Towards an Electronic Voting System in Support for Consensus in On-line Learning Discussions

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Abstract

Many e-learning tools have been widely used in on-line learning settings to support on-line classroom discussions. A typical discussion and reasoning process is based on three stages or types of generic contributions, namely specification, elaboration and consensus. While the two first stages are fully supported by current e-learning tools and systems, the consensus stage is usually neglected. To overcome this deficiency, in this paper we propose an electronic voting system to support on-line discussions and in particular the consensus stage as part of collaborative learning practices. For validation purposes we test a proof of concept of our application in order to validate the notion and nature of the EVS. The results show that our application enhances and improves the user's experience in on-line discussions and during the consensus stage. Furthermore, it is shown that innovative uses of this application can meet new pedagogical needs in an e-learning context.

1. Introduction

The discussion process plays an important pedagogic and social task where participants can think about the activity being performed, collaborate with each other through the exchange of ideas that may arise, propose new resolution mechanisms, as well as justify and refine their own contribution, and thus acquire new knowledge [1]. The discussion and reasoning process is based on three types of generic contributions, namely specification, elaboration and consensus [2]. Specification occurs during the initial stage of the process carried out by the tutor or group coordinator, who contributes by defining the group activity and its objectives (i.e. statement of the problem) and the way to structure it in sub-activities. Elaboration refers to the contributions of participants (mostly students) in which a proposal, idea or plan to reach a solution is presented. The participants can then elaborate on this proposal through different types of participation, such as questions, comments, explanations and agree/disagree statements. Finally, when a correct proposal of solution is achieved, the consensus contributions take part in its approval (this includes different consensus models, such as voting [3]). When a solution is accepted the discussion terminates. Therefore, the consensus phase becomes an essential part of the discussion [4]. However, despite the many e-learning tools and systems supporting on-line discussions, a very few consider the consensus stage [3], [4].

Electronic Voting Systems (EVS) have been widely used for several purposes, such as elections and polls [5], assessments tests [12] and Audience Response Systems (ARS) [13] among other uses. However, the application of EVS for pedagogic purposes has been, to the best of our knowledge, little investigated [3]. In this paper, the concept of EVS is further exploited in the context of on-line discussions to show its suitability to support and assist students and tutors during the discussion process, and in particular during the consensus stage. To this end, an EVS was developed in conjunction with an advanced discussion tool to support large in-class discussions in formal e-learning.

The research presented in this paper is currently undertaken in the context of the Open University of Catalonia[1] and in particular as a Master's thesis [6] in the area of Computer-Supported Collaborative Learning (CSCL) [2], [7], [8]. This interested area is intended to provide graduate students with specific resources to assist them during all the stages of their developments. Representative resources are a software platform called Collaborative Learning Purpose Library (CLPL) [9], which helps develop CSCL applications in a systematic and effective fashion, and a collaborative learning tool called Discussion Forum (DF) [10] (built through the extensive use of the CLPL) that provides advanced support to on-line discussion processes in the collaborative learning

[1] The Open University of Catalonia (UOC) is located in Barcelona, Spain. Since 1995, the UOC offers full distance tertiary education via Internet to currently 60,000 students. http://www.uoc.edu

courses of the UOC. These two resources have become essential for all the development projects carried out in this area of Master's thesis [9], including the EVS system presented in this paper, which extensively leverages the CLPL platform and the resulting application is integrated into the DF, thus enriching this discussion tool with specific support to the consensus stage of the discussion processes.

The rest of the paper is organized as follows. Section 2 presents the state of the art of existing EVS systems currently used to support discussions for different purposes. Section 3 describes the main guidelines that conducted the design and development of the EVS and its integration into the DF tool that overall gives new opportunities to learning by discussion and is applied to meet new pedagogical needs. A proof of concept of the resulting EVS and a technical testing on is reported in Section 4 for validation purposes. Finally, Section 5 concludes the paper by summarizing the main ideas of this contribution and outlines ongoing and further work.

2. Background of EVS Systems

Using EVS systems to support on-line discussions is not something new. A common usage of an EVS in the discussion context is to promote user contributions by peer evaluation. Some decision-making forums and web pages like *Yahoo Answers*[2] or *Quora*[3] follow this approach. On the same basis, the project Y*ourconsensus* [4] provides a new approach for a consensus in the discussion process by using categories or tags for each post, such as rejection, objection or reservation. Peer evaluation and tagging are found in some discussion tools, such as the DF, to provide the intention and summary of the posts [10]. However, by just tagging posts during the elaboration stage, consensus is not reached as without specific support for consensus the discussion becomes an ordered, well tagged discussion.

Moreover, Virtual Learning Environments (VLE), such as Moodle[5], are nowadays working in supporting face-to-face or blended courses instead of full distance courses. Actually, most of VLE focus on EVS in combination with *responseware* systems (ARS) as a catalyst for lectures [11]. Having a poll, a survey or even an assessment test in a discussion forum it is not a new concept but having an EVS that focuses specifically on collaborative learning has been, to the best of our knowledge, little investigated. In addition, existing EVS solutions offer an ad hoc approach that does not fit specific CSCL educational needs. These motivations guided us to develop an EVS system to extend common discussion forums and their uses both for consensus purposes.

Previous studies on EVS [14], [15] prove that the successful use of EVS tools to support in-class assignments based on discussions comes from fostering the interaction in the classroom rather than from the voting system itself [14]. In addition, it is reported that a large number of students feel uncomfortable in asynchronous communication from EVS tools due to the lack of technical skills and the public identity exposure [15]. Finally, educational and CSCL features are to be considered in addition to pure voting functionalities, such as providing knowledge in terms of awareness and feedback to students and tutors in terms of evaluation and monitoring [10] on the EVS usage and activity thus increasing students' participation and engagement in the discussion-based collaborative practices.

3. A New EVS in Support for Consensus in Discussion-based CSCL Practices

In this paper, we describe the development of an EVS and its integration with an existing discussion forum tool (DF) in order to support the consensus phase in the discussion process. This novel experience is reported here from all stages of its development that conducted the design of the EVS prototype that gives new opportunities to learning by discussion, and is applied to meet new pedagogical needs. To this end, a discussion and reasoning process is first described briefly in the form of requirements and then the design of the application is treated in certain detail.

3.1 Pedagogical Purposes and Requirements

This section examines how consensus can be supported in the context of an asynchronous collaborative discussion in a virtual learning environment while fostering interactivity, easy query creation, privacy and knowledge management. To this end, we propose a complete discussion and reasoning process for modeling consensus and understanding how learning evolves and how knowledge is consolidated during the consensus stage of the discussion process. In this process, we consider consensus as a three-phase stage, namely query creation, voting (i.e., decision-making) and collection of the results. In addition, we consider that group discussions usually involve the role of the group coordinator. This role, named *facilitator*, is responsible

[2] http://answers.yahoo.com/
[3] http://www.quora.com/
[4] http://yourconsensus.org/
[5] http://moodle.org/

for the consensus stage and in particular s/he can assist in the crucial phase of the query creation so as to facilitate the participation of non-technical students in the discussion. Also, discussions in small groups can prevent participants from large public exposure.

Counting votes in democracy usually implies a winner option and complex algorithms. For the sake of the pedagogical purposes of our EVS system there is no need for a winner option. In case of two options with the same number of votes the EVS determines that consensus is not achieved and further discussion is needed or queries need to be reformulated. Participation, usefulness and other factors as blank votes may help decide the reasons about a draw situation with the ultimate responsibility of the facilitator to determine when and how consensus is achieved and whether more discussion or new queries are needed. Eventually, the discussion process is assisted by the EVS, which in turn relies on the group facilitator to decide about whether consensus was achieved or not in the group.

Finally, despite open answers, ranking counting and so on provide more users' input information, simple queries are easier to implement and create by all type of users, and particular non-technical users.

3.2 Application Design

The design of the EVS includes a simple one-click form template in order to make the query creation easier to use to all users. In addition, in order to facilitate the voting during consensus, contributions to be voted are listed by certain parameters, such as contribution usefulness provided by peer evaluation in the moment of the query creation. Votes are not publicly uncovered, they cannot be changed once they are cast and users can cast just a single vote for each and every query created. Presentation of the voting results is decided and determined by the tutor whose involvement and participation in the consensus process is supported by providing adequate privileges. The aim is to regulate at tutor's will the amount of information provided to students thus keeping the interest in discussion and meeting the pedagogical goals.

EVS assessment is performed by the quality of the EVS contributions and the active participation during the consensus process thus avoiding a subjective assessment based on the students' answers to the queries, which are not known by the tutor. Blank votes are addressed as weak consensus or poor query elaboration. Finally, user anonymity is protected and guaranteed. Individual votes can be uncovered by the owners who cast them with the aim of comparing individual votes to the option most voted.

Knowledge management in terms of awareness and feedback to all participants is managed and provided by prompt flags informing about the news and statistics on users' and group' activity during the consensus process. For the sake of a rapid prompt of the awareness and feedback information in the EVS to students and tutors, this information has to be embedded into the group activity in an efficient manner, even in real time. Indeed, there is a need to monitor and evaluate real, long-term, complex, collaborative problem-solving situations [10]. Given the real needs of any online collaborative learning situation, in order to provide different types of awareness and feedback, we need to capture all and each type of possible data that could result to a huge amount of information that is generated and gathered in data log files.

The knowledge provided to the EVS user is related to the number of queries, number of voted queries, flags on each query to identify not voted queries, participation, usefulness evaluation by peers, last five queries opened and last five queries closed. In addition a user can consult the vote cast, and teacher is able to perform assessment marks and check extended statistics relatives to students' activity including student blank voting counts. General statistics of the EVS include thread usefulness, most contributors in terms of number of queries, thread interest and mark (available for the tutor only).

3.3 Implementation Issues

As a CSCL application, the design of the EVS took great advantage of a generic, reusable service-oriented, component-based Collaborative Learning Purpose Library (CLPL) [9] so as to enable a complete and effective reutilization of its generic components for the construction of specific CSCL applications. As for the integration issues, the development of the DF was also fully supported by the CLPL, thus sharing with the EVS the same software engineering principles and components, such as User Management, Security and Authentication, which were directly reused from the DF implementation. Concrete EVS functionalities rely on the Functionality and Knowledge components from the CLPL, such as activity logging, knowledge extraction for awareness and feedback, contribution management and so on (see [9] for a complete view of the CLPL platform).

Following the CLPL, the EVS is based on a three-layer architecture –user interface, business and data. From the technological perspective, the EVS is based on SOA and *web services* technologies, such as Java AXIS and PHP. EVS clients access the PHP-based

front-end installed in a web server, which communicates to the back-end (installed in an application server) by means of web services. The back-end communication is permitted only through layers, being the business layer the only with direct access to the data layer. The data layer is responsible for the DBRMS, no other part of the system has access to the data. Therefore, this architecture allows for full client independence from the application. Furthermore each architecture layer can be easily deployed in separated servers in order to deal with distributed infrastructure requirements.

Figure 1. A voting query (consensus) is provided on top of the discussion thread (elaboration) in the DF.

The integration of the EVS with the DF application is achieved by sharing the same user interface and discussion structure in terms of discussion threads and dialogs (see [10] for a complete view of the DF design). Hence, for instance, EVS queries are treated as a new DF contribution and are shown on the top of the discussion thread in the DF tool (Fig. 1). This way the whole discussion process –specification, elaboration and consensus- is grouped into a single discussion thread. Specific areas to EVS management for awareness and feedback have been implemented in order to provide a complete EVS application.

3.4 Using the EVS to Support Discussion-based CSCL Activities

As previously mentioned, the EVS was integrated in the DF application to support the consensus stage of the discussion process. In this section, we start describing the DF tool and then the addition of the EVS presented in this paper.

The DF was especially designed to provide students with additional and important features to support the specification and elaboration stages of the discussion process [10], such as threads in fully separated rooms (Fig. 2), open-closed branched dialogs (Fig. 3), and updated awareness and feedback, which includes complex indicators about the collaboration (Fig. 4).

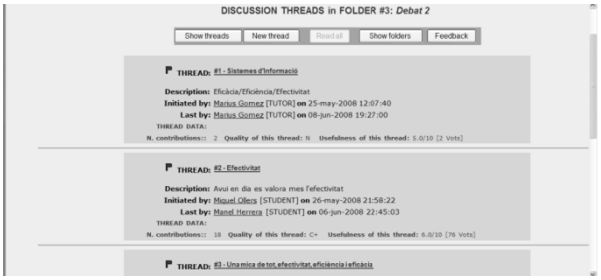

Figure 2. Discussion threads inside a folder holding the discussion.

Figure 3. Two dialogs in the same thread.

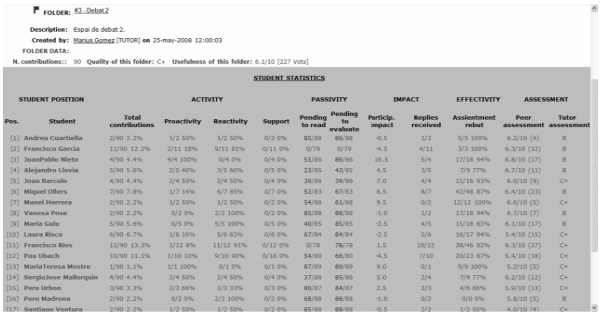

Figure 4. Complex and updated feedback provided to all participants.

Using the discussion forum in combination with the newly created EVS we explored further features and improvements in the context of the discussion process:

- Discussion initiation: propose a query and discuss about the results (Fig. 5).
- Consensus test: use a query to evaluate the grade of consensus about a discussed topic (Fig. 1).
- Efficient interaction teacher from/to students: to test students for common misconceptions before real assessment; collect feedback from students about the course in a direct and quick way.

- Effectiveness of the discussion: to allow students to create as many queries as needed for more effective discussions (Fig. 5).
- Argumentation scenario: provide a scenario for argument exposition where any student can be converted into an arbiter for the argumentation (Fig. 6).
- Enhancement of the cognitive state [16]: allow for sharing and understanding students' views, which may enter into conflict by others exposing opposed contributions by voting (Fig. 7)
- Extended awareness and feedback on the discussion: query assessment provides implicit information on the quality and performance of the consensus stage (Fig. 8).

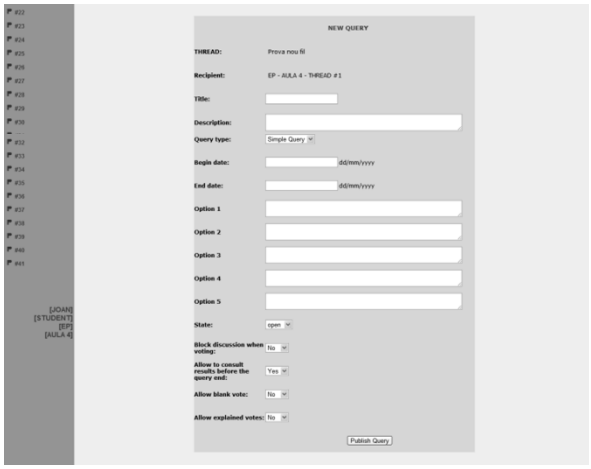

Figure 5. Form for a new query.

Figure 6. Consensus scenario driven by queries.

4. Evaluation of the EVS

In order to validate the notion and nature of the EVS presented in previous sections, this section reports on the evaluation activities performed on a sample of EVS incorporated into the DF.

Figure 7. Query assessment.

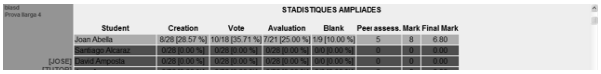

Figure 8. Extended statistics with information of the consensus in the discussion

4.1 Prototyping the EVS embedded in the DF

A proof of concept of our extended DF system with an embedded EVS was carried out (see Figs. 1, 6, 7, 8). To this end, a source of a collaborative learning discussion was considered from the DF used to support in-class collaborative learning activities based on discussion. Then, for each discussion thread, users could create as many queries as needed to that specific thread. From the EVS incorporation, the upgraded DF tool provided consensus capabilities to the participants showing how people discussed and collaborated by queries, how discussion threads were refined and consolidated by voting and how new knowledge was constructed, by exposing opposed contributions.

4.2 Results and Discussion

A representative group of three testers formed by an expert (i.e., researcher in e-learning), a skilled technician and a novice user performed a series of testing of the extended DF tool with the EVS by using different data input (coming from different threaded discussions) and running five executions. Results will be used to evaluate the concept of the EVS embedded in our DF. Four indicators of interest were selected and presented to the DF testers in a questionnaire. The testers had to choose a score in the scale 0-5 (from total disagree to total agree). Also, three indicators had an additional field to collect open comments:

1. Build an effective query in a threaded discussion. Score on scale 0-5 and open comments.
2. The DF allows non-expert users to build new queries and vote on them (i.e., in a friendly way and efficiently). Score on scale 0-5.

3. Create, edit, and manage queries for further use. Score on scale 0-5 and open comments.
4. The DF prototype allows users to observe how knowledge is refined and consolidated by means of the EVS. Score on scale 0-5 and open comments.

Testers	Indicators of interest				
	#1	**#2**	**#3**	**#4**	**Total M**
Expert	4	4	2	2	3.0
Technician	4	3	2	2	2.75
Novice	3	3	1	1	2.0
Total M	3.6	3.3	1.6	1.6	**2.52**
SD	0.0	0.0	0.0	0.0	**0.0**

Table 1. Mean (M) and Standard Deviation (SD) score for each indicator in the scale of 0-5.

Table 1 shows, on the one hand, some basic statistics of the quantitative marks on the scale 0-5 scored by all testers for each of the four indicators of interest considered. Each tester performed 5 executions in a row before providing the scores. On the other hand, Table 2 shows an extract of qualitative results from those indicators with open comments provided by the testers after the test in questionnaires.

Indicators of interest with open comments	**Testers' open comments (type of the tester: E: Expert; T: Technician; N: Novice)**
Build an effective query in a threaded discussion.	"I could create a new query in a thread for promoting further discussion" (E) "Query creation works just fine but the UI needs improvements."(T) "I could create a new query but I missed on-line help."(N)
Create, edit, and manage queries for further use.	"A real discussion should be provided to be tested appropriately" (E) "I could not edit nor copy a query for further use."(T) "I made a mistake and I cannot edit the query."(N)
The DF prototype allows users to observe how knowledge is refined and consolidated by means of the EVS.	"Yes, it was possible to observe some knowledge consolidation but new queries were confusing on the goal of consensus" (E) "If you know what you are looking for then some knowledge consolidation is observed."(T) "There is not any visible indicator about that." (N)

Table 2. Excerpt of the questionnaires on the 3 commented indicators #1, #3 and #4.

From the quantitative results, we can see that despite the total score is promising it is not high due to a poor user interface design. The user interface is not communicating efficiently the data and knowledge collected by the application.

In particular, indicators #3 and #4 were scored low by all testers (see Table 1). According to this tester's comments (see Table 2), query management has a lack in functionalities and need improvements. Knowledge consolidation is present if we know how to manage the data collected, but not well communicated to testers who do not have technical background in how to interpret this data.

5. Conclusions and Future Work

This paper has shown how it is possible to create a functional application and explore new e-learning educational possibilities trough the use of the CLPL platform. We shown that is possible to use an EVS in a DF context to test and promote consensus and how further educational applications have been inspired by the EVS bringing new opportunities to e-learning environments.

The testers observed that due to the project time limitations the user interface was presented without a complete set of management functionalities. In addition, the EVS action over the discussion was not clearly showed in the user interface. Finally, an improvement in data presentation is still needed. We plan to develop and test these and other improvements in order to extract more useful data from the actual use of the EVS in the context of a discussion.

Ongoing work is also the evaluation of the DF with the EVS prototype in the real context of learning of the UOC. Experimentation and validation will be conducted in on-line courses of UOC in order to provide consensus capabilities to the collaborative learning activities, in particular in-class discussions.

It would be necessary to train our students before the use of the EVS to allow them to deal with the current application limitations. If the results are favorable then the efforts should be done to improve the application itself and fix the detected issues.

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