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

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# 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).

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

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

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

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

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

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

42 The analysis of the different features of the communication patterns that  
43 characterise synchronous and asynchronous communication tools, as well as the content  
44 profile detected in student communications when using both of them, will provide  
45 evidence-based recommendations for improving communication in online education, and  
46 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 (Karahana 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

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3 better understand the learning process of students (Koç, 2017). The most-used metrics  
4 were number of logins, posting frequency, number of read messages, and messages  
5 lengths (although other metrics also exist). This quantitative approach measures learning  
6 performance mainly by course marks.  
7

8 The inconsistent findings and gaps encourage a continued exploration of the  
9 impact of learner interactions on their learning which should also include qualitative  
10 measures of interaction and learning achievement.  
11

## 12 2.2. *The effects on learning of synchronous and asynchronous* 13 *communication tools* 14

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16 Interaction in online learning revolves around a variety of communication modes  
17 (Madden *et al.*, 2017) but, basically, these can be classified into synchronous and  
18 asynchronous (dos Santos and Cechinel, 2019).  
19

20 Previous research on both types of interaction at an educational level has been  
21 focused on better understanding their characteristics and roles (dos Santos and Cechinel,  
22 2019). Scholars have generally considered the two types as complementary (deNoyelles  
23 and Raider-Roth, 2016; Muniz-Solari and Coats, 2009), because both support  
24 collaboration. Mostly, they are considered together, without remarking on the differences  
25 between them and their different purposes (Meyer, 2015; Wang and Walker, 2013; Yueh  
26 *et al.*, 2014). A few studies, however, do contrast their differences and suitability.  
27

28 Some of these studies have emphasised the different characteristics and features  
29 of communication patterns in synchronous versus asynchronous mode. For example, the  
30 study conducted by Alario-Hoyos *et al.* (2018) analysed learning interaction tools when  
31 running MOOCs in terms of time spent and accesses, and found that in the case of  
32 synchronous modes the use of the tool is concentrated in shorter periods of time but the  
33 accesses to the tool were higher. Similarly, Sere *et al.* (2011) pointed out that a higher  
34 percentage of social interactions occurs in synchronous rather than asynchronous modes,  
35 while students spend more time in task-oriented interaction in asynchronous discussions.  
36

37 Analyses of the preference for one specific form of communication over the other,  
38 sometimes explained by the user type, are also found in the literature. For example, dos  
39 Santos and Cechinel (2019) noted that, although both forms received good ratings  
40 assessments, students and supervisors preferred asynchronous forms of communication.  
41 Hampton *et al.* (2017) studied the preferences of students and teachers in online nursing  
42 courses by considering different modes of synchronous and asynchronous tools (videos,  
43 narrated PowerPoint presentations, Adobe Connect education sessions, article readings,  
44 e-mails, wikis, simulations/games and case studies). They found that the most engaging  
45 method depended on the students' generation (Baby Boomer, Generation X or  
46 Millennial). Smithson *et al.* (2012) demonstrated in their study on mental health system  
47 that synchronous formats of participation encouraged the users more, while professionals  
48 showed a preference for asynchronous formats.  
49

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

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

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

8  
9 For the purpose of this study, a quasi-experiment research was conducted, where  
10 the teachers offered only one communication mode to each course, and students chose  
11 voluntarily whether or not to participate using it. These communication tools were either  
12 asynchronous, through the online discussion forum provided by the game; or  
13 synchronous, using an instant messaging app. Specifically, the teachers decided to use  
14 Telegram, which is a free cloud-based instant messaging service whose the client-side  
15 code is open-source software. Telegram allows creation of a Telegram Bot access and  
16 record the communication within the teams using this tool. The students were informed  
17 about this, and whether or not to participate in the experiment, using the instant messaging  
18 app, the online discussion forums, or none of them, knowing that no personal data would  
19 be used and that all the information retrieved would be treated anonymously and only for  
20 academic research purposes.

21  
22 The participation ratio of the students was very high, especially in the courses  
23 where the interaction mode proposed was the instant messaging app, which exceeded  
24 94%, and reached 81.9% in the courses where the communication mode was the online  
25 discussion forum. The Mann-Whitney U test confirmed that there were no significant  
26 differences in the grade levels of students who decide to take part or not in the experiment  
27 ( $U = 6.876$ ,  $p \text{ value} = .562$ ), as well as in the main financial indicator of the game, the  
28 total cumulative shareholders' return ( $\chi^2 = 11.367$ ,  $p \text{ value} = .854$ ).

29  
30 From a total population of 551 students, the final sample was composed of 478  
31 (267 using online discussion forums and 211 using the instant messaging app); distributed  
32 among 106 teams (63 using online discussion forums and 43 using the instant messaging  
33 app); and playing in 13 different competitions (9 in the case of the online discussion  
34 forums and 4 in the case of the instant messaging app). Teams were composed of an  
35 average of 4.24 members in the case of the courses using online discussion forums  
36 (ranging from 2 to 6 students), and an average of 4.9 members in the courses where the  
37 instant messaging app was used (ranging from 4 to 6 students). Likewise, 213 students  
38 were female (44.56% of the sample, 117 in the online discussion forums courses and 96  
39 in the instant messaging app courses) and 265 were males (55.44% of the sample, 149  
40 in the online discussion forums courses and 116 in the instant messaging app courses). The  
41 average age of students was 31.40 years in the online discussion forums courses and 30.8  
42 in the instant messaging app courses.

### 43 44 45 46 47 3.2. *Measurement of variables*

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

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

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3 tools. Specifically, like previous research, we considered the number of words, the  
4 number of messages, and the number of words per message, to measure the volume of  
5 interactions and the concentration of these interactions when synchronous and  
6 asynchronous communication modes are used (Alario-Hoyos *et al.*, 2018; Sere *et al.*,  
7 2011). However, we make a step further by analysing the communication patten over time,  
8 with this purpose we measured the number of messages depending on the hour of the day,  
9 and the minutes that elapse between messages.

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

16 For the data analysis, we use learning analytics techniques because they provide  
17 response to the need for evidence-based analysis through the use of large educational  
18 datasets (Ray and Saeed, 2018). The purpose of using these techniques matches with  
19 those of our research questions, given that these analyses provide feedback on the details  
20 and improve the understanding of the learning process, through information that goes  
21 beyond just quantitative data. Among the most commonly used methods in learning  
22 analytics, text mining and natural language processing, have been usually applied to  
23 analyse the contents of discussion forums and chats (Author *et al.*, 2019; Ray and Saeed,  
24 2018). They refer to set of processes used with unstructured texts deriving valuable  
25 information from raw data (Ray and Saeed, 2018).

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

## 4. Data Analysis

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

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

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

59 [Insert Table 1]  
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3 From Table 1, we can observe that significant differences exist in the mean value  
4 of all the quantitative learning results related to the Marks obtained by students, as well  
5 as the economic and financial key indicators of the game (TCSR, EPS and Profit at the  
6 end of the game). These results are higher in the case of students using asynchronous  
7 communication through online discussion forums, who outrank the students using  
8 synchronous communication in all the indicators.  
9

#### 11 4.2. *Communication patterns in synchronous and asynchronous* 12 *communication tools*

13  
14 To respond to the second research question, that explores the different features of the  
15 communication patterns that characterised synchronous and asynchronous learner  
16 interactions, we extracted some descriptive statistics. Table 2 exhibits characteristics of  
17 the communication patterns of students, in terms of messages, words, and words per  
18 message.  
19

20  
21 [Insert Table 2]

22 These basic data from Table 2 show that the total number of words used by  
23 students in their interactions with both tools were almost the same, however the number  
24 of messages in the app was much higher than that in the online discussion forums (almost  
25 9 times more). This finding implies that the number of words per message was higher in  
26 the online discussion forums than in the instant messaging app. That confirms expected  
27 results, such as the longer length of the messages in the forums in comparison with instant  
28 messaging.  
29

30 The histograms for the online discussion forums (Figure 1) and the instant  
31 messaging app (Figure 2), evidence their different distribution in the length of the  
32 messages (number of words per message). The interaction with forums is characterized  
33 by few short messages, this number grows when the number of words also enhances to  
34 decrease afterwards, when the number of words grows. That means the frequency of  
35 messages with a medium length. In the interaction with instant messaging, the most  
36 frequent situation is messages with very few words, very few long messages (for example,  
37 messages over 100 words are almost non-existent) and a high number of messages with  
38 a similar length.  
39

40 [Insert Figure 1]

41 [Insert Figure 2]

42 In addition to the number and length of messages, the time aspect of the  
43 communication pattern is relevant. Our analysis allowed us to explore, for example, when  
44 communication took place, or the concentration of communication at specific time points,  
45 and the time between responses. To conduct these analyses, we used the start time of each  
46 message as given by the forums and instant messaging tools.  
47

48 Figure 3 and 4 exhibit the time of day at which communication takes place, for  
49 the online discussion forums and the instant messaging app, respectively.  
50

51 [Insert Figure 3]

52 [Insert Figure 4]

53 The distribution of the number of messages depending on the hour of the day  
54 shows that the communication of students participating in the simulation online took  
55 place mostly in the evening (after 8 p.m.). The distribution also shows that interactivity  
56 in the sample of students using the online discussion forums during the morning (since  
57 10 p.m.) and in the afternoon (after 3 p.m.) was also frequent, but in a lesser extent, the  
58 bias towards night messages being larger in the case of instant messaging than in the case  
59 of forums.  
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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]

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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,

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

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

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

18 [Insert Figure 7]

19 [Insert Figure 8]

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

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

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

## 41 Discussion

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

49 With regards to the first research question, which explores the quantitative  
50 learning results of students using synchronous and asynchronous communication when  
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3 participating in business simulation games, the results confirm that marks as well as  
4 economic and financial key indicators of the game were higher in the case of students  
5 using asynchronous communication—these outrank the students using the instant  
6 messaging app. This finding agrees with previous studies that found a positive impact of  
7 learner interactivity on learning results in online discussion forums, as a result of higher  
8 satisfaction, the construction of learning communities, and a reduction in isolation in the  
9 learning process, as the social constructivist learning theory confirms (Boticki *et al.*,  
10 2015; Chaparro-Peláez *et al.*, 2013; Wei *et al.*, 2015). Few studies have conducted  
11 comparative analyses between the two forms of communication, and even fewer have  
12 specifically compared the learning results achieved with them. Among such studies as do  
13 exist, there is no clear consensus, but some scholars have remarked on the benefits of  
14 asynchronous tools over synchronous ones when any difficulties relating to language  
15 skills exist (Korkmaz, 2013). As opposed to other studies which highlighted the positive  
16 impact of synchronous communication in terms of social relationships and negotiation  
17 (Lim, 2008; Santoveña-Casal, 2012). In our case, we found that the impact on learning  
18 results was greater when asynchronous tools of communication were used, which  
19 highlights the relevance of the characteristics of the different forms of interaction, being  
20 more beneficial those that involve more time and commitment (Thune and Støren, 2015).  
21 The main reason for this finding emerges in the responses to the second and third research  
22 questions, that evidence that interactions through asynchronous tools are more task-  
23 oriented and better aligned with learning purposes.

24  
25 With regards to the second research question, about the description of the different  
26 communication patterns that characterize both tools, our findings highlight that they are  
27 really different. In line with previous research, our results concluded that synchronous  
28 modes showed more accesses (higher number of messages), were more concentrated in  
29 time (Alario-Hoyos *et al.*, 2018), and were linked to a higher percentage of social  
30 interactivity (Sere *et al.*, 2011). However, our study takes a step further by analysing in  
31 depth the communication pattern over time and extracting some relevant conclusions. For  
32 example, in terms of the time of day when communication occurs, the bias towards night  
33 messages was larger in the case of the app than in the case of forums. A possible reason  
34 for this might be related to the different devices normally used in each communication  
35 form, usually computers for the online discussion forums, and mobile phones for instant  
36 messaging. Communication via mobile phone facilitates interactions at any time,  
37 especially in the evening or at night, when students have more time after finishing other  
38 work, but also fosters more disperse communication, not just task-oriented. Finally,  
39 although a shorter time lapse between messages might be expected in instant messaging,  
40 our findings confirm that messages were quite immediate in both cases, but among  
41 students using online discussion forums the number of responses remains approximately  
42 constant, only dropping after very considerable amount of time has elapsed. This finding  
43 confirms the idea of time-pressure as a more relevant feature of instant messaging,  
44 compared to discussion forums.

45  
46 Finally, regarding the third research question, which refers to the content analysis  
47 of communication using synchronous and asynchronous tools, our findings note the  
48 sparsity of the stems, a great overlap between the most repeated stems in the two  
49 communication tools, and the fact that most of them referred to concepts that constitute  
50 the core of the game (such as the industry of the simulated companies, the purpose of the  
51 game, their main functional areas, and economic and the in-game financial indicators).  
52 Stems relating to time management and uncertainty were also frequent. This content  
53 schema was similar to that of previous studies on business games (Author *et al.*, 2019;  
54 Author and Author, 2018), and appeared in both communication tools. In addition, these

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3 concepts were highly correlated, appeared together, were not exclusive, and were task-  
4 oriented in line with the purposes and characteristics of the game, as previous studies on  
5 online discussion forums also showed (Author *et al.*, 2019; Sere *et al.*, 2011). However,  
6 the correlations between the most frequent stems when interactions take place with the  
7 instant messaging app were not so strong, and sometimes did not emerge between stems  
8 related to the core concepts of the game, which means that conversations using this tool  
9 were more disperse and not so game and task-oriented as in online discussion forums.  
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11

## 12 **Conclusions**

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15 This research contributes to the field of game learning analytics, where the nature of  
16 games, results in player conversations are not always being focused on learning contents.  
17 This explains the mixed results on the influence of interactivity on in-game learning,  
18 making worthwhile the comparison of conversation content when players use different  
19 communication tools.  
20

21 More specifically, from a theoretical point of view, this research reinforces the  
22 assumptions of the social constructivist learning theory underlining the connection  
23 between interactivity and learning. But our findings take this theory a step further by  
24 supporting the idea that the effects of learners' interactivity depend on the tool used, on  
25 the communication pattern that characterises each tool, as well as on the contents usually  
26 exchanged.  
27

28 From an empirical perspective, this study reveals the usefulness of learning  
29 analytics techniques in gaining insight on learner communication content and the students  
30 educational experience through a better assessment and understanding of their learning  
31 process, which might be lacking for teachers in online education, either because of lack  
32 of awareness of the interactions among students and the consequent effects on learning  
33 (Author *et al.*, 2019) or because of information overload that hampers teachers' attention  
34 (Van Leeuwen *et al.*, 2014). Even more, the application of learning analytics is especially  
35 valuable in the case of business simulation games, due to their open-ended nature and the  
36 multiple behaviours developed by students while playing, which makes remarkably  
37 difficult to assess student learning through traditional measurements (Lee *et al.*, 2019).  
38

39 **This study makes also relevant contributions for practitioners, teachers and**  
40 **educational institutions that use online environments, suggesting the suitability of**  
41 **implementing communication platforms that foster and record student interactions. Due**  
42 **to the complementarity of different communication tools, these platforms could be both**  
43 **synchronous and asynchronous, asynchronous tools being especially suitable for task-**  
44 **related communication and synchronous ones for speeding up and facilitating interaction**  
45 **among online students. Our results also suggest the suitability of applying learning**  
46 **analytics to the information collected from student interactions to gain a better knowledge**  
47 **and a fuller picture of their learning process.**  
48

49 Our research is not exempt from limitations. It is necessary to mention that this  
50 study has focused on business simulation games, to the exclusion of other educational  
51 computer systems. This specific focus places the contributions of this study in the field  
52 of game learning analytics (Alonso-Fernández *et al.*, 2019b). The application of learning  
53 analytics to interactions in other educational computer scenarios, such as learning  
54 management systems or massive open online courses, could offer fuller knowledge on  
55 the contribution of student interactivity to the learning process, and the specific role  
56 played by different communication tools.  
57

58 Another relevant limitation is the exploratory nature of this study which  
59 encourages further explanatory analyses, considering the learning results as a  
60

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.

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Education + Training

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 ( $\pm 11.7$ )	53,80 ( $\pm 133,87$ )

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Fig. 1. Words per message in online forums

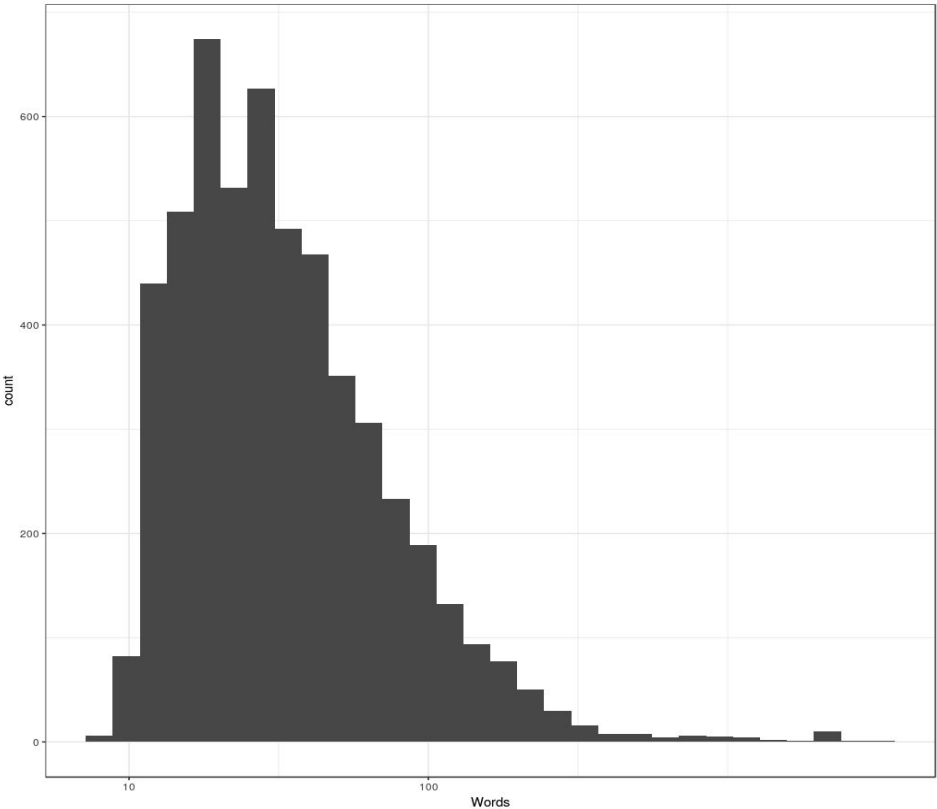


Fig. 2. Words per message in instant messaging app

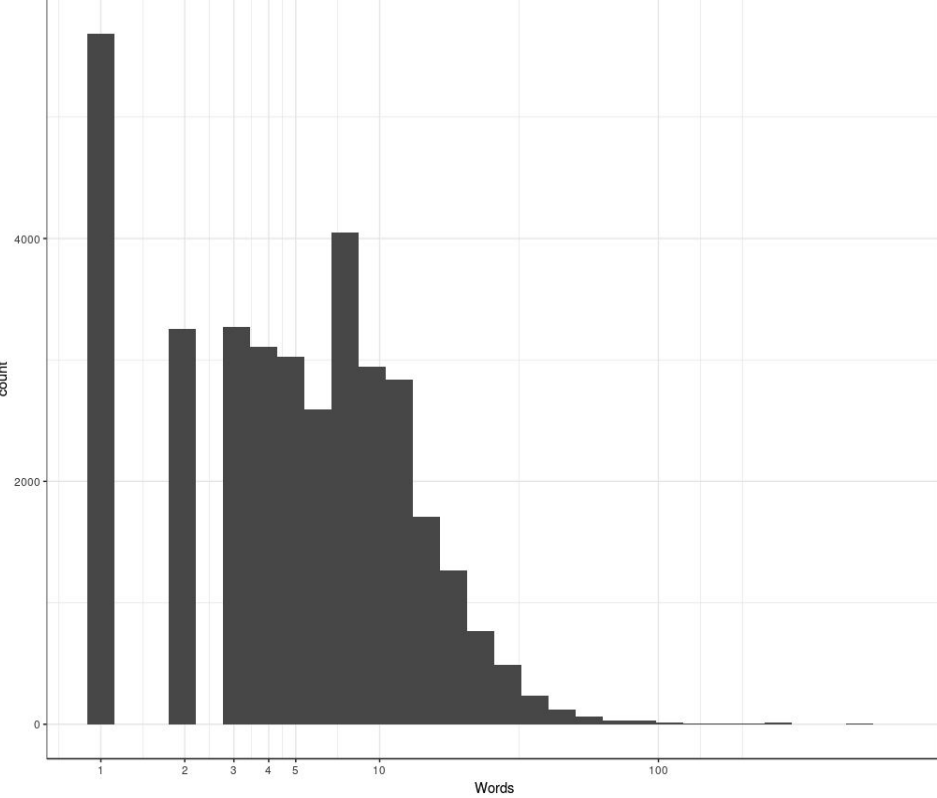


Fig. 3. Messages per hour/day forums

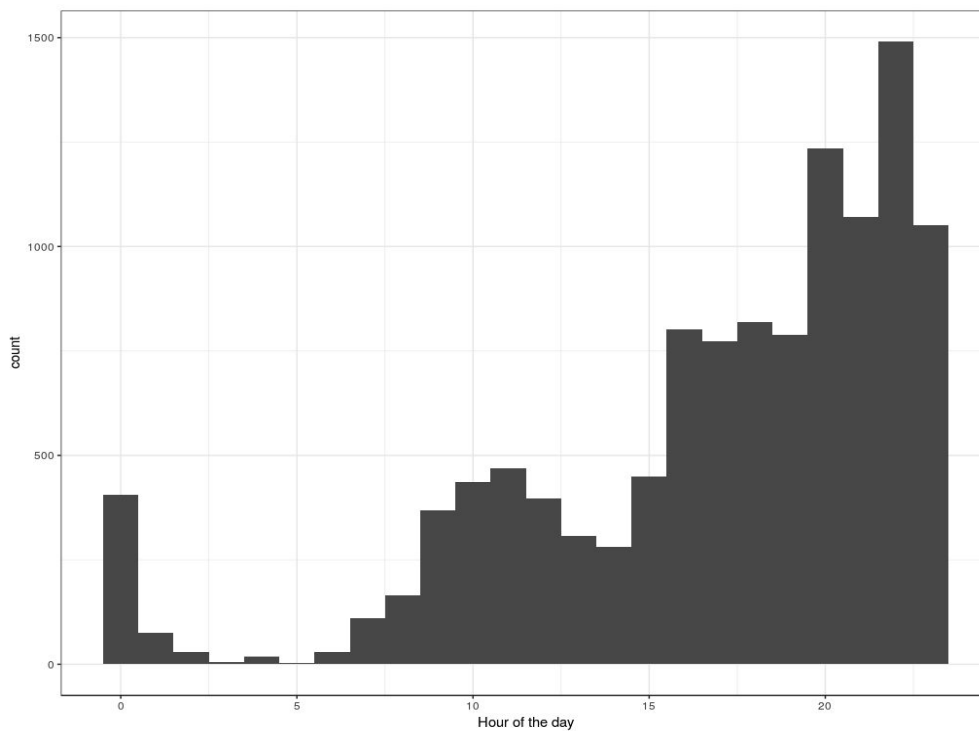
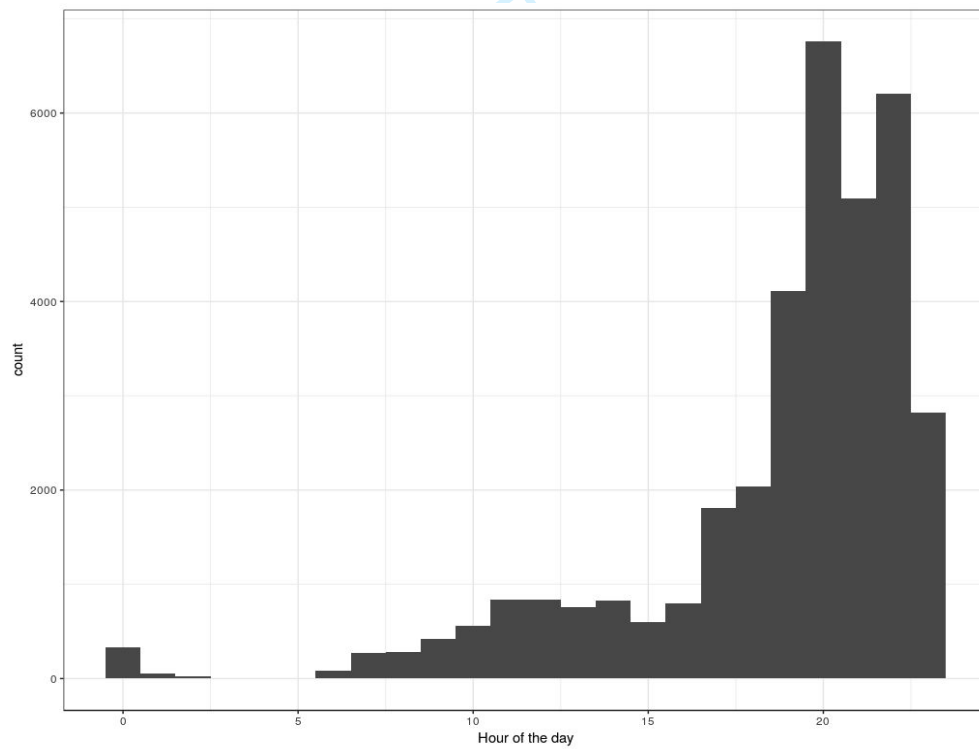


Fig. 4. Messages per hour/day instant messaging app



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Fig. 5. Minutes between messages forums

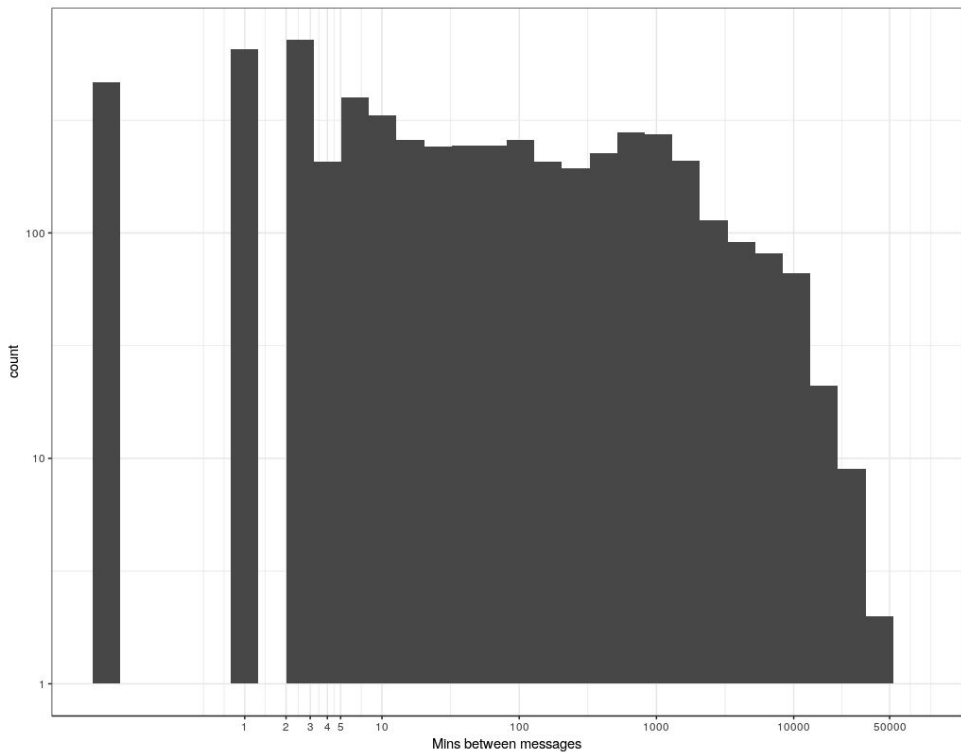


Fig. 6. Minutes between messages instant messaging app

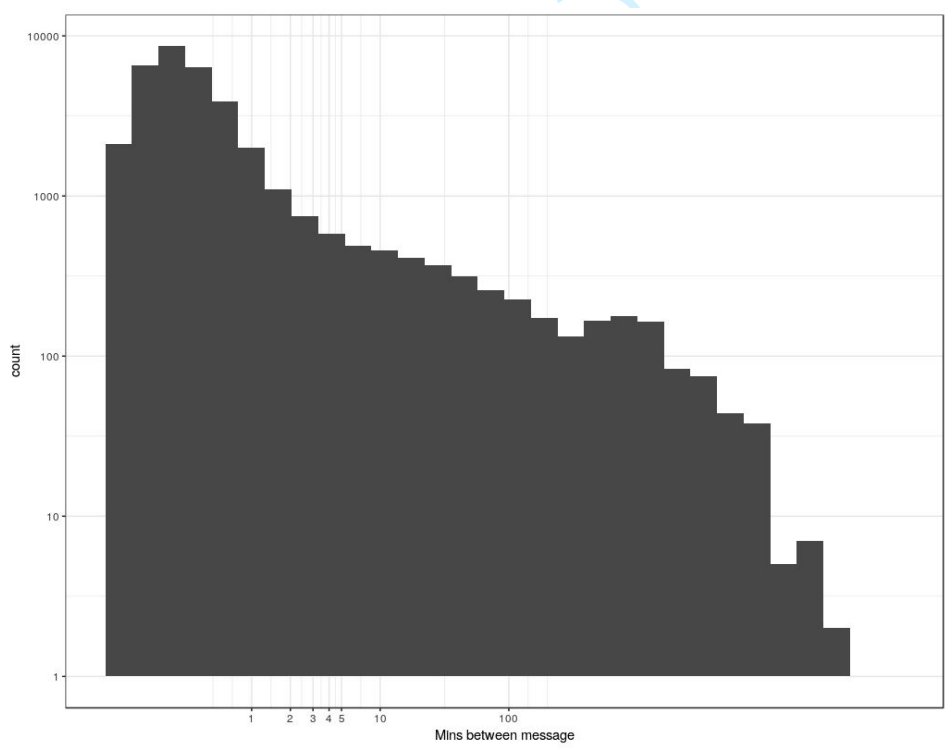
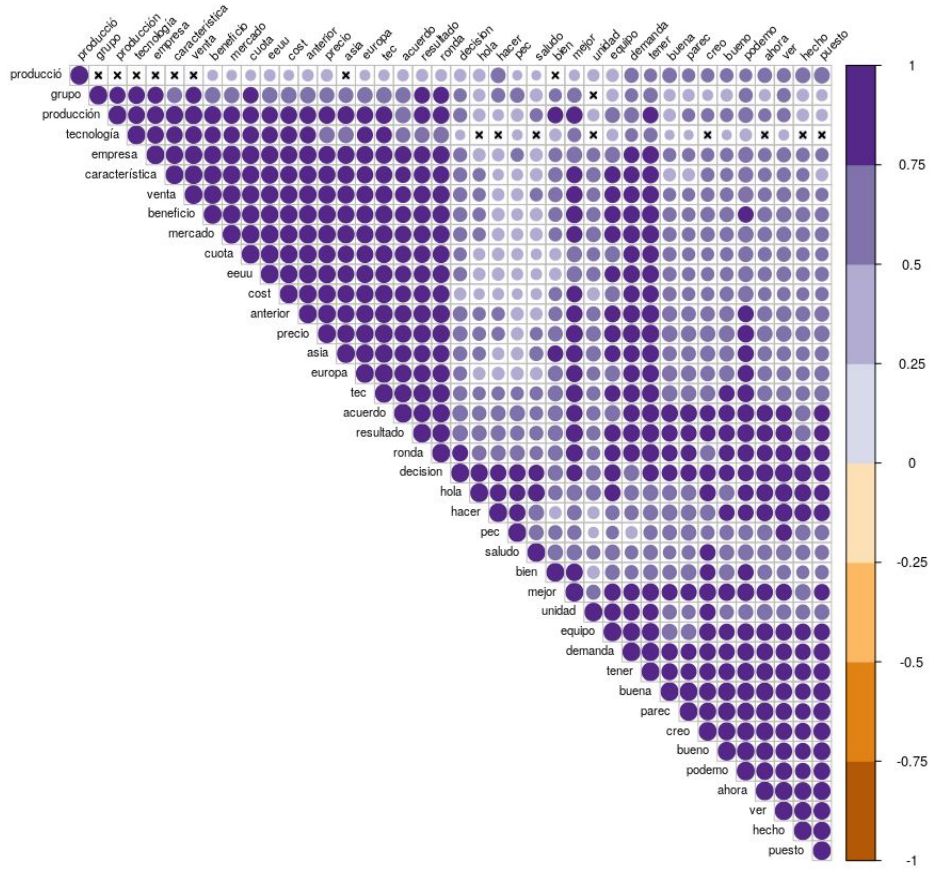


Table 3. Absolute count of most frequent 30 stems

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  $p < 0.05$ )



training

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

