et al., 2016). We also measured the economic success of the player teams in the game, considering operational and financial key performance indicators, as follows: earnings per share (EPS), the total cumulative shareholder return (TCSR), and profit at the end of the game (Profit). The winners were the teams with higher TCSR, which is an indicator that includes the change in the share value, the dividend paid out to shareholders and the profitability of these dividends over time.

Communication patterns were measured through different features that characterise how students communicate when they use synchronous and asynchronous

tools. Specifically, like previous research, we considered the number of words, the number of messages, and the number of words per message, to measure the volume of interactions and the concentration of these interactions when synchronous and asynchronous communication modes are used (Alario-Hoyos *et al.*, 2018; Sere *et al.*, 2011). However, we make a step further by analysing the communication patter over time, with this purpose we measured the number of messages depending on the hour of the day, and the minutes that elapse between messages.

Finally, the communication contents showed by students when using synchronous and asynchronous communication tools were measured though the most frequent stems that appeared in students' messages, considering their absolute count and the relationships between them (Author *et al*., 2019; Sere *et al*., 2011).

For the data analysis, we use learning analytics techniques because they provide response to the need for evidence-based analysis through the use of large educational datasets (Ray and Saeed, 2018). The purpose of using these techniques matches with those of our research questions, given that these analyses provide feedback on the details and improve the understanding of the learning process, through information that goes beyond just quantitative data. Among the most commonly used methods in learning analytics, text mining and natural language processing, have been usually applied to analyse the contents of discussion forums and chats (Author *et al*., 2019; Ray and Saeed, 2018). They refer to set of processes used with unstructured texts deriving valuable information from raw data (Ray and Saeed, 2018).

The 478 students of the sample posted a total of 39,503 messages. The complete text corpus was composed of 560,123 words, with an average of 14.18 words per message in an unstructured format. The analysis of the content of students' conversations was conducted using natural language processing (NLP). It included pre-processing the corpus, stripping white space, conversion to lower case, elimination of stopwords (Rajaraman and Ullman, 2012), removal of punctuation and stemming (suffix stripped; R tm v.0.6e2 (Feinerer et al., 2008). A document term matrix (DTM) was constructed with the pre-processed corpus, including the frequency of terms per forum and instant messaging interactions in a sparse matrix that represents the corpora. The DTM was subject to a sparsity filter ($\rho$>.8) and normalized to the number of occurrences per message. R version 3.3.2 (R Core team, 2018) was used to conduct the NLP, specifically the tm R package (v. 0.6e2, (Feinerer et al., 2008)).

## 4. Data Analysis

### *4.1. Learning results using synchronous and asynchronous communication*

In order to respond to the first research question, that explores the quantitative learning results of students using synchronous and asynchronous communication when participating in the business simulation game, we conducted mean comparison analyses of the learning outcomes and results achieved by students (Marks, TCSR, EPS, Profit).

These learning outcomes were not normally distributed, as the Shapiro test confirms in all of them (W=0.96, p-value<0.001 for Marks; W=0.79, p-value<0.001 for TCSR; W=0.91, p-value<0.001 for EPS; W=0.89, p-value<0.001 for Profit). This implies the use of the non-parametric Mann-Whitney U test to conduct the mean comparison analyses between both groups, students using online discussion forums and the instant messaging app. Results are displayed in Table 1.

[Insert Table 1]

From Table 1, we can observe that significant differences exist in the mean value of all the quantitative learning results related to the Marks obtained by students, as well as the economic and financial key indicators of the game (TCSR, EPS and Profit at the end of the game). These results are higher in the case of students using asynchronous communication through online discussion forums, who outrank the students using synchronous communication in all the indicators.

### *4.2. Communication patterns in synchronous and asynchronous communication tools*

To respond to the second research question, that explores the different features of the communication patterns that characterised synchronous and asynchronous learner interactions, we extracted some descriptive statistics. Table 2 exhibits characteristics of the communication patterns of students, in terms of messages, words, and words per message.

[Insert Table 2]

These basic data from Table 2 show that the total number of words used by students in their interactions with both tools were almost the same, however the number of messages in the app was much higher than that in the online discussion forums (almost 9 times more). This finding implies that the number of words per message was higher in the online discussion forums than in the instant messaging app. That confirms expected results, such as the longer length of the messages in the forums in comparison with instant messaging.

The histograms for the online discussion forums (Figure 1) and the instant messaging app (Figure 2), evidence their different distribution in the length of the messages (number of words per message). The interaction with forums is characterized by few short messages, this number grows when the number of words also enhances to decrease afterwards, when the number of words grows. That means the frequency of messages with a medium length. In the interaction with instant messaging, the most frequent situation is messages with very few words, very few long messages (for example, messages over 100 words are almost non-existent) and a high number of messages with a similar length.

[Insert Figure 1]

[Insert Figure 2]

In addition to the number and length of messages, the time aspect of the communication pattern is relevant. Our analysis allowed us to explore, for example, when communication took place, or the concentration of communication at specific time points, and the time between responses. To conduct these analyses, we used the start time of each message as given by the forums and instant messaging tools.

Figure 3 and 4 exhibit the time of day at which communication takes place, for the online discussion forums and the instant messaging app, respectively.

[Insert Figure 3]

[Insert Figure 4]

The distribution of the number of messages depending on the hour of the day shows that the communication of students participating in the simulation online took place mostly in the evening (after 8 p.m.). The distribution also shows that interactivity in the sample of students using the online discussion forums during the morning (since 10 p.m.) and in the afternoon (after 3 p.m.) was also frequent, but in a lesser extent, the bias towards night messages being larger in the case of instant messaging than in the case of forums.

Figures 5 and 6 exhibit the concentration of messages over time, when students used online discussion forums and instant messaging, respectively. It gives an idea of the time that elapses between messages, measuring the minutes between them to discover whether or not players respond immediately.

[Insert Figure 5]

[Insert Figure 6]

These Figures point out that a high number of messages was immediate in the two samples. However, while when using the app, the majority of messages occurs within the first minute, and this number decreases when time goes by; among students using online discussion forums the number of responses remains more or less the same as time passes, the decrease in the number of messages over time being lower than in the instant messaging app sample. Only after a very considerable time lapse (for example 1,000 minutes, around 16 hours), is there a noticeable decrease in the number of messages in the sample using the forums.

### *4.3. Communication contents in synchronous and asynchronous tools*

The third research question is focused on analysing the content profile of the students' communications when using both synchronous and asynchronous tools.

To respond to this question, some exploratory analyses were conducted. Firstly, we show the most frequent stems in the text corpora of both tools. Table 3 displays their absolute count in the corpus of the sample using online discussion forums and the instant messaging app, respectively.

[Insert Table 3]

The analysis in Table 3 evidences the sparsity of the stems (higher in the case of instant messaging), which means that very many stems have a low frequency of occurrence. The findings also show considerable overlap between the most repeated stems in each communication tool. Another relevant conclusion is that most of the frequent stems are task-oriented, and only a few refer to other communications, such as salutations ("hola" or "saludos" would be good examples, as the Spanish words for hello and good-bye).

Some of the most frequent stems referred to concepts related to the core of the game. This is the case for "tec" (abbreviation for technology), which refers to the industry of the simulated companies, this being the most frequent stem in both samples (5,806 times in the forums and 2,384 in the app). Other frequent stems that point in the same direction are: "mercado" ("market" in Spanish that appeared 2,625 times in the forums), EEUU (1,828 times in the forums and 705 times in the app), Asi (2,203 times in the forums and 1,253 in the app), Europ (1,463 times in the forums and 510 in the app), which are Spanish stems for the three geographical areas that constitute the international markets in the game); "preci" or "precio", price in Spanish (2,572 times in the forums and 578 in the app); "demanda" or "demad" as one of the main functional areas requiring in-game decisions (1,796 times in the forums and 502 in the app); or economic and financial terms related to the performance of the simulated companies, like "beneficio" ("profit" in Spanish appearing 772 times in the forums); "cuota" ("market share" in Spanish, 1,121 times in the forums); or "resultado" ("outcome" or "result" in Spanish, 1,090 times in the forums).

Besides the concepts that illustrate the content of the game, other frequent stems referred to its purposes. This happens for example with the stem "decisión" (2,340 times in the forums and 457 in the app); or characteristics of the course like pac or pec (the names used to refer to the reports delivered by students for their assessments and marks,

which appeared 1,092 times in the forums and 500 times in the app), or "grupo" and "equipo" (the Spanish words for team, i.e. the way players participate in the game, appearing 900 times in the forums).

There are also frequent stems referred to time, like "ahora" ("now" in Spanish), which relates to time-oriented issues of the game. Finally, the most frequent verbs in the conversations express most of the time uncertainty, which is another relevant feature of the game related to competition and the uncertain changes in the markets and the global environment, as evidenced by of "parec" or "sembl" (it seems), "pued" (it could be) and "cre" or "crec" (I think).

After indicating the most frequent content of the students' conversations, we explore if some kind of relationship exists between the most frequent stems and concepts that appeared in the students' online interactions. To confirm these relations, we calculated the bivariate correlation between the most frequent terms per message. This analysis is exhibited in Figures 7 and 8, for 40 of the most frequent stems in the online discussion forums and the instant messaging app respectively.

[Insert Figure 7]

[Insert Figure 8]

The correlograms show some differences between the online discussion forums and instant messaging. Higher, stronger and positive correlations between frequent stems were found in the sample using the online discussion forums, in comparison with the sample using the instant messaging app, where the correlations were fewer, weaker and less positive, in general. Both correlograms allow us to conclude that the most frequent and related contents, were not exclusive and were game-oriented to the tasks, purposes and characteristics of the game.

Stems like "tec" (technology), "cuot" (market share), "EEUU" (USA), "Asi" (Asia), "Europ" (Europe), "producción" (production), "benefici" (profit), "mercado" (market), "grupo" (team), "empresa" (company), "característica" (technology features), "venta" (sales), "coste" (cost), "precio" (price), "acuerdo" (agreement), "resultado" (outcome), "ronda" (round), "decisión" (decision), "mejor" (better), etc. are positively and strongly related in the sample using online discussion forums

In the interactions with the instant messaging app, the stems related were: "demand" (demand), "Asi" (Asia), "Europ" (Europe), "EEUU" (USA), "vend" (sales), "tec" (technology), "preci" (price), "buen" (good), "parec" (to seem), "bien" (well or fine), "pod" (to can), "hac" (to do), "pon" (to put), "pued" (to can), "cre" (to think), "decisión" (decision), "merc" (market), "cost" (cost), among others. It can be seen that the correlations in this case were not so strong, and not always related to the core concepts of the game (conversations were more disperse using the instant messaging app than online discussion forums).

## Discussion

The principal objective of this study consists in analysing the effectiveness of two basic synchronous (an instant messaging app) and asynchronous communication tools (online discussion forums) used in digital education, specifically in the case of business simulation games. The purpose is to gain a better understanding of the students' learning results and achievements associated with their communication tools, the different features of their communication patterns, and the content profile of their interactions when using these different tools.

With regards to the first research question, which explores the quantitative learning results of students using synchronous and asynchronous communication when

participating in business simulation games, the results confirm that marks as well as economic and financial key indicators of the game were higher in the case of students using asynchronous communication—these outrank the students using the instant messaging app. This finding agrees with previous studies that found a positive impact of learner interactivity on learning results in online discussion forums, as a result of higher satisfaction, the construction of learning communities, and a reduction in isolation in the learning process, as the social constructivist learning theory confirms (Boticki *et al*., 2015; Chaparro-Peláez *et al*., 2013; Wei *et al*., 2015). Few studies have conducted comparative analyses between the two forms of communication, and even fewer have specifically compared the learning results achieved with them. Among such studies as do exist, there is no clear consensus, but some scholars have remarked on the benefits of asynchronous tools over synchronous ones when any difficulties relating to language skills exist (Korkmaz, 2013). As opposed to other studies which highlighted the positive impact of synchronous communication in terms of social relationships and negotiation (Lim, 2008; Santoveña-Casal, 2012). In our case, we found that the impact on learning results was greater when asynchronous tools of communication were used, which highlights the relevance of the characteristics of the different forms of interaction, being more beneficial those that involve more time and commitment (Thune and Støren, 2015). The main reason for this finding emerges in the responses to the second and third research questions, that evidence that interactions through asynchronous tools are more task-oriented and better aligned with learning purposes.

With regards to the second research question, about the description of the different communication patterns that characterize both tools, our findings highlight that they are really different. In line with previous research, our results concluded that synchronous modes showed more accesses (higher number of messages), were more concentrated in time (Alario-Hoyos *et al.*, 2018), and were linked to a higher percentage of social interactivity (Sere *et al.*, 2011). However, our study takes a step further by analysing in depth the communication pattern over time and extracting some relevant conclusions. For example, in terms of the time of day when communication occurs, the bias towards night messages was larger in the case of the app than in the case of forums. A possible reason for this might be related to the different devices normally used in each communication form, usually computers for the online discussion forums, and mobile phones for instant messaging. Communication via mobile phone facilitates interactions at any time, especially in the evening or at night, when students have more time after finishing other work, but also fosters more disperse communication, not just task-oriented. Finally, although a shorter time lapse between messages might be expected in instant messaging, our findings confirm that messages were quite immediate in both cases, but among students using online discussion forums the number of responses remains approximately constant, only dropping after very considerable amount of time has elapsed. This finding confirms the idea of time-pressure as a more relevant feature of instant messaging, compared to discussion forums.

Finally, regarding the third research question, which refers to the content analysis of communication using synchronous and asynchronous tools, our findings note the sparsity of the stems, a great overlap between the most repeated stems in the two communication tools, and the fact that most of them referred to concepts that constitute the core of the game (such as the industry of the simulated companies, the purpose of the game, their main functional areas, and economic and the in-game financial indicators). Stems relating to time management and uncertainty were also frequent. This content schema was similar to that of previous studies on business games (Author *et al*., 2019; Author and Author, 2018), and appeared in both communication tools. In addition, these

concepts were highly correlated, appeared together, were not exclusive, and were task-oriented in line with the purposes and characteristics of the game, as previous studies on online discussion forums also showed (Author *et al*., 2019; Sere *et al*., 2011). However, the correlations between the most frequent stems when interactions take place with the instant messaging app were not so strong, and sometimes did not emerge between stems related to the core concepts of the game, which means that conversations using this tool were more disperse and not so game and task-oriented as in online discussion forums.

## *Conclusions*

This research contributes to the field of game learning analytics, where the nature of games, results in player conversations are not always being focused on learning contents. This explains the mixed results on the influence of interactivity on in-game learning, making worthwhile the comparison of conversation content when players use different communication tools.

More specifically, from a theoretical point of view, this research reinforces the assumptions of the social constructivist learning theory underlining the connection between interactivity and learning. But our findings take this theory a step further by supporting the idea that the effects of learners' interactivity depend on the tool used, on the communication pattern that characterises each tool, as well as on the contents usually exchanged.

From an empirical perspective, this study reveals the usefulness of learning analytics techniques in gaining insight on learner communication content and the students educational experience through a better assessment and understanding of their learning process, which might be lacking for teachers in online education, either because of lack of awareness of the interactions among students and the consequent effects on learning (Author *et al*., 2019) or because of information overload that hampers teachers' attention (Van Leeuwen *et al.*, 2014). Even more, the application of learning analytics is especially valuable in the case of business simulation games, due to their open-ended nature and the multiple behaviours developed by students while playing, which makes remarkably difficult to assess student learning through traditional measurements (Lee *et al.*, 2019).

This study makes also relevant contributions for practitioners, teachers and educational institutions that use online environments, suggesting the suitability of implementing communication platforms that foster and record student interactions. Due to the complementarity of different communication tools, these platforms could be both synchronous and asynchronous, asynchronous tools being especially suitable for task-related communication and synchronous ones for speeding up and facilitating interaction among online students. Our results also suggest the suitability of applying learning analytics to the information collected from student interactions to gain a better knowledge and a fuller picture of their learning process.

Our research is not exempt from limitations. It is necessary to mention that this study has focused on business simulation games, to the exclusion of other educational computer systems. This specific focus places the contributions of this study in the field of game learning analytics (Alonso-Fernández et al., 2019b). The application of learning analytics to interactions in other educational computer scenarios, such as learning management systems or massive open online courses, could offer fuller knowledge on the contribution of student interactivity to the learning process, and the specific role played by different communication tools.

Another relevant limitation is the exploratory nature of this study which encourages further explanatory analyses, considering the learning results as a

consequence of the communication developed by students. This more advance research will allow us to determine which is the most efficient communication tool in terms of the student learning achievements.

In addition, this research only considers learners' interaction, ignoring the role of instructors or the interaction between learners and contents (Cheng and Chau, 2016). The inclusion of a whole view of the plethora of interactions involved in the learning process will provide a better idea of how social interactions influence learning construction.

In a more general way, the use of students' communication to explore their learning process through learning analytics tools constitutes an emerging field with huge potential to address the contribution of being members of social and cultural groups on what students learn due to their social practices and interactions.

All these research lines constitute an interesting challenge for the future research agenda.**Acknowledgements**

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Table 1. Mean comparison of the quantitative learning results of students using synchronous and asynchronous communication tools

| | Synchronous (instant messaging app) | | Asynchronous (online discussion forums) | | Mann-Whitney test | |
|---|---|---|---|---|---|---|
| | Mean | sd | Mean | sd | U | p-value |
| Marks | 7.62 | 0.903 | 8.16 | 1.13 | 30962 | *** |
| TCSR | -33.6 | 41.77 | -1.40 | 19.56 | 39781 | *** |
| EPS | -16.3 | 37.93 | 12.2 | 26.24 | 40482 | *** |
| Profit | -571,085 | 1,304,688 | 307,637 | 1,037,164 | 39518 | *** |

H0: mean ranks not differ between groups - H1: mean ranks differ between groups ***p<0.001; **p<0.01; *p<0.05; +p<0.1

Table 2. Messages, words and words per message

| Metric | Synchronous (instant messaging app) | Asynchronous (online discussion forums) |
|---|---|---|
| Words | 269739 | 290384 |
| Messages | 35538 | 3965 |
| Words/Message | 7.59 (±11.7) | 53,80 (± 133,87) |

Fig. 1. Words per message in online forums

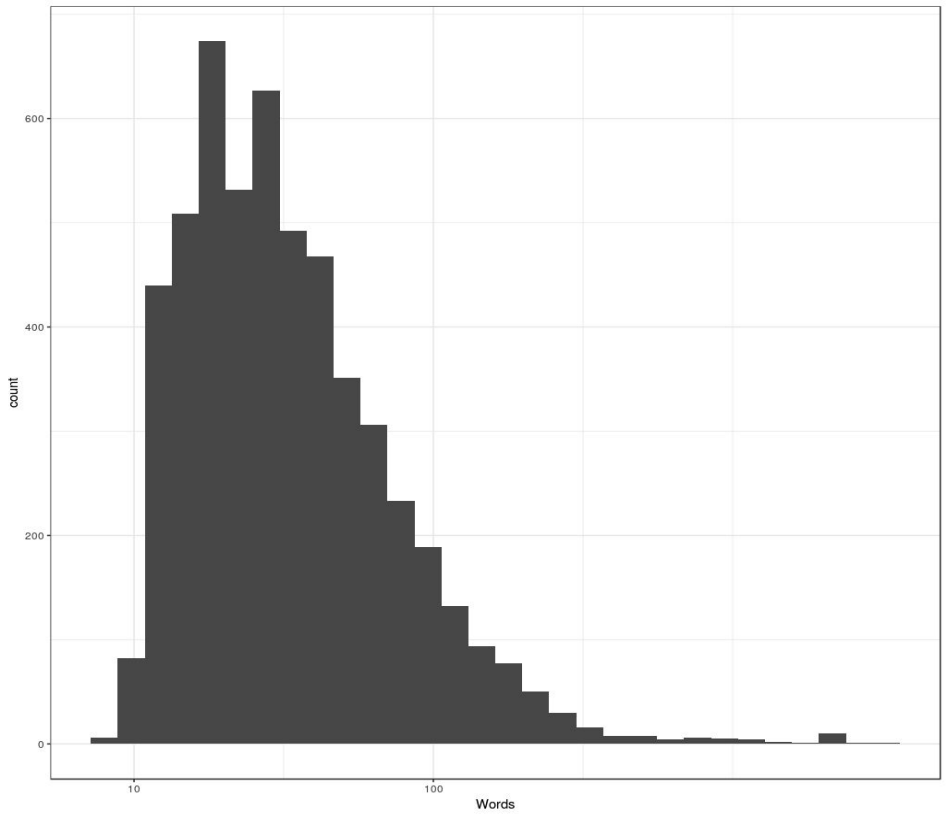


Fig. 2. Words per message in instant messaging app

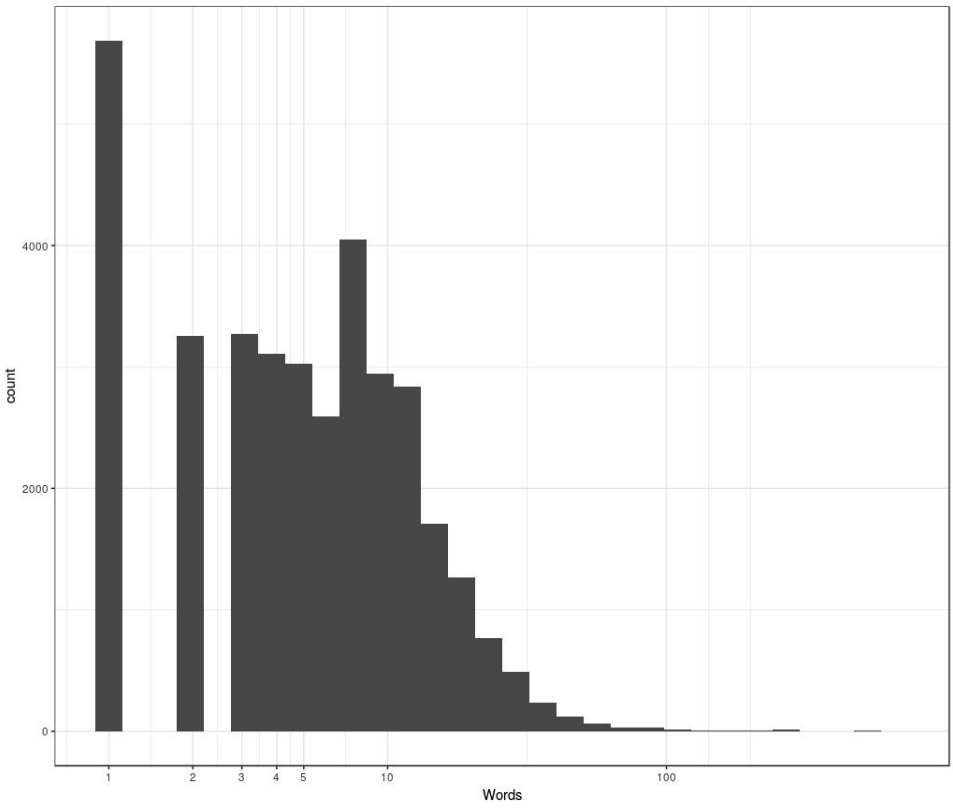

Fig. 3. Messages per hour/day forums

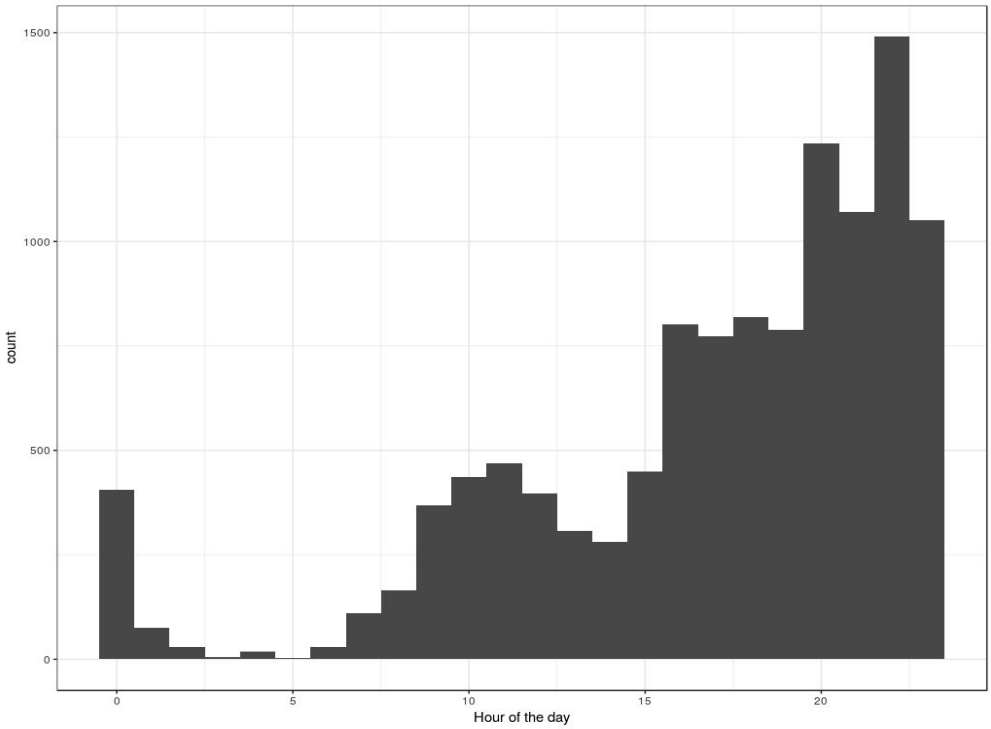


Fig. 4. Messages per hour/day instant messaging app

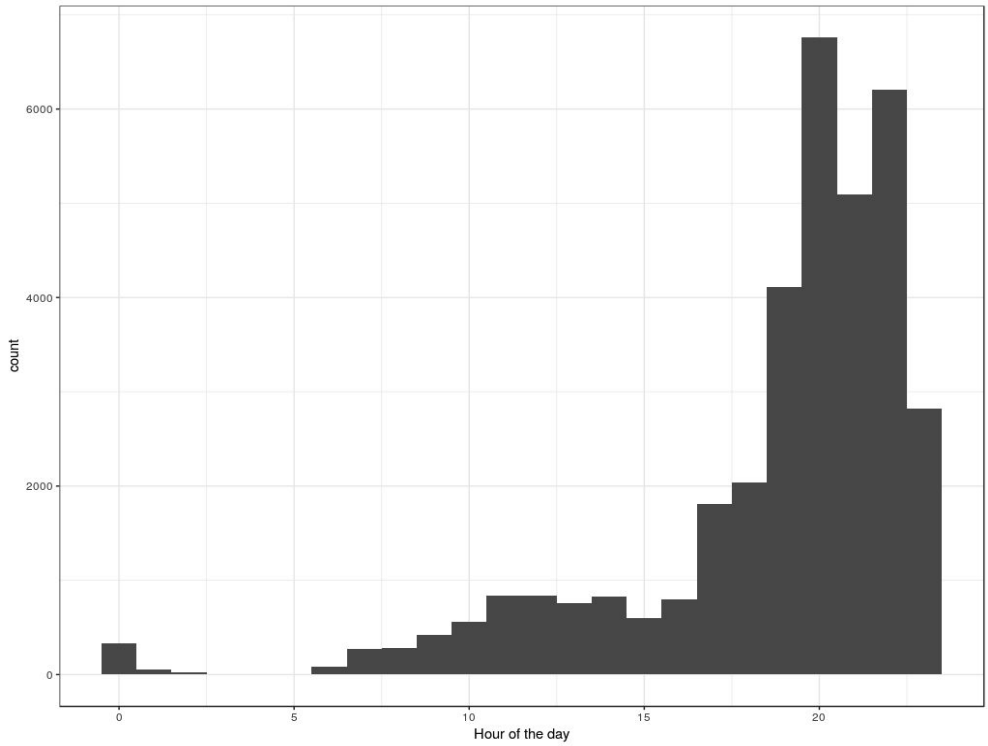

Fig. 5. Minutes between messages forums

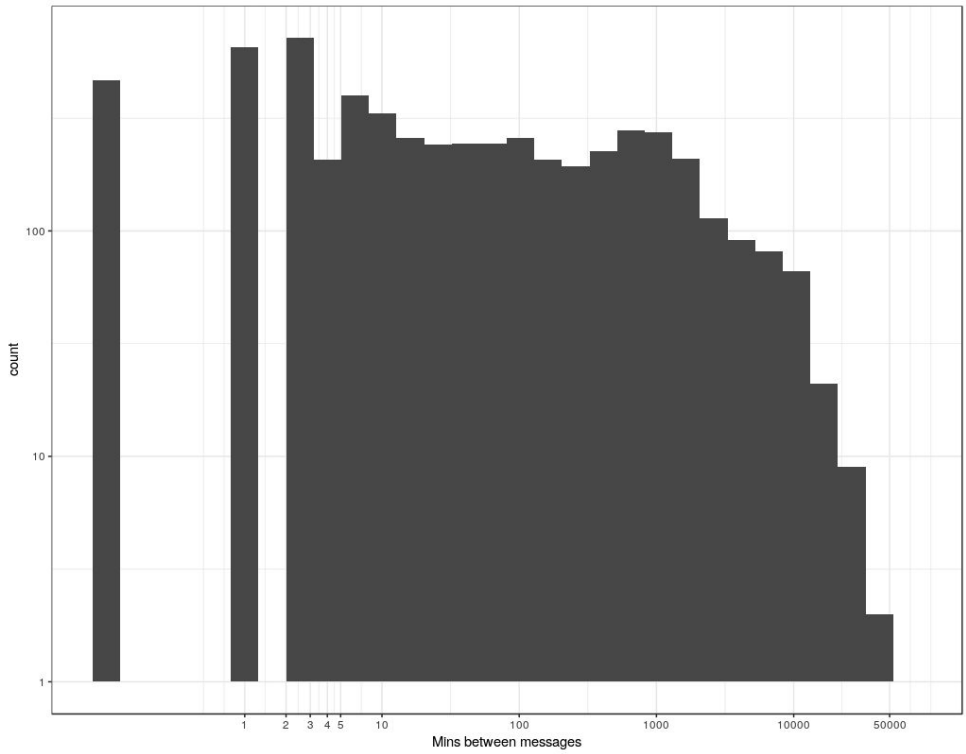


Fig. 6. Minutes between messages instant messaging app

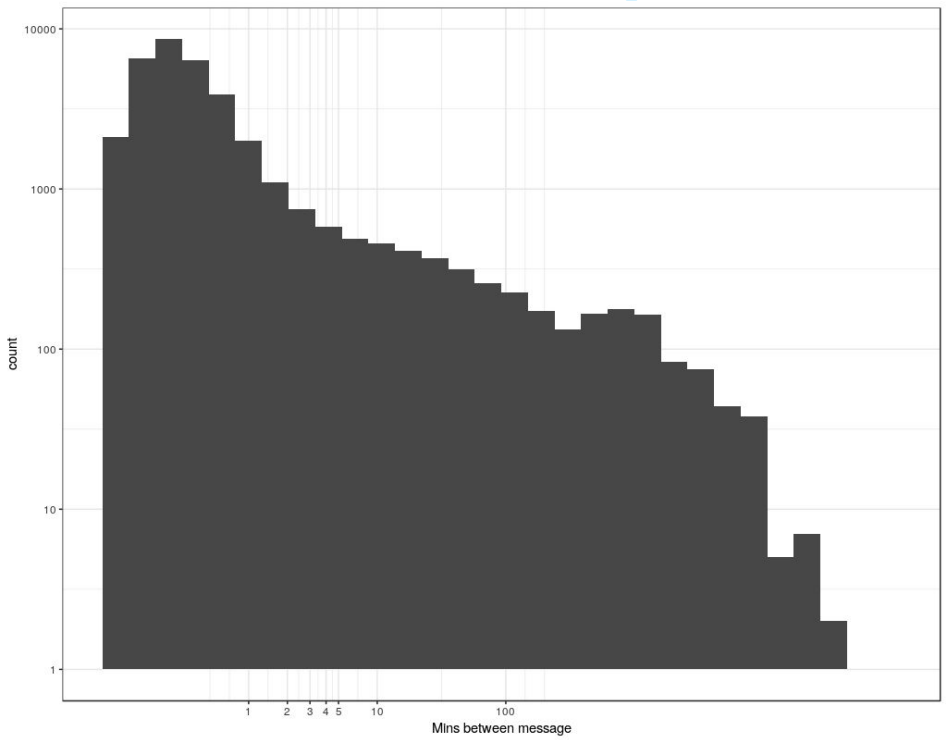

Table 3. Absolute count of most frequent 30 stems

| Asynchronous (Online discussion forums) | | Synchronous (instant messaging app) | |
|---|---|---|---|
| tec | 5,806 | tec | 2,384 |
| mercado | 2,625 | asi | 1,253 |
| precio | 2,572 | eeuu | 705 |
| decision | 2,340 | mir | 683 |
| asia | 2,203 | qued | 653 |
| eeuu | 1,828 | buen | 635 |
| demanda | 1,796 | val | 618 |
| creo | 1,497 | hac | 611 |
| europa | 1,463 | bien | 606 |
| hola | 1,334 | fer | 603 |
| equipo | 1,243 | preci | 578 |
| característica | 1,184 | cre | 538 |
| cost | 1,148 | crec | 525 |
| saludo | 1,138 | europ | 510 |
| parec | 1,132 | part | 502 |
| buena | 1,129 | demand | 502 |
| cuota | 1,121 | pod | 500 |
| puesto | 1,105 | pac | 500 |
| pec | 1,092 | fet | 500 |
| resultado | 1,090 | tenim | 482 |
| empresa | 1,083 | decision | 457 |
| hacer | 1,019 | perfect | 453 |
| grupo | 900 | cos | 450 |
| ahora | 863 | sembl | 450 |
| ver | 859 | parec | 436 |
| ronda | 834 | pon | 435 |
| podemo | 812 | pues | 421 |
| producción | 794 | ver | 418 |
| tecnología | 788 | pued | 418 |
| beneficio | 772 | veur | 409 |

Fig. 7. Correlogram plot for online discussion forums (crossed positions mark non-significant correlations $p<0.05$)

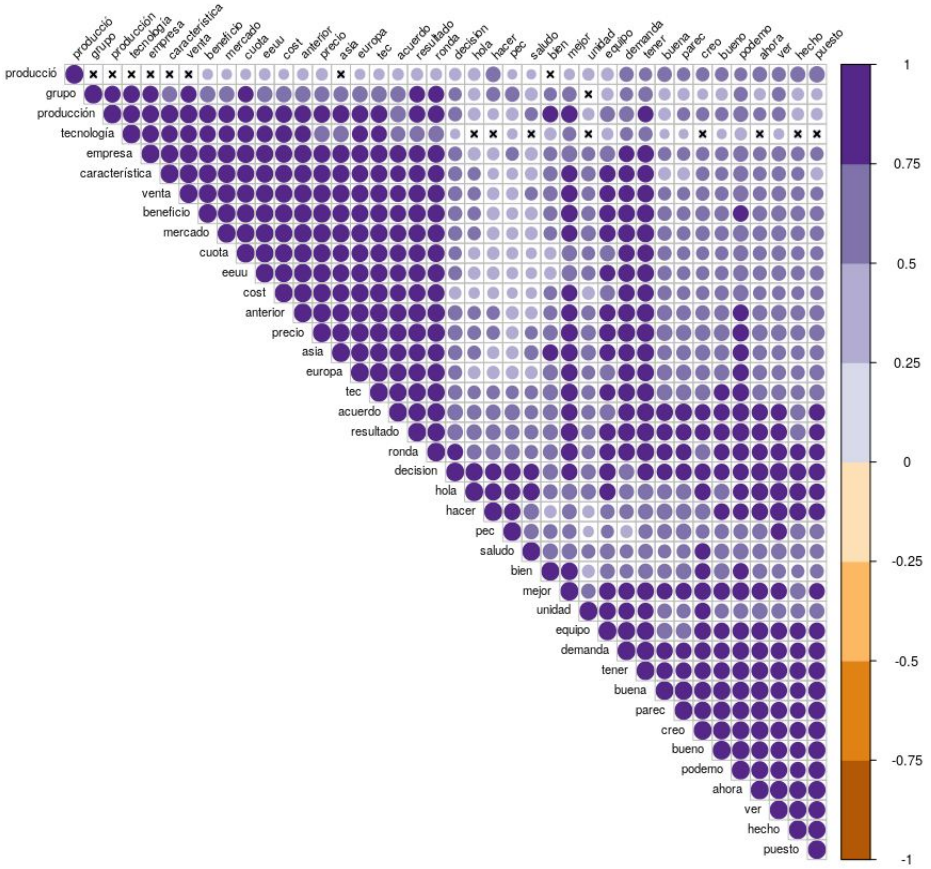

Fig. 8. Correlogram plot for instant messaging app (crossed positions mark non-significant correlations p<0.05)