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SUPPORTING COLLABORATIVE DISCUSSIONS ON ASYNCHRONOUS TIME

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Supporting collaborative learning discussions on asynchronous time: a technological perspective

ABSTRACT

The aim of this paper is to report on an experience of using an innovative on-line learning tool to support real, collaborative learning through discussion in asynchronous time. While asynchronous interaction gives rise to unique opportunities that support active, collaborative learning, unique problems also arise, such as frustration, caused by waiting for other peoples' reactions and feedback and the consequent loss of motivation, which has a negative impact on learning outcomes. In order to alleviate these problems, we focus the asynchronous discussion process on two crucial aspects: First, we provide an appropriate dialogue structure and conversational types that promote meaningful contributions and achieve more effective interaction. Second, we extract relevant knowledge in order to increase the awareness of learners and tutors and give them feedback on what is happening, as well as to monitor the performance and collaboration of learners. The ultimate goal is to increase the motivation, involvement and feeling of "on-site presence" among the actors participating in the collaboration and to ensure more effective support and assessment of the asynchronous discussion process in order to enhance and improve the on-line asynchronous experience. For the validation of this model, a real virtual learning environment is used to support collaborative activities based on asynchronous discussion.

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KEYWORDS

Collaborative learning tool; Asynchronous collaborative discussion; Interaction data analysis; Knowledge management.

INTRODUCTION

The discussion process plays an important social role through which participants can think about the activity being performed, collaborate with one another by exchanging ideas, propose new resolution mechanisms, and justify and refine their own contributions, thus acquiring new knowledge (Stahl, 2006). In this context, when developing applications for on-line collaborative learning in general and collaborative discussions in particular, several issues must be taken into account to guarantee full support to the on-line learning activity. One key issue is the asynchronous timing of the interaction, which gives rise to new paradigms for teaching and learning, with both unique problems of coordination and unique opportunities to support active, collaborative learning (Harasim, 1990).

Indeed, there is no question that the asynchronous nature of collaborative learning has disadvantages as well as advantages in comparison with traditional classroom contexts. The main advantage is convenience ("anytime/anywhere"), which allows students to have more total interaction each week with the teacher and their peers, and to learn at their own pace and at times best suited to their individual needs (Hiltz, 1997). The major shortcomings are:

- Limited bandwidth or "media richness" (Daft & Lengel, 1986) and

- The frustration of waiting for an unpredictable length of time to receive reactions or feedback.

However, the weaknesses of the asynchronous mode of communication reduce the feeling of the "social presence" of the teacher and the other group members. This can severely undermine feelings of motivation and involvement, and thus negatively affect the learning outcomes. However, by emphasizing collaborative learning we can highlight the advantages and overcome some of the disadvantages of asynchronous computer-mediated communication. One such emphasis is interaction management and analysis to support awareness, coaching and evaluation, based on information captured from the actions of participants during the collaborative process (Soller, 2001; Puntambekar, 2006; Schellens & Valcke, 2006; Daradoumis, Martínez & Xhafa, 2006; Caballé et al., 2010).

Therefore, the success of asynchronous collaborative learning applications depends to a large extent on the ability of these applications to embed information and knowledge extracted from group interaction and use it for more effective group monitoring (Dillenbourg, 1999). Given the added value of asynchronous discussion groups, one of the main elements of the UOC teaching model, it is essential to provide adequate on-line tools to support the whole discussion process, which also includes student monitoring and evaluation (Caballé et al., 2008).

Large amounts of information are generated from asynchronous discussion, which includes complex issues of the collaborative work and learning process (e.g. group well-being (McGrath, 1991) and self, peer and group activity evaluation (Daradoumis, Martínez & Xhafa, 2006).

All this information can easily be collected and automatically processed and analyzed by computers as a source of quantitative and qualitative data, before being presented to participants to provide effective information on aspects such as how the participants overall are actually performing during discussions and the dynamics of the individual participants with respect to the group. Consequently, the efficient embedding of all this information and the extracted knowledge into collaborative learning applications sets the basis for enhancing support (Puntambekar, 2006), awareness (Gutwin, Stark & Greenberg, 1995) and feedback (Zumbach, Hillers & Reimann, 2003) to ensure a successful discussion process in collaborative environments.

In this paper, all these approaches take shape with the introduction of a new collaborative learning tool called Discussion Forum (DF), which was developed to support and enhance the asynchronous discussion process used in many virtual courses of the UOC in the form of on-line discussions. This system implements many of the approaches described thus far and preliminary results taken from real collaborative learning are very promising in terms of the benefits for students in the learning context of the UOC and in education in general.

The paper is organized thus: point 2 describes the methodological aspects and main guidelines used for the design and development of DF. This design is based on the principles of a theoretical framework whose purpose is to identify and classify the main exchange categories, which describe a generic discourse goal during a collaborative discussion process. Point 3 reports the experience and evaluation results of the use of this application in a real context. Lastly, point 4 concludes by summarizing the main aspects of the contributions presented in this paper and proposes further lines of research.

METHODOLOGY

The aim of this paper is to describe the development of a prototype for a web-based collaborative learning system called Discussion Forum (DF) (Caballé & Xhafa, 2009). Here, we report on all stages of the development of this novel experience that led to the design of the prototype providing new, discussion-based learning opportunities, applied to meet new teaching needs.

TEACHING BACKGROUND AND REQUIREMENTS

This section examines how learning and knowledge building can be supported in the context of an asynchronous collaborative discussion in a virtual learning environment. Hence, we propose a complete discussion and reasoning process for modeling dialogues and understanding how learning develops and how knowledge is constructed during the discussion process.

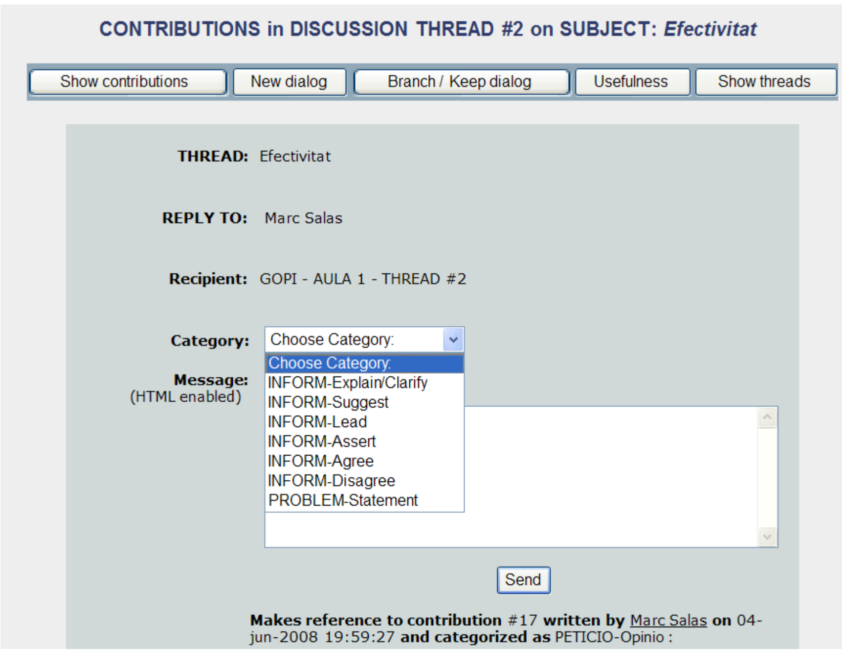
To meet the assessment requirements of the courses, contributions to discourses also need to be evaluated as effectively as possible. The evaluation of hundreds of contributions in a multi-member discussion can be a tedious task for tutors and needs adequate support. Moreover, self-assessment and peer assessment should also be encouraged and made possible by intuitive means. Thus, we need to provide a dialogue model for asynchronous discourse that can capture, analyze and evaluate both the process and the result of the building and distribution of knowledge. This model should essentially be defined in terms of types and the structure of student/student interaction.

Lastly, in discussion processes, participants play a role that differs according to their profile (e.g. coordinator, member, guest, etc.), have personal collaborative preferences (e.g. language) and must set up environment features (e.g. sound or visual effects, text or audio warnings, etc.) based on their personal characteristics. Participant needs are not static and they evolve as the discussion moves forward.

DEVELOPMENT OF THE APPLICATION

The design of DF includes certain thematic annotation tags based on the low-level exchange categories identified in point 2, such as information/clarification and requests for opinions (see Figure 1 for a subset of all categories, which can be found in Caballé et al., 2011). Each category qualifies each contribution and, as a result, structures the discussion process. To avoid unnecessary options, each discussion process context will give rise to a brief but precise list of the categories possible at a certain point of the discussion process (e.g. when replying to any sort of request, only the options for providing information are available for classifying the reply).

Figure 1. Specific list of options for replying to a contribution categorized as INFORM-Explain.



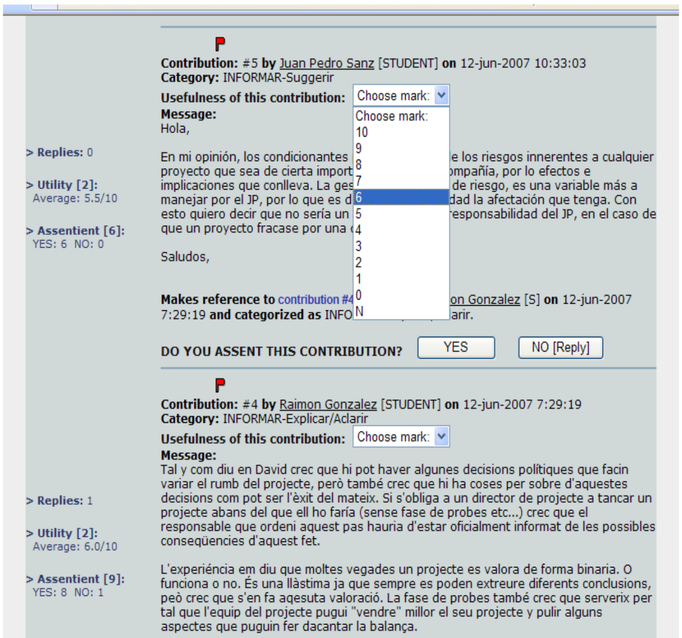
As a result, all contributions are recorded as acts of exchange, and analyzed and presented as information to participants either in real time (for direct guidance of students during the learning activity) or when the task has been completed (in order to comprehend the collaborative process). Hence, the structured interaction generated underwent full treatment, allowing the system to keep participants informed of the contributing behavior and dynamics of others, check certain argumentative structures during discussions, help find more satisfactory solutions to problems during the consensus phase and, lastly, to provide feedback based on the data produced.

Therefore, DF was especially designed to give students important extra features to support discussions in comparison to the traditional discussion tool commonly used in the virtual classrooms of the UOC, such as threads in entirely separate rooms, open/closed branched dialogues, contribution evaluation and assent (see Figure 2), contribution qualifiers (see Figure 1) and updated feedback, which includes the current average number of all contributions and complex indicators relating to the collaboration (see Figure 3). See Caballé et al. (2010b) for a general overview of DF.

COLLECTION OF INFORMATION

Consequently, the users of DF were asked to classify their contributions (see Figure 1) before sending a reply or new post and decide whether their contribution closed the current dialog. Specifically, the contributions of the participants in each thread were designed as structured dialogs with the aim of separating the different types of low-level exchange. Moreover, dialogs had to be both closed (when a request is met or basic problem is solved) and branched from a specific exchange (i.e. problem-statement) to allow different solutions to the same statement. Lastly, a contribution had to be assented to based on the context and evaluated by the other participants in terms of its usefulness in the course of the discussion (see Figure 2).

Figure 2. Rating of posts and assent addressed to students.



Discussion processs are conducted by tutors, who continuously monitor discussion threads both to assess the contributions and to offer support when needed by posting clarifying contributions in a thread and/or by starting supporting threads. Tutors assess contributions in a similar way that peers do, and this process is very smooth even with large groups (see Figure 2).

PROVISION OF KNOWLEDGE

Based on the previous assumptions, all contributions are recorded in DF as exchange movements, which are subsequently analyzed and presented as knowledge to participants either in real time (for direct guidance of students during the learning activity) or when the task has been completed (in order to comprehend the collaborative process). Finally, relevant feedback is given to the discussants and tutors based on the data collected and the following methodology, which identifies and measures relevant dimensions of the discussion process (see Figure 3)

- *Participation* behavior indicators are classified as proactive, reactive and supportive (or assentive). Participants are proactive when they take the initiative to open a new exchange of the type "give information" or "raise an issue". Participants are reactive when they reply to movements such as "elicit information", "set up an issue/problem" or "provide solution". Participants are supportive if they give their assent to previous contributions.

- Passive participants are those who merely read the contributions of others or evaluate the usefulness of these contributions.

- Impact values are assigned an initial (default) numerical value between 0 and 1, which is modified (increased or decreased) according to the impact (number of reactions received).

- The effectiveness value is calculated from the mean value of the number of assents obtained. Note that only "give information" and "raise an issue" exchange acts can be assented to. A negative assent requires a reply, which moves the discourse forward.

- Lastly, tutor and peer assessment indicators are used to evaluate the quality of the content of the contribution by the lecturer monitoring the discussion process and to evaluate the usefulness of the contribution by the student participating in the discussion. Both indicators are on a scale of 0 to 10 to ensure the accuracy of their mean values.

The tutor assessment, as with the rest of the indicators, is processed automatically and continuously by the system. For monitoring purposes, the system proposes an updated final mark for the progress of each student based on all the indicators described. The last column in Figure 4 shows a numerical mark on a scale of 0 to 10 for each student, automatically generated and updated by the system. This final mark is based on all the indicators described, which are adjusted with different weightings. For this discussion, the weightings were set as follows:

- activity: 10%;
- passivity: 10%;
- impact: 20%;
- effectiveness: 10%;
- assessment: 50%.

Note that only the tutor can access the information containing the final marks of students, since the final grades of students cannot be published in Spain, although the publishing of both the names of the students and their non-conclusive assessment (i.e. quality assessment) is permitted. These indicators must be adjusted with the appropriate weightings by the tutor in order to reinforce certain aspects of the discussion process based on the specific teaching aims of the learning task.

Figure 3. Monitoring information available to tutors. The same information, except for the last column, (Final Mark) is available to all students.

FOLDER: #3 - Debat 2

Description: Espai de debat 2.
Created by: Marius Gomez [TUTOR] **on** 25-may-2008 12:00:03
FOLDER DATA:
N. contributions:: 90 **Quality of this folder:** C+ **Usefulness of this folder:** 6.1/10 [227 Vots]

STUDENT STATISTICS

STUDENT POSITION		ACTIVITY				PASSIVITY		IMPACT		EFFECTIVITY	ASSESSMENT		
Pos.	Student	Total contributions	Proactivity	Reactivity	Support	Pending to read	Pending to evaluate	Particip. impact	Replies received	Assientment rebut	Peer assessment	Tutor assessment	FINAL MARK
[1]	Andreu Cuartiella	2/90 2.2%	1/2 50%	1/2 50%	0/2 0%	85/88	86/88	-0.5	1/2	5/5 100%	6.2/10 (4)	B	6.58
[2]	Francisco Garcia	11/90 12.2%	2/11 18%	9/11 81%	0/11 0%	0/79	0/79	-4.5	4/11	3/3 100%	6.3/10 (12)	B	6.57
[3]	JuanPablo Nieto	4/90 4.4%	4/4 100%	0/4 0%	0/4 0%	51/86	86/86	16.5	5/4	17/18 94%	6.8/10 (17)	B	6.53
[4]	Alejandro Lluvia	5/90 5.6%	2/5 40%	3/5 60%	0/5 0%	23/85	42/85	4.5	3/5	7/9 77%	6.7/10 (11)	B	6.46
[5]	Joan Barcelo	4/90 4.4%	2/4 50%	2/4 50%	0/4 0%	39/86	39/86	7.0	4/4	15/16 93%	6.0/10 (9)	C+	6.21
[6]	Miquel Ollers	7/90 7.8%	1/7 14%	6/7 85%	0/7 0%	52/83	67/83	6.5	8/7	42/48 87%	6.4/10 (23)	B	6.15
[7]	Manel Herrera	2/90 2.2%	1/2 50%	1/2 50%	0/2 0%	54/88	61/88	9.5	0/2	12/12 100%	6.6/10 (5)	C+	6.14
[8]	Vanesa Pose	2/90 2.2%	0/2 0%	2/2 100%	0/2 0%	85/88	88/88	-1.0	1/2	17/18 94%	6.7/10 (7)	B	6.05
[9]	Maria Guiu	5/90 5.6%	0/5 0%	5/5 100%	0/5 0%	40/85	85/85	-2.5	4/5	15/18 83%	6.1/10 (17)	B	5.84
[10]	Laura Risco	6/90 6.7%	1/6 16%	5/6 83%	0/6 0%	67/84	84/84	-2.5	5/6	16/17 94%	5.4/10 (15)	C+	5.8
[11]	Francisco Rios	12/90 13.3%	1/12 8%	11/12 91%	0/12 0%	0/78	78/78	1.5	10/12	38/46 82%	6.3/10 (27)	C+	5.75
[12]	Pau Ubach	10/90 11.1%	1/10 10%	9/10 90%	0/10 0%	54/80	66/80	-4.5	7/10	20/23 87%	5.4/10 (18)	C+	5.59
[13]	MariaTeresa Mestre	1/90 1.1%	1/1 100%	0/1 0%	0/1 0%	87/89	89/89	9.0	0/1	9/9 100%	5.2/10 (5)	C+	5.47
[14]	SergioJose Mallorquin	4/90 4.4%	2/4 50%	2/4 50%	0/4 0%	37/86	85/86	5.0	2/4	7/9 77%	6.2/10 (12)	C+	5.33
[15]	Pere Urbon	3/90 3.3%	2/3 66%	1/3 33%	0/3 0%	80/87	84/87	2.5	3/3	4/6 66%	5.9/10 (13)	C+	5.29
[16]	Pere Madrona	2/90 2.2%	0/2 0%	2/2 100%	0/2 0%	68/88	88/88	-1.0	0/2	0/0 0%	5.8/10 (5)	B	4.53

RESEARCH METHODOLOGY

To evaluate the DF prototype and analyze its effects on the discussion process, 80 graduate students who enrolled on the Methodology and Management of Computer Science Projects course last term took part in this experience. Students were split equally into two classes and took part in the experience at the same time. Students from one class used the standard asynchronous threaded discussion forum offered by the virtual campus of the UOC while the other group of students used the new DF outside the virtual campus to support the same discussions according to the same rules and at the same time (i.e. five weeks in all).

The experience consisted of two discussion assignments separated in time with very different goals and procedures in order to validate the flexibility of the approach. The first assignment lasted two weeks in both groups and required discussion of the same issue: project management requirements vs. product requirements. In this assignment, each student was required to start a discussion thread by posting a contribution on the issue in question, which resulted in as many threads as students. At the end of the discussion, each student was asked to close his/her thread with an improved contribution on the issue according to what s/he had learnt in the discussion. During the discussion, students could contribute both to their own and any other discussion thread as often as necessary, as well as starting additional threads to put forward new arguments or approaches relating to the issue addressed. The aim was to evaluate the effect of the discussion process on the acquisition of knowledge by each student, by comparing the quality of the first and last contributions posted by each student on each thread.

RESULTS AND DISCUSSION

A statistical analysis of the results on the first discussion comparing the standard and DF tools is shown in Table 1. Although the standard tool generated more threads, most were actually empty (i.e. just 8 threads had more than 1 post, compared to 42 threads in DF). Moreover, the SD statistic for the mean of posts/thread appears to be high in DF, which points to the heterogeneity of the discussion, which involve threads of very different lengths. Note that the very high SD statistic in the mean of posts/students is due to a single outlier, without which the SD is 6.3. Lastly, statistics on quality are shown in terms of the number of words per contribution and the tutor assessment of the content. The higher number of number of words in the standard tool is due to the lack of discussion, since most threads were simply started with a long opening contribution as a problem statement. DF, however, generated actual discussions and, as a result, the contributions became highly structured and specific. The tutorassessment row refers to the average quality of content of all of the contributions.

Table 1. Main statistics extracted from the first class assignment using both discussion tools.

Statistics	Standard tool	DF
N umbers of students	40	40
Numbers of threads	48	44
Total posts	95	351
Mean number (posts/thread)	M=1,9 SD=2,4	M=7,9 SD=5,0
Mean number (posts/student)	M=2,3 SD=1,9	M=8,7 SD=8,1
Mean number (words/contribution)	M=352 SD=139	M=286 SD=85
Tutor assessment (average, out of 10)	7,2	7,6

The qualitative evaluation of this first discussion was carried out both by examining the discussion threads containing enough discussion (i.e. more than 7 posts) and by checking whether the student responsible for each thread had posted both a starting and closing contribution on the same issue. The results for DF showed that, in the 28 threads fulfilling these requirements, 32% of students improved their qualitative mark through the discussion in their threads, 68% obtained the same mark, and none saw their mark reduced. No results were extracted from the discussion using the standard tool as the contributions were poor, with just 8 threads showing some form of discussion and only 4 with more than 7 posts.

The second assignment for the two groups was completed at the end of the same academic term, one month after the previous one was completed, and lasted for three weeks. It consisted of discussing the closing stage for a software project. The procedure was as follows: students were free to start zero, one or several discussion threads in which they proposed specific aims, activities and processes required to close a software project adequately. Hence, in this discussion, there was no requirement to start a discussion thread and students could all participate in discussion threads as they wished. At the end of the discussion, the students who had started a discussion thread were asked to close it by sending a contribution that summarized and concluded the main points discussed in the thread.

The statistical analysis of the results extracted from the second discussion comparing the standard and DF tools is shown in Table 2. In comparison to the previous assignment, there is a decrease in the number of contributions from the two groups. There are two explanations for this: although the number of potential participants was the same as in the previous discussion, 40% of each group had already taken the decision to drop out of the course before this second discussion started and, as a result, most of these students did not pay attention or contribute to the discussion. Secondly, as participation was not a requirement in this assignment, some students chose not to participate.

Table 2. Main statistics on the second class assignment using the two discussion tools

Statistics	Standard tool	DF
N umbers of students	40	40
Numbers of threads	43	21
Total posts	71	199
Mean number (posts/thread)	M=1,6 SD=0,4	M=9,4 SD=3,2
Mean number (posts/student)	M=1,7 SD=1,1	M=4,9 SD=4,1
Mean number (words/contribution)	M=421 SD=139	M=310 SD=85
Tutor assessment (average, out of 10)	8,1	7,5

The qualitative evaluation of the second discussion was carried out in a similar way to the previous one. Although the standard tool had high numbers of threads, only one was actually a discussion (i.e. with more than 7 posts). Hence, it could be argued that no discussion was obtained with the standard tool. DF, on the other hand, performed much better, providing real discussions in 16 of the 21 threads started.

The mean number of words per contribution in the standard tool also rated higher than DF in this second experience. This confirms the effects of the inherent structure and richness afforded to the discussion process by DF, whereas the standard tool encourage long, monolithic one-sided points of view. Lastly, the standard tool achieved higher average marks for qualitative content of contributions.

It could be argued that most of the participants of the standard tool were good students, whose first and only contribution to a thread was correct. However, many important aspects were missed out due to the lack of discussion, such as reactive participation behavior and peer involvement skills, which are key to achieving a successful discussion process. All these aspects must be combined with the evaluation of the qualitative content to determine the final assessment of the collaborative learning activity.

Table 3 contains the results of a structured qualitative report produced at the end of the discussions for DF users, who were also asked to compare it to the standard tool they had already used on previous courses at the UOC.

Table 3. Excerpt of the findings of a questionnaire on DF and the standard tool supporting the discussion process.

Selected questions	Average structured responses (0-5)	Excerpt of student comments
Assess Discussion Forum (DF)	3	"Apart from some technical problems, DF met my expectations" "The display of statistical data and the quality assessment influenced my participation" "The standard tool is chaotic for large debates [...] The DF discussion rooms made discussion much easier for me" "DF should be used to support debates on other courses"
Evaluate how DF encouraged you to actively participate	4	
Did DF help you to acquire knowledge on the issue under debate?	4	
Compare DF to the standard forum tool of the campus	4	

Lastly, in order to evaluate the reliability of the semi-automatic assessment approach in the two assignments, the tutor supervising the discussions supported by DF was required to (1) submit an accurate assessment of the content quality of every contribution posted, which was given to students as feedback (see 'Provision of knowledge' and Figure 3 for further information on tutor assessments) and (2) manually evaluate student performance by filling out a spreadsheet that helped to grade each student's participation according to both the content quality of each of his/her contributions and the purpose and context in which the contribution took place (e.g. new argument or a reply, whether it brought up interesting opportunities for further discussion, just a greeting-type post, etc.). This second evaluation task could be complemented by extra information on individual behavior in the discussion contributed by the tutor based on his/her knowledge and experience in this type of class assignment.

The ultimate aim of this dual evaluation process was to compare the manual evaluation performed by tutors to the semi-automatic assessment process offered by the system. Hence, each evaluation process proposed a final mark for each student and a list of positions in which the students were ranked by their final marks. In the semi-automatic evaluation, the system looked at four indicators, namely activity, passivity, impact and effectiveness, which accounted for 50% of the automatic evaluation. The rest of the evaluation came from the quality indicator, which was calculated by the tutor in charge of assessing the quality of content of the contributions (40%), and the peers, who assessed the usefulness of other students' contributions as an average. These percentages may vary according to the type of discussion and can be set by the tutor. The manual evaluation process was carried out entirely by the tutor and followed the same assessment procedure as the one used by the standard discussion tool of the UOC.

The results of the semi-automatic assessment were very promising since the tutor in charge of DF agreed with the final marks proposed by the system in more than 75% of cases. A total of 31 out of 40 students in the DF classification had the same position in the classification on the tutor's spreadsheet. The tutor also reported promising benefits from DF in discussion monitoring, since the new tool relieves tutors and moderators from the tedious task of manually tracking and evaluating the dynamics and outcomes of the discussion. However, a clear inconsistency was identified since all of the final marks proposed by the system were an average of 1.1 points less than the mark proposed by the tutor, thus indicating the need for a more objective weighting of indicators in DF. Overall, while these results are not conclusive they do encourage us to undertake more experiments – and validation processes in particular – in the semi-automatic assessment approach.

CONCLUSION

This paper describes a promising attempt at enhancing knowledge management that contributes to the improvement of the asynchronous discussion process in virtual collaborative learning environments. Firstly, we pinpointed and analyzed the learning advantages of the discussion process when the discussion takes place in asynchronous time. However, certain potential disadvantages of asynchronous time must be considered, including frustration, caused by waiting for other peoples' reactions and feedback, and the consequent loss of motivation, which has a negative impact on learning outcomes. The results show that we can alleviate these problems through the analysis of interaction data on what occurs during the discussion and feeding this knowledge back to the students. The technological approach described in this contribution certainly attempts to fill the gap left by the asynchronous nature of on-line discussion by creating a sense of "presence" of the student's tutor and peers and by increasing student motivation and involvement, and, hence, their engagement in the on-line learning process.

The experience of an innovative Discussion Forum reported in this paper constitutes a significant step forward in the development of distance learning tools that support on-line asynchronous discussions (see the developments described in the studies by Hew and Cheung, 2008; Schrire, 2006; De Wever, et. al., 2006; Schellens & Valcke, 2006). Although the results are not conclusive due to their exploratory nature, they promise significant benefits for students in the context of project-based learning and in education in general. In particular, a multi-functional model has been built that fosters knowledge sharing and construction, develops a strong sense of community among students, provides the tutor with a powerful tool for monitoring students and regulating discussions, while encouraging the formation of peers through self, peer and group awareness and assessment.

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