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Analysis and Evaluation of Discussion Forums in the Teaching Process of Industrial Organization Engineering*

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A series of practical on-line classroom using the forums as a tool were developed in different subjects of Industrial Organization during five consecutive years instead of the traditional face to face sessions. The purpose of this paper is to develop an evaluation system and determine whether the qualification of the forums can be considered a substantial part of the overall qualification process of each subject or not. To achieve this objective, it was necessary to analyze in depth the participation of the students in the forums and to establish an evaluation procedure that can be considered objective, realistic, transparent, fair, easy to be implement and feasible to be incorporated as a part of the traditional evaluation process.

Keywords: asynchronous discussion forum; case method; collaborative learning; text mining; discussion behaviors

1. Introduction

There are different studies focused to predict students' performance in a course from data about their participation in forums [1], and studies that support that participation in discussion forums improves course performance [2]. However, it is difficult to find studies targeting the evaluation of students' participations in forums, even when it is recognized that instructors face the difficult and time consuming task of interpreting and assessing those participations [2, 3] mentioning that data mining together with quantitative and qualitative indicators, are a solution.

According to [4] in every collaborative experience three stages can be distinguished: design, development and evaluation. During the first one, objectives are defined; in the second one, the process of management is developed and implemented; during the last one the information collected is analyzed and finally conclusions are drawn. In discussion forums for educational purposes, numerous studies have considered to analyze the first two above mentioned steps but not the evaluation process.

The students' participation is evaluated in discussion forums to determine precisely their authentic contributions from a pedagogical point of view. The process is hampered by the textual nature of the information exchanged and its asynchronous essence, being especially difficult when the topic discussed is complex and there are hundreds of different contributions with a diversity of nuances that must be analyzed from different aspects and perspectives. The evaluation procedure is restricted, in the absence of indicators and tools, to analyze and provide information about the interaction among the participants, [3].

The present section introduces the objectives of this analysis, as well as the context of the study, section 2 describes materials and methods proposed to organize, process and analyze the information exchanged, section 3 describes the model to process and evaluate the information and finally section 4 details the developed experiences and answers to the research questions through the analysis of the results obtained, being main conclusions reached in the last section 5.

1.1 Objective

The major goal is to determine a method or system of qualitative and quantitative evaluation of forums' participation that would be agile, practical, objective, realistic, easy to be implemented and transparent to the student.

Consequently, the research questions are:

1. Do forums increase creativity?
2. What should be the model of qualification for teamwork contributions and individual interventions, and consequently, what should be the evaluation and reward model?

1.2 Context

This paper describes a series of practical laboratories developed in the area of Industrial Organization, in English and Spanish, with students of different nationalities in the subjects Fundamentals of Business Management (second course of

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Mechanical engineering degree), Business Administration (third course in Technical Telecommunication Engineering), Marketing Management and Production and Logistic Systems (last Industrial Engineering course).

The problems to be solved are based on descriptions of real and practical situations taken from the economic and business environment of the manufacturing and heavy industry—secondary economy sector—and are founded on the application of "*methodology Case 3.0*", created by [5] and also known as "*analysis of case study*" that was applied for the first time at Harvard University as a learning technique at the beginning of the last century.

The "*Case Method*", is also known as "*analysis or case study*" and was applied for the first time at Harvard University as a learning technique at the beginning of the last century. The objective was that students could face real situations, make decisions, evaluate actions and issue judgments and finally adopt the most suitable solution.

These series of practices were developed instead of the traditional master classes where the students do not take part in participatory and cooperative sessions, because the work is individual, developed in a session of three hours with no trace of the development of the work and low levels of cooperation and teamwork.

1.3 Case study: cooperative engineering business cases

Case studies can be analyzed individually by the student or in group. However, there are different studies showing that case studies are best taught in a collaborative environment [6]. The interaction with peers and lecturers during case discussion improves emotional engagement, which plays an important role in academic performance [7]. Therefore, a collaborative methodology is applied in this study through the use of online forums.

With the introduction of forums in the study of the cases the students participate in "*formal*" team works, [4, p. 45] terminology that means groups of students acting for several weeks, instead of only two hours, sharing common goals with the objective of completing the learning task.

The debates should be self-sufficient, and students must have prior knowledge required for the development and resolution of cases with the minimum intervention of the teacher, [8]. It was intended to create a real experience of cooperative learning techniques where there is "positive interdependence and individual accountability". The term "positive interdependence" is used to mean that group-mates work together to complete a task, [9].

According to [10], large discussion forums present limitations in the interactivity level, while small-groups enhance quantity and quality of participation. Within these small-groups, [8] found a positive correlation between group size, ranging from 2 to 10, and frequency of knowledge construction occurrences in forums. Anyway, there is not a common agreement about the adequate group size as many factors can influence such as the type of activity, the heterogeneity of the members of the group, level of skills of students, or the topic which is learnt. For example [10] finds the optimum size in 5 members while a size of 4 is recommended by other authors [11].

So, groups or team works (4 members per group on average) were involved per forum competing each other to reach to the most suitable solution. In total 39 discussion forums were developed for five consecutive academic courses (9 semesters) in the period from January 2007 to December 2012 with 702 students participating.

This complete context provides a wide variety of situations during the diverse **phases of the discussion process**, each one with different characteristics, nuances and peculiarities which helped to give consistency and solidity to the study.

Fig. 1 shows the evolution of a typical forum in terms of duration and the tasks performed in the different stages.

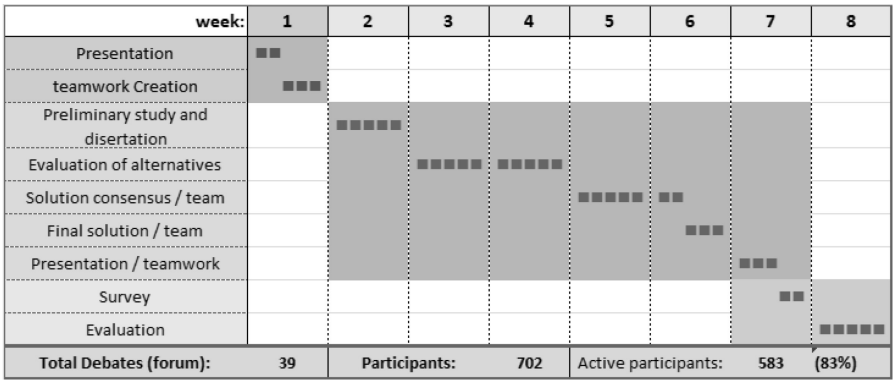

Fig. 1. Evolution of a forum (layout) and number of participants.

2. Material and methods

In recent years, text analytics has gained a lot of attention in commercial contexts, because it helps decision makers to understand people behavior or to predict market trends from their texts in tweets, blogs, forums, etc. [12]. In the academic area, analytics also provides the opportunity to improve learning and assessment processes, as well as commercial and administrative procedures [13]. A text mining technique has been used in this case to extract useful information (patterns, models, trends, rules, etc.) from unstructured text documents. Specifically, in the context of the study, it is possible to talk of **EDTM** (*Educational Data Text Mining*) as data are pieces of student's text that require a process of preparation using "*text mining techniques*" before trying to infer models and rules of behavior from the conversations, (see Fig. 2, where the stages of a typical text mining process are displayed) [14].

In Data Mining it is usual that several sources of data have to be analyzed. However, in these experiments only a single source (text registers) is provided and it is not necessary to apply a previous process of integration or aggregation of data from different environments, but in any case, a cleaning process of deletion of irrelevant data has to be applied (paragraphs with errors or no relevant information) before starting de phase of analysis.

In qualitative analysis the most important is to eliminate the superfluous and try to reduce redundant descriptions, explanations, etc. The "*process of cleaning*" is essential as [1, p. 470] indicates "messages or queries posted to a discussion forum often span multiple sentences, are incoherent (in the computational sense), include extra (informal) content and lengthy description, especially in technical discussions".

It is necessary to develop a procedure to transform the "plain text" obtained (see Fig. 3), into a more easily and actionable data structure (*minimally structured transcripts*), because in the same message there are relevant pieces of information (significant ideas) and others which had little or no relation to the case or even contain just information not pertinent for the study. As [15, p. 370] declares "only messages with content related to the course matter improved the accuracy of all the algorithms in all cases".

The instructor needs to know what information is useful to extract from the transcript to begin a valid evaluation of student performance in the forum and develop meaningful feedback to the student. The instructor also needs to have a comprehensive view of the information that is contained in the written dialogue [3]. The data-mining technique is capable of providing relevant information or prompters and helps students refer to more relevant information during discussion, which leads to more extensive and in-depth discussion [16].

It was necessary to apply a "*normalization process*" to the texts, so we can talk of a process of **Text Structured Mining**, which requires determining the conceptual units or attributes that are going to be analyzed and establishing the relation among them. The coding scheme of messages is generally regulated to simple counting and categorization of contributions that are easily visible within the forums transcript [17].

The initial step consists of carrying out an analysis of the structure and standardized transcripts to transform them into "*meaning units*" and "*specific categories*", according to the type of message under discussion.

Since the series of data is sequential, it is not necessary to apply a process of clustering or grouping records by common attributes, but only to apply a mechanism of filtering and aggregation that occurs when different types of information are mixed in the same message [18].

In Fig. 3 we can see the mixture of different ideas among different kind of information (paragraphs and phrases) on a sample of plain text of the discussions where it is necessary to differentiate the significant data and, among these, the important

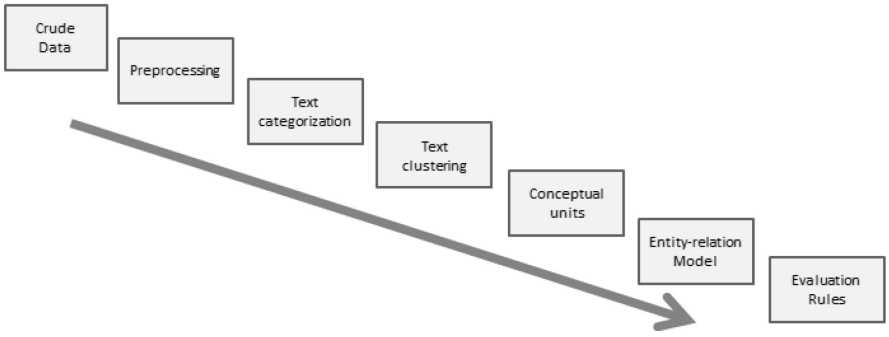

Fig. 2. Educational Text Mining Process used.

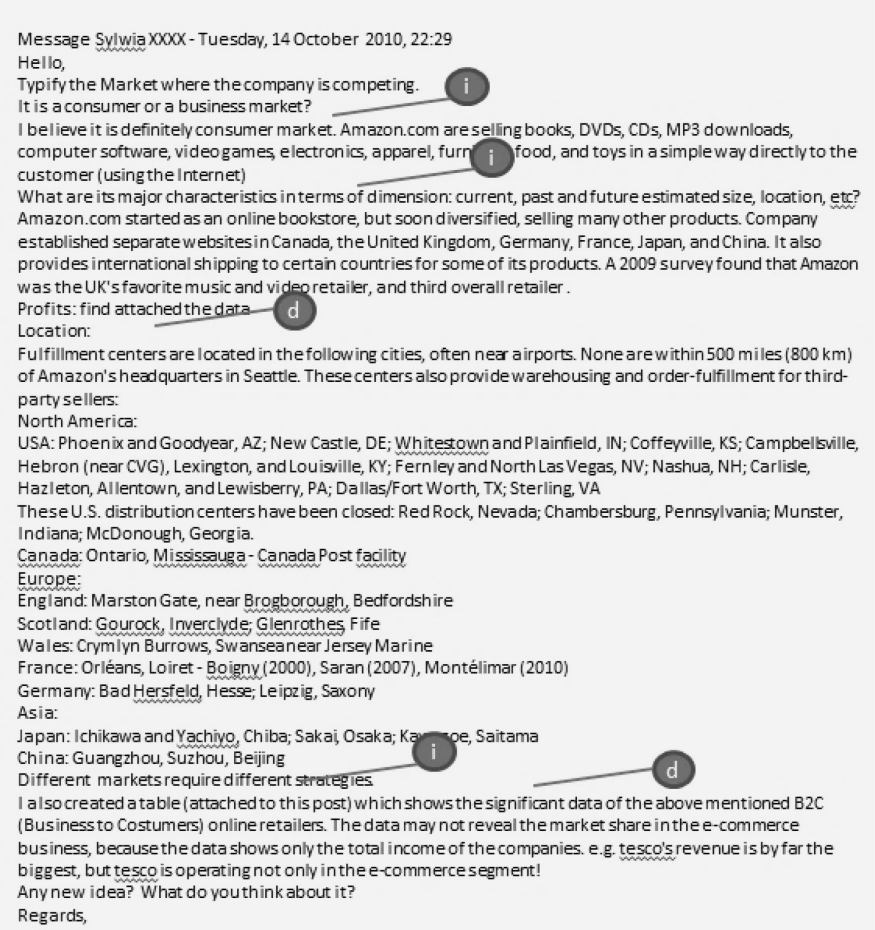

Fig. 3. Crude data example: message inside a conversation with different ideas (i) and data (d).

Table 1. Strategy of Analysis

Topic	Generalization	Differentiation
Coding	General division	Specific categories
Sizing	General dimensions (direction, Location, position)	Concrete dimensions (performance, specific topic, particular aspect)

ideas, the secondary ones, and even to classify then according to certain criteria. Two different general strategies can be applied: generalization or differentiation.

Table 1 shows the differences between generalization and differentiation. Generalization strategy moves from the particular details towards the general, paying attention to the important details and grouping them into more general meanings. On the contrary, the differentiation strategy moves from general ideas to particular things, from the top to the bottom.

A ''generalization strategy'' is not considered appropriate in qualitative data analysis of forums information since it develops dozens and even hundreds of different codes, and when interpreting small data segments, almost line by line, we run the risk of not distinguishing the essential, so in this case a differentiation process is applied.

3. The evaluation model

Students exchanged on a regular basis various types of information in a same message repeated periodically according to a certain pattern of behavior.

To implement a strategy of differentiation it is necessary to identify the basic unit of information to be exchanged. A ''*unit of meaning*'' is the minimum unit that has to be identified as a basic source of significant information that contains an important concept or entity to be taken into consideration: in this research an original ''*idea*'' conceived by a single student. To reconstruct the ''*meaning system*'' con-

sists of identifying "*units of meaning*" and determining the regular links among them in the text.

The professor will identify the basic units of information ("*units of meaning*") to be exchanged that need to be differentiated, categorized and classified. The characteristics of the basic unit of information will depend on what we want to investigate, the objectives of the research, and to do this we have to build a system of meanings recognizing regular links between the text data, unifying significant segments and associating them with a code that identifies the distinctive unit of information.

The "*Entity-Relationship*" theoretical model is applied [19], as the most appropriated for a process of qualification because it uses the concepts of entity, attributes and relationships to text analysis. In this particular case, three types of dimensions were established: *information units*, *dimensions*, a significant general aspect to qualify the information units from the pedagogical point of view, and finally the *topics of discussion*.

Only with this approach, a global view of the text can be achieved without falling into the mistake of choosing just some partial aspects, maybe isolated from their context, through the subjective point of view of our personal analytical perception. It is necessary to avoid the common mistake of reducing the encoding scheme to a simple counting and classification of contributions that are easily visible in forums transcription.

The following steps were developed manually by the instructor:

(a) To rebuild the subjective system of meanings of the text through the "meaning units" selected from the text database files.
(b) To seek for regular links among units of meaning.
(c) Identify them within a certain typology or classification.

The interpretation and validation of the information of this research procedure is based on previously made patterns or models and, in addition, it might be influenced by the bias perpetrated by the fact that the data are under the direct control of the researcher.

In each research phase, it is necessary to carry out the process in an unbiased way because, as [20] argues in his study on the development of scientific, knowledge is articulated around two key issues: "ontological impartiality and impartiality of procedure". The first one refers to "the willingness to establish a true and impartial version of the reality". The procedure followed a systematic process of external supervision, continuous reflection and recursive analysis by two external observers with experience in the methodology of the forums and in the didactics of the industrial organization engineering.

3.1 The use of categories

The word "category" generally refers to a concept that encompasses elements or aspects with common characteristics or which have a relationship among them and it is used to establish classifications, grouping elements, ideas and expressions around a concept.

A pioneer in the use of categories, [21] argues that in social science every object under investigation has multiple attributes, relationships and situations so the researcher should identify the relevant aspects of the components and describe each object using a personal system of "*categories*".

The process of "*categorization*" consists of providing a variety of *categories*, qualifying data to facilitate the description, understanding the meaning and deepening in the subject. Categories or significant classes have to be established according to the meaning of each sector, message, event, or single data.

For [22] the use of categories is very useful to categorize interventions and consequently to assign scores according to the type and level of the intervention. A practical way to use categories is that every time the student starts a speech in the debate he should assign his intervention to a type of predefined standard "category" according to the kind of contribution that the student wants to make, so the label or identifier of the message intuitively shows the kind of information contained. According to the findings of [23] the use of categories promotes the consistency of the information and increases the level of cohesion in the conversation. Unfortunately, the management tool of the forums available for this experiment does not allow the use of such kind of categories and the process of categorization must be done by the instructor after analyzing the texts.

The following aspects have been taken into account to determine categories in the present evaluation method:

(a) The level of knowledge of the participants.
(b) The ability of analysis, synthesis and abstraction.
(c) Whether conceptual mistakes were made in the interventions.
(d) The order followed along the dialogues.

The methodology [24] for reducing texts was adapted to the following sequence of actions:

1. To identify a main idea or "*central category*".
2. To find the "*subordinate categories*".
3. To examine the hypothetical relationships

between subcategories and between these categories and the main idea comparing text segments.

3.2 *Process of codification*

Coding must precede categorization, so is necessary to identify the basic units of information, assign a code and finally to group them by category. As the forums management tool does not allow making a previous labeling of each intervention, it was necessary, after analyzing the texts, to designate different codes to the basic ideas (''*units of meaning*'') included in a message.

Therefore, certain codes were created that as far as possible covered the varied types of information to be exchanged in messages. Applying a differentiation strategy two different types of ''information units'' has to be considered:

Message (M): ''Complete communication unit of the forum messaging manager that contains general information sent by a member of the debate''. A message of this type can be used to initiate, continue or terminate a communication and may contain several types of information in its body or in additional attached files. Members who have subscribed to a forum receive a copy of every message sent to the forum in their mailboxes instantly.

Idea or interpretation (I): ''Basic significant unit of information that should be encoded.'' A message may contain one or several different kinds of ideas.

In this way a message (**M**) could include several ideas or interpretations (**I**) that have differential identity, consistency and coherence and require an individualized treatment.

Relying on [25], the interactive responses must be differentiated of those that are not, as well as the contributive ones, so it was considered essential to introduce also the concept of ''*Collaborative Idea*'' (**CI**) as a communication unit that encourages dialogue between members of a debate creating new ideas or continuing and/or replicating in a contributive way to any previous characterized information.

In the Fig. 4, the message (M) includes several basic ideas or ''*units of meaning*'' with different codes, R (Reflection), N (New idea), IS (Special Intervention), IES (Special Excellent Idea) and D (Dummy or trivial information).

The types of encoding and categorization are also directly related to the objectives of the process of evaluation and the dimensions or basic aspects to be

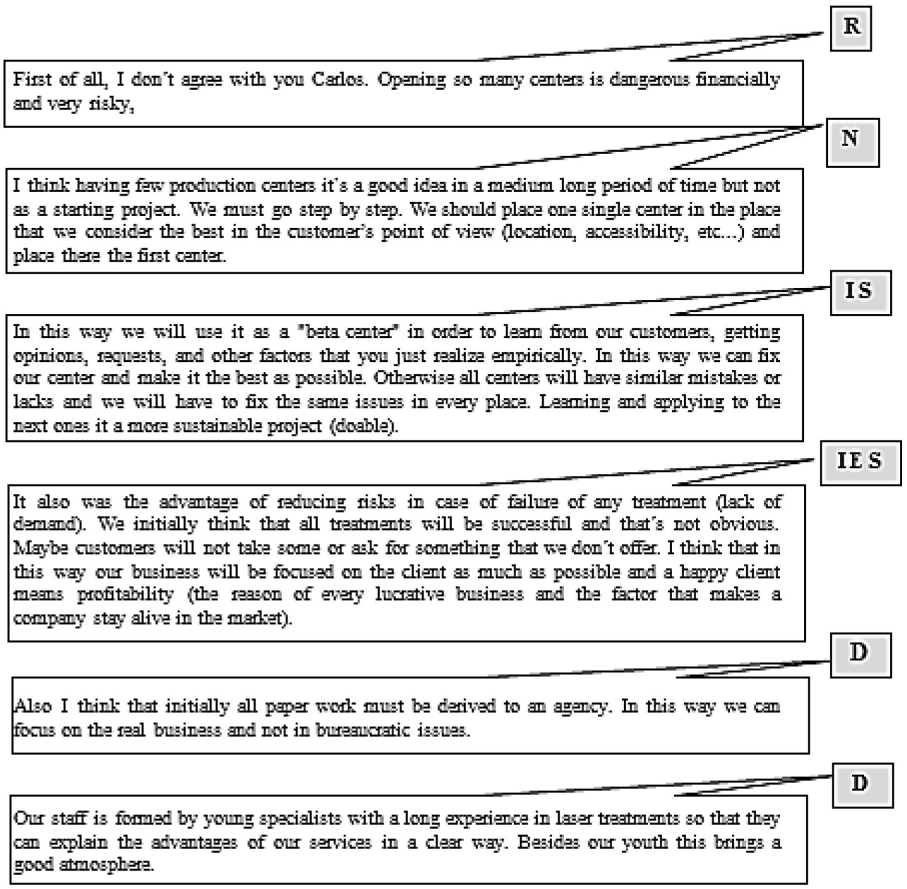

Fig. 4. Sample of a message of one of the forums with different paragraphs identified and coded.

evaluated. These dimensions or aspects of the assessment process determine different codes or categories to be assigned to different basic ideas or "*units of meaning*".

The aspects to be evaluated in the experiment are:

(a) The student activity.
(b) The degree of effective interaction of students.
(c) The level of knowledge, relevance or significance of the contributions of students.
(d) The quality of the rules applied in the organization of the forums.
(e) The creativity of the contributions and exchanged information.
(f) The excellence or notoriety of the arguments and conclusions.

These factors are associated with *dimensions* or the major aspects or basic characteristics to be evaluated. In these experiences the major dimensions to be evaluated are: order, collaboration and knowledge.

Table 2 shows these dimensions and their associated ideas with the codes.

3.3 The evaluation method

The evaluation process is a complicated and laborious process that has been studied by many authors. We agree with [26] in the need to identify patterns of dialog and evaluate individual participation, according to the number and duration of contributions and the evaluation of the group according to the number of interventions among members. Other authors such as [17] classified the interventions according to the type of intervention and levels of discussion in the different phases of the discussions.

For a correct assessment of students in their participation and contribution to the discussions, the following five factors were considered (see Table 3):

(a) The student activity in their interventions.
(b) The degree of effective interaction or cooperation of students.
(c) The level of knowledge, relevance or significance of the contributions of students.
(d) The creativity of the contributions and exchanged information.
(e) The excellence or notoriety of the arguments, the conclusions reached, and the data and information exchanged.

The evaluation system should be qualitative, transparent and shared with the participants and is defined with the intervention of the external evaluators. The phases of the evaluation system are:

(a) To qualify the number of interventions of each type per student and per group.
(b) To determine the coefficients or levels of the different aspects that interested to evaluate (Table 3): level of activity (NA), interaction (NI), knowledge (NR), organization (NO), creativity (NC) and excellence (NE).
(c) To assign group and individual score according to the reference level of the previous coefficients obtained according to the given quantitative data and weighted according to the degree of contribution to the learning objectives.

To determine the "*scale of assessment*" of each factor, it was necessary to identify and quantify the limit values for this scale. An analytical process had to be conducted retrospectively gathering all the

Table 2. Aspects to be analyzed and their type of ideas

Order	GO	General idea about organization
	FH	Fellow Help
	TH	Teacher Help
Cooperation	NC	New cooperation idea
	NR	New Reflection
	CA	Cooperative answer
Knowledge	SI	Significant new idea
	PO	Personal Opinion (not supported)
	BI	Bad or poor idea

Table 3. Quantification factors for evaluation

	Factor	Concept
A	**Activity**	Activity of the student in the debates—Number of weekly messages/student. The higher number of messages/student, the higher level of activity
C	**Cooperation**	Level of effective interaction and cooperation messages per teamwork—Number of answers or responses that create cooperation in a conversation. The higher this value is, the greater level of interaction and cooperation
K	**Knowledge**	Knowledge of the student of the subject deliberated in the discussions determined by the importance or significance of the contributions of the student. The greater idea value is, the higher acknowledge of the student (based on professor criteria)
N	**Novelty–Creativity**	% of new contributions, information or hypotheses that have a high level of novelty/total number of ideas (based by professor criteria)
E	**Excellence–Significant Ideas**	Excellence or high level of knowledge of the student demonstrated on the activity (based by professor criteria)

records in a database and identifying and classifying them by message and /or intervention, then the extreme values of the scale (maximum and minimum) had to be calculated and, from them, the intermediates ones were determined.

The student rating was calculated according to the weighted average of the objectives to be achieved, the difficulty of each debate and the values obtained for the different coefficients or levels previously considered.

4. Results

This section describes the results obtained by applying the evaluation methodology above described to the 39 discussion forums.

First research question focused on how forums help to increase the level of student's creativity. Data analysis reveals that the level of creativity can be considered high as more than 4,000 original new ideas were presented, 1.6 ideas per active message on average, while the degree of activity can be considered acceptable because 83% of students enrolled in subjects participated in discussions with an average of 7 ideas generated per student (see Table 4).

Table 4. Summary of quantitative data

Quantitative Data		
Students/debate	18	
Teamwork/debate (average)	5	
Total participants	702	
Active participants (at least 1 message/debate)	583	83%
Active participants/debate (average)	15	
Total students messages	2.624	
Messages per debate (average)	67	
Messages/active student (average)	5	
Total ideas	4.198	
Ideas/active student (average)	7	
Professor messages	105	3.8%

The level of creativity of the ideas presented was evaluated by the professor and then by the external supervisors taking into account the didactic objectives of these activities established in the teaching guides of the subjects under study.

The objective was that a student should present at least 3 significant ideas during a debate and finally this aspiration was achieved by more than 90% of students that engaged in the discussions forums (see Fig. 5) and 11% of the students reached more than 10 significant ideas during their participation in the debates.

To answer to the research question number 2 about the most convenient model of evaluation and the reward models to be applied a survey among participants was conducted which results are shown in Table 5. Most students think that the debates were very interesting (78%) and that the organization was very good (89%). It is important to drive the attention to the high levels reached in terms of personal motivation (93%) and the acceptable degree of cooperation (68%) perceived by teamwork's members.

There was no unanimity in the worthiness of the evaluation system applied: the methodology to check the level of participation was considered appropriate, however most of the students think that the effort and time dedicated to the discussions required greater weight in the final qualification of the course (see Table 5). This aspect could not be modified because the institution rules limited the weight of the qualification of such practices to 20% of the final grade of the subjects.

The availability of a more extensive temporal

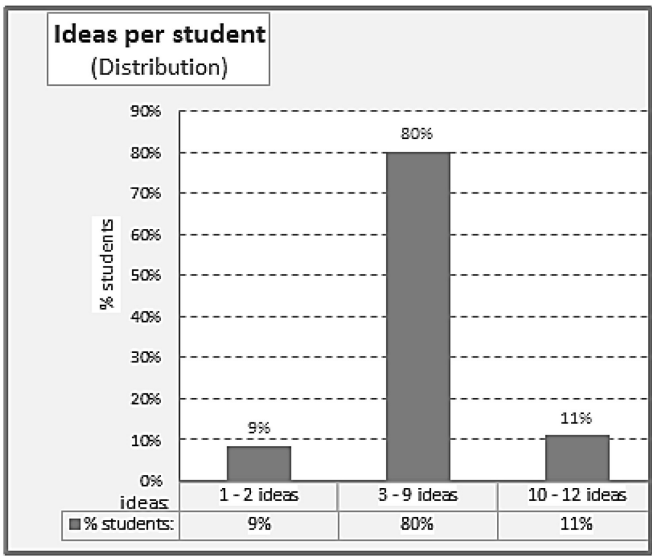

Fig. 5. Significant ideas per student (distribution).

Table 5. Qualitative results

Qualitative results	
Debates were very interesting	78%
Forum organization was of good quality	89%
The theme was very interesting	74%
There were cooperation among teamwork members	68%
Rules were clear and concise	69%
The evaluation system was correct but the weight in the final grade of the course of forums participation had to be higher	65%
Personal motivation was high	93%

horizon in each practice developed through discussion forums (weeks in the forums/hours in the face-to-face practices) and the higher degree of cooperation (Fig. 6) in the forums, originated a greater proportion of meaningful and creative ideas of the students in the case of the forums (30% higher than in face to face practices).

In general, the students considered the experiences with forums very positive; indicating that they considerably improved the learning process compared with the traditional method based on face to face classrooms (Fig. 7).

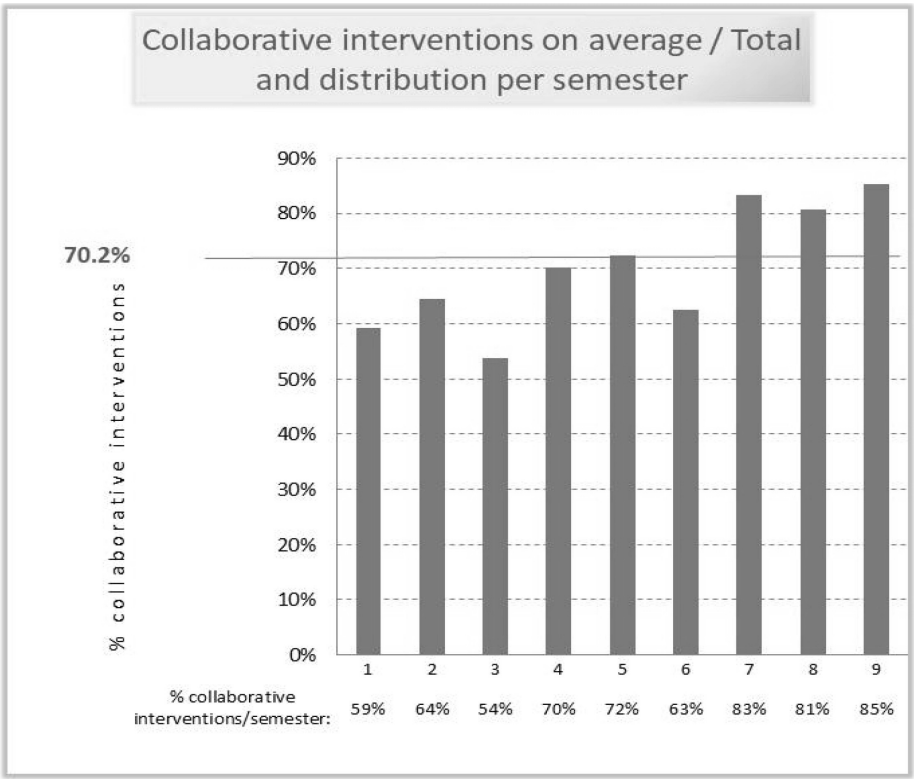

Fig. 6. Percentage of collaborative interventions/total ideas (per semester).

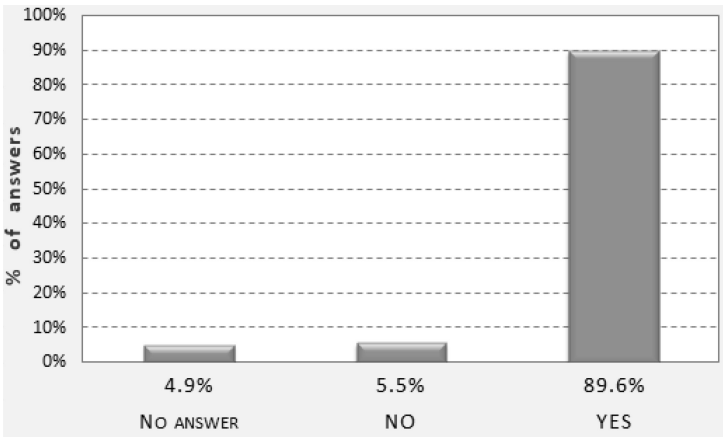

Fig. 7. Forums utility vs face to face classrooms: debates considered of great utility compared with face to face class.

5. Discussions

The results were presented as a project to improve the teaching of the Polytechnic School, by promoting creativity in students. The method has been introduced in a regular basis as a mechanism of learning Engineering Organization because it permits:

(a) To introduce new nuances to enrich and expand the area of study.
(b) To study business cases in the discipline of engineering organization from a more practical and ample prospective.
(c) To introduce new forms of collaboration outside regular classroom hours.

The researcher and the external observers, after the analysis data collected during the experiment and the survey, reach to the conclusion that the level of creativity was higher during the learning process with forums that in parallel face to face traditional classrooms. The objective of at least 3 significant ideas per student was achieved by more than 90% of students and, of these ones, 6 significant ideas were presented per student on average.

These figures improve significantly the statistics of creativity of the traditional face to face classroom where 50% of the students achieve only 1 or 2 significant ideas in their final reports allowing answering positively to research question 1.

Final solutions reached by the forums participants were compared by the teamwork of external evaluators with similar solutions obtained in face to face sessions, reaching to the conclusion that forums contribute to get more creative solutions to these kinds of problems in engineering industrial organization.

With regard to research question 2, the results allow to draw the following considerations:

- There is a series of positive aspects of the evaluation system of forums participation such as the opportunity to take into consideration a great number, type and variety of collective and individual data of the interventions and the possibility of analyzing much better aspects as level of cooperation and teamwork effort.
- On the contrary, one negative aspect is the difficulty of subsequent treatment of the activity data exchanged that increases considerably the time spent by the teacher in the evaluation process.
- In forums with more than two-week of duration it is important to make a progressive evaluation that have to be developed by stages: during the experiences the variety of students and the extensive period of debates allowed to modify the rules of the debates. Thus, during the first two years problems arose as for example discoordination of the groups of debate, organizational disorder and confusion in the dialogues. These problems were solved by modifying the rules of participation of students and teacher and establishing the need to reach partial milestones.

6. Conclusions

The great variety of engineering cases developed during these series of experience, the extensive period of time of the research, the variety of students involved, the participation indicators, the methodology applied and finally the students opinions permit to conclude that forums of this kind increase students creativity and provide an extensive framework to analyze wider and deeper the subject under study enriching the understanding of complex situations in industrial organization.

The results of this case study reveals that it is necessary to develop a policy of the use of forums and to develop an appropriate ergonomic and user friendly tools for the management of the information for the evaluator, aspects in which this paper describes new perspectives, by highlighting the drawbacks of interpreting complex Multilanguage texts. The existence of an evaluation methodology and tools that enable computer processing of data records is essential to achieve an effective and practice evaluation of students in this kind of forums.

The present study shows that the existence of deliveries and partial comments, especially when discussions are longer than two weeks, provides the ability to synthesize and learn more about the status of the discussions, something very important as a moderating action of an educational debate, allowing the moderator to make order in the issues, concrete the objectives, avoid deviations and set priorities and subtopics. A proper evaluation of the performance of these partial milestones as soon as possible along the debates allows improving the global process of evaluation and permits to introduce changes that enhance the achievement of the final goals.

This paper opens new research lines to develop a normative based on "*message categories*" that, without introducing rigidities, hampers spontaneity, improves order, spontaneity and rigor in the talks and introduces a discipline of use that makes *text mining software tools* easier.

Finally, it should be indicated that, due to the limitations in scope and time of this pilot experience, it is not recommended to generalize its results to other environments or kind of studies, nevertheless its conclusive outcomes can be used as a base to

support further investigation in *analysis of the dialogues* or *techniques of interpretation an evaluation* that could help to put ahead the use of forums in on-site universities.

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