A Debate and Decision-Making Tool for Enhanced Learning

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Abstract—Debates have been used to develop critical thinking within teaching environments. Many learning activities are configured as working groups, which use debates to make decisions. Nevertheless, in a classroom debate, only a few students can participate; large work groups are similarly limited. Whilst the use of web tools would appear to offer a convenient solution, none of those currently available provides an automated system for organizing contributions into a logical structure, or for making decisions. To address this problem, this paper describes a new tool for managing and structuring debates over the Internet, and presents the results of a series of trials in an educational context. The tool enables users to post opinions and proposals, and to make multiple group decisions. The main advantages are that it does not require a moderator, and all contributions are automatically arranged into an intuitive structure. Thus, it enabled large groups to carry out bigger projects. Empirical results showed that it also encouraged the involvement of all the students in debates and allowed the participation of each student to be evaluated. The tool demonstrated its advantages over traditional oral debates and, as far as we are aware, it incorporates features not found in any other comparable web tool.

Index Terms—Collaborative learning tools, discussion forums, learning management systems, social networking

1 Introduction

In recent years, universities have increased off-site teaching. On-line and blended learning have replaced the traditional face-to-face configuration, making educational opportunities available to those unable to attend university in person, such as people living far away, or those with an incompatible work schedule, and so on [7]. The possibilities for distance learning have been greatly enhanced by web tools which provide and manage communications between teachers and students and motivate the latter to learn [36]. Examples include learning platforms like Moodle or Claroline [22], remote labs [12], and videoconferencing [1] amongst many other tools. Nevertheless, with the exception of classic forums, very few of these focus on enabling students to manage the demands of working in groups.

Our experience in remote labs and collaborative student projects suggests that such groups need a tool for debating and decision-making [3]. Web forums work fine with small teams. However, there are many occasions when teachers might want to work with larger groups [26]. It may be that the demands or complexity of a task require it to be entrusted to a large team, or simply that the activity is more suited to more numerous contexts (e.g., oral presentations and case studies). In certain instances, the larger the team, the more productive the activity (e.g., elaboration of projects). In all such cases, a tool for managing discussion and negotiating decision-making would be useful.

Debates have been used successfully as a teaching tool for centuries [6]. Students learn more effectively by analyzing, discussing and applying content in meaningful ways than by passively listening to a lecturer [10], [40]. Nevertheless, it is often the case that teachers are faced with having to coerce students into participating, and even so, only a minority of students actually gets the opportunity to speak. In this sense, discussion online forums have been used showing advantages over face-to-face debates [32], [38]. The problem of unequal participation could be solved by a web application which allowed students to simultaneously post their opinions. Such a tool would ideally incorporate a voting system so as to show the most accepted opinions, and a structure to organize them. Likewise, if all the votes and opinions could be stored in a database, they could then be evaluated. Furthermore, if proposals were sent instead of opinions, the most accepted proposal in any discussion would represent the decision made by the group. In other words, the requirements for both discussions and working groups can be unified. The desired features of such a web tool would include: the capability for multiple decisions or discussion questions (reflecting actual debates); a logical and intuitive structure for finding contributions (proposals or opinions), a lack of administrators (self-organizing); equal status between users; and ease of use. As will be seen below, there are many web tools which attempt to incorporate these features, but none achieves all of them simultaneously.

With the aim of enabling students to debate and make decisions remotely, a basic web-based debate and decision-making tool was developed, the preliminary results of which were published in short papers [13], [14]. The success

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of the resultant tool motivated us to improve it and study its potential further. This paper presents the new version of the tool, called DDT (Debate and Decision making Tool) giving a detailed description, a list of examples of potential applications organized as case studies, and the results of a study involving its use for educational purposes with more than one hundred students.

This paper is organized as follows: Section 2 reviews other applications similar in approach; Section 3 describes the desired features and uses of DDT, and the manner in which these were implemented; the following section discusses the results of an empirical application of DDT with different groups of students; finally, the last section presents some conclusions and other considerations about the new tool.

2 Related Work

A web tool enabling groups, whether in the classroom or participating remotely, to manage debates and reach concerted agreement must follow a process which allows users to send ideas, evaluate them and chose those meeting predetermined criteria (e.g., the highest degree of acceptance). With respect to managing debate, there are many tools available that create intuitive diagrams of arguments, for example Argunet[1] [29], DebateGraph[2] [33], Araucaria[3] [24], Carneades[4] [8], bCisive[5] [2] and Knowledge Forum[6] [28]. Fig. 1 provides an illustration of a typical argument structure, taken in this instance from DebateGraph. The graphs are easy to build for users, who can collaborate with others over the Internet. The tools can also incorporate chatrooms, forums, and the sharing of documents, but none of them has the capability of organizing the information or decision-making autonomously, that is, a moderator is required.

Collective decisions imply retrieving the opinion of every member, in other words, collating votes. There are many web voting systems like TakeOnIt[7], Ivoting[8] [34] or Agora voting[9] [37]. All of them focus on debating a single statement that can be put to the vote. They consist of an area for supporting and opposing arguments, a forum for discussion, and a voting system. Nevertheless, they are difficult to use in contexts requiring more than one proposal; moreover, a moderator is needed to select which statement in the forum is to be voted on.

Another approach takes the classic forum set-up to manage debate and adds tools for organizing contributions. Web semantic technologies have been successfully applied here [29], in some cases by analyzing the opinions posted freely on the forum in order to arrange them [21], in others by imposing format rules on contributors at the composition stage so that the debate can structure itself [39]. When debates are successfully described by an ontological language, it is possible to share them over the Internet [23].

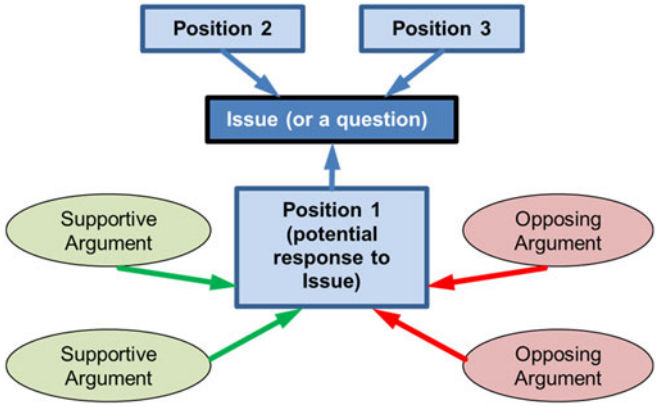


Fig. 1. Logic structure used in Debategraph[2] [33].

However, the chief drawback of these tools is that none incorporates a voting system.

In the web semantic area, there are popular tools that order contribution lists through a voting system. For example, Loomio[10] distinguishes between opinions and proposals, works autonomously, and allows anybody to send proposals, which are kept on a list. Appgree[11] interacts with users in a predetermined process to determine which opinion achieves the highest degree of acceptance within a short period of time, but can deal with only one question at a time. Reddit[12] and Digg[13], on the other hand, are social news aggregators [12], but although they work with news, their algorithms –based on votes and user preferences to order the news –can be applied to opinions. The result is a debate ordered chronologically with the preferred threads at the top of the list. Academic Talk [19] incorporates a set of prompts in order to arrange the dialog between students, but in this case, the resultant structure is a list that does not match the argument topology preferred by the graphic tools mentioned above.

In recent years, new web applications combining the features of the above tools have been developed. Most of these focus on areas known as eParticipation, eDemocracy or eGovernment [27]. For example, MyUniversity[14] [4] makes use of a voting system for a platform of ordered forums (Gov2Demoss). A solution closer to our approach is Deliberatorium[15] [11], a tool developed by MIT that incorporates a strategy very similar to the one presented in this paper. However, all these tools require moderators.

Table 1 provides a comparison of the tools described above in terms of the following aspects: whether the tool is autonomous or needs a moderator, whether or not the contributions are arranged in a logical and intuitive manner (logic map), the presence or absence of a voting system, and the capability to consider more than one proposal at a time. The table shows that none meets all the desired features. The next section explains the necessity for all these features, which are brought together in DDT.

1. http://www.argunet.org/
2. http://www.debategraph.org/
3. http://araucaria.computing.dundee.ac.uk/doku.php
4. http://carneades.github.io/carneades/Carneades/
5. https://www.bcisiveonline.com/
6. http://www.knowledgeforum.com/
7. http://www.takeonit.com/
8. http://www.ivotingtool.com/
9. https://agoravoting.com/
10. http://www.loomio.org/
11. http://www.appgree.com/
12. http://www.reddit.com/
13. http://digg.com/
14. http://www.myuniversity-project.eu/
15. http://cci.mit.edu/klein/deliberatorium.html

3 Debate and Decision Making Tool

3.1 Features

The initial aim of this application was to enable students to participate in debates and to reach decisions remotely. The idea was to extend the seminar room, or lab, to a virtual space unencumbered by the constraints of time or material resources. For students the advantages would be, amongst others, flexibility in scheduling their time, the opportunity to undertake larger projects, to participate in more complex practicals in remote labs, and being able to ensure full participation in discussions. The available web tools have opposing features [20] that do not match the mentioned needs. The most natural way to achieve these objectives was by enhancing a forum with the elements needed for the decision-making process. The desirable features of the new tool were considered to be the following:

1. *The tool must function without moderators*. If a student were designated as moderator, he/she could favour a certain viewpoint, perhaps unconsciously. At a more basic level, the student might simply neglect the duty. In either case, such a solution would be unsatisfactory. Conversely, if the teacher were given the role, there would be a strong possibility that the students would become passive in the expectation that the teacher guide them, which is not desirable [16]. Furthermore, irrespective of whoever took the role, it would involve a disproportionate amount of extra effort and additional work. The best solution, then, would be to divide this labour among the participants.
2. *All students should be able to submit proposals, discuss them and vote in equal conditions*. The aim is that students should defend proposals, persuade their peers and ultimately make decisions on the strength of their argumentation, without the influence of charisma [22] and other interpersonal strategies that tend to occur in face-to-face contact. Of course, written text is not devoid of such resources, and a skilful communicator has at their disposal a wide variety of means of persuasion. Nevertheless, a web interface goes some way to filtering out both overt and subliminal effects that can bend opinions in a standard meeting format.
3. *Proposals must be organized in an intuitive structure*. If proposals were to be added sequentially, they would very soon accumulate into an unstructured mass [31]. To avoid this, the proposals would need to be organized such that relations between them could be recognized and participants could navigate them logically. This is the most difficult feature to achieve as there are no moderators to entrust with the task and participants must do it for themselves.
4. *The tool must be as simple as possible*. This is an obvious but relevant point – if the tool turned out to be more complicated to use than chatrooms, traditional forums or even meetings in person, the tool would simply never be used. It must therefore be simple to use.

The decision making tool presented in this paper accomplishes all these features, contrary to the tools shown in Table 1. For example these ones that do not need moderators (i.e., Loomio, Appgree, Reddit and Digg) cannot build an intuitive structure or logic map (central column of Table 1). Moreover, the tool is able to accept votes and multiple proposals which shares with the lowest items of the table (features of the last two columns). The simplicity can be deduced from the very few actions that users can carry out and that are explained in the next section.

TABLE 1
Debating Tool Comparative

Debate tool	Without moderators	Logic map	Receive votes	Multi-proposal
Argunet	No	Yes	No	Yes
DebateGraph	No	Yes	No	Yes
Araucaria	No	Yes	No	Yes
Carneades	No	Yes	No	Yes
bCisive	No	Yes	No	Yes
KnowledgeForum	No	Yes	No	Yes
TakeOnIt	No	No	Yes	No
Ivoting	No	No	Yes	No
Agora voting	No	No	Yes	No
Loomio	Yes	No	Yes	Yes
Appgree	Yes	No	Yes	Yes
Reddit	Yes	No	Yes	Yes
Digg	Yes	No	Yes	Yes
MyUnivestity	No	No	Yes	Yes
Deliberatorium	No	Yes	Yes	Yes

3.2 Operation

Designing a tool that accomplishes all the above features would seem to be very difficult task. However, DDT is actually very simple. Before going into an explanation, it is useful to briefly consider the actions a student can take. These actions, depicted in Fig. 2, are represented as three arrows. Basically a student can send a proposal, discuss proposals, or vote on them. Sending a proposal means placing it in an appropriate location in the structure and initiating the vote (proposal 1.2 in Fig. 2). Discussion consists in sending opinions which are gathered in pull-down lists under each proposal (at the bottom of Fig. 2). Every proposal can receive a vote in favour or against from each participant, and the cumulative percentage are given next to each proposal (the green and red circles on the right in Fig. 2).

DDT was developed by searching for the simplest way of enabling these actions. Students open a browser window to see an html page showing a list of proposals. In appearance this looks just like a forum with an indented list of items, though with three key differences (see Fig. 3).

The first of these is that a vote panel is added to each proposal, showing the global result of the votes as a percentage. Right-clicking with the mouse on this panel allows users to cast their votes by means of a dialog box (see Fig. 4). The value of the vote can be adjusted from -100 to $+100$ percent so that students can indicate the strength of their opinion. This is a key feature over other web tools where users can only cast a 'yes' or 'no' vote. If students can express the strength of their agreement, teachers can assess their degree of confidence with respect to their knowledge. The boxes at the end of each proposal (Fig. 3) show the averages of votes. For example, the value 100 percent in the yes box would mean that all the students have cast their vote and the value

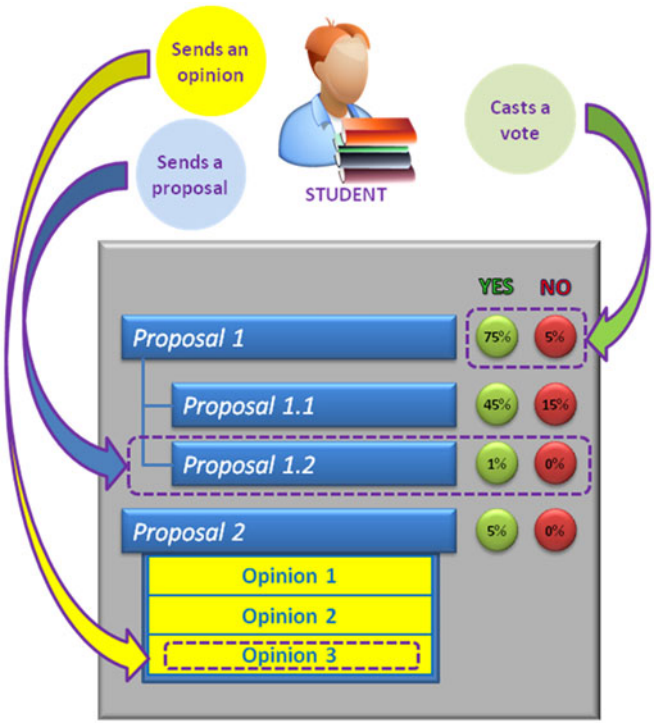


Fig. 2. Actions that a student can take.

of each vote was totally agreement (e.g., 100 percent in Fig. 4). Thus, DDT shows the general opinion at the time. In this way, the teacher can detect common mistakes and topics that must be clarified in the class.

The second difference in relation to forums is a button (labelled 'F' in Fig. 3), which opens the list of opinions attached to every proposal. This list can be displayed or hidden under the proposal with the same button. Students can discuss the proposal sending their opinions, which are ordered sequentially.

The third difference is the organizational method for the proposals. Classical forums use a tree structure to organise answers, with responses nested within the corresponding

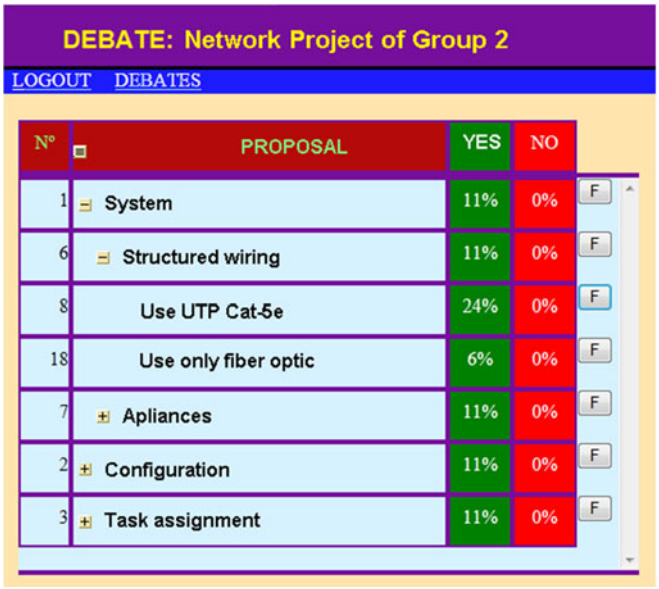


Fig. 3. Main panel of the decision-making tool.

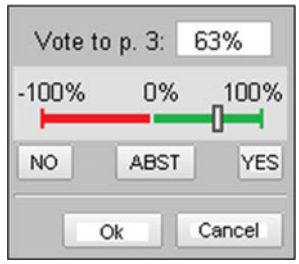


Fig. 4. Dialog Box to cast votes.

statement of opinion. However, with proposals this becomes a more complex task. The solution applied here is to classify the proposals into three categories: independent proposals, alternatives, and sub-proposals. An independent proposal does not interact with the existing ones and can be sent in addition to them. An alternative proposal implies the rejection of others, such that if it wins, all others will be rejected. A sub-proposal defines how the main proposal must be applied. In other words, it can only modify an existing proposal or detail the way in which it must be carried out. The chosen structure for the debate is a tree structure. Independent and alternative proposals are placed as branches at the same level in the tree, whereas sub-proposals are nested within the main proposal. As sub-proposals can have new sub-proposals too, the tree can branch out many times, causing quite a few levels of nesting. The resulting appearance is very similar to a folder tree.

When a student adds a proposal, he or she selects the appropriate category, i.e., independent, alternative or sub-proposal. He or she also writes the number of the proposal to which it should be related. Proposals selected as independent are all given equal status, in the same way as new topics in a forum. Alternative proposals are also placed at the same level as the proposal to which they are related, but in this case voting for this alternative implies rejecting the related proposal. Sub-proposals are nested within the appropriate proposal, as selected. In fact, a sub-proposal is an independent proposal embedded at a deeper level within the main proposal. In this way, a tree of proposals is gradually grown and given shape without the need for moderators and following very simple rules of use. The branches at any particular level are proposals that provide detail, modify or suggest how to carry out the proposal defined at the root level. These proposals are brought together in sets of alternatives or released as independent proposals. If a participant fails to put his or her proposal in the right place, it will not be found by the other participants and consequently will not receive any votes and so be forgotten. On the other hand, if another participant considers it misplaced, he or she can re-write it in a better location. By this means, the same proposal can re-occur at different locations. The proposals located at the most appropriate locations will take most of the votes while the others will be rejected. In short, it is the users themselves who manage DDT and filter out misuse. It is important that students care about the status they give their proposals and where they locate them if they wish them to be successful.

The form used to submit proposals (Fig. 5) consists of three elements: a small text area for writing the new proposal, a larger area for expanding on the proposal if

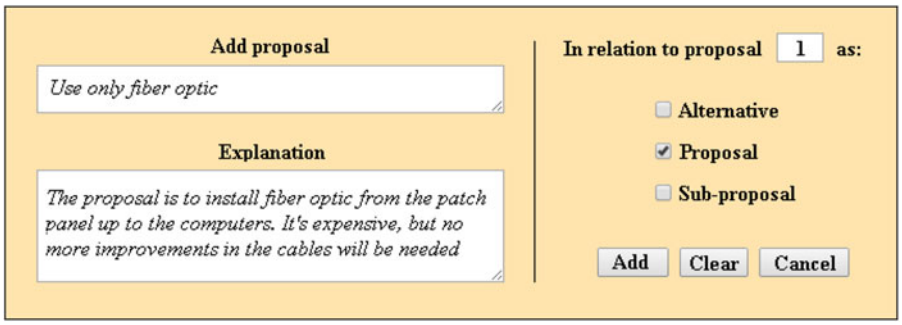


Fig. 5. Proposal form.

necessary, and a choice of checkboxes to select the category of proposal (independent, alternative or sub-proposal), above which is a text box for writing the number of the existing proposal to which the new one is to be related. The larger text box allows a more detailed description of the proposal, or supporting arguments, to be provided. The box can be opened by right-clicking the mouse over the proposal. In this way, proposals can be kept concise, improving the readability of DDT. As an additional feature, proposals can be listed in order of date, voting percentages or keywords. In these cases, the tree hierarchy is lost and proposals are shown as a list; the usual appearance can be recovered, however, simply by clicking on the proposal.

Another functionality of DDT is to list the votes of a user, so he/she can check which proposals have not been voted. A user cannot see the votes of other users. Therefore when a proposal appears, they cannot know who send it. Only the teacher, by examining the data base, can do it.

Table 2 shows a summary of these functionalities. Left column lists the actions a user can take and right column the effects of these actions, as explained above. For example voting against misplaced proposal is a method to keep the debate organized, therefore an arrow indicate this. Whenever a proposal overtakes fifty percent of votes most of students support it, as a result it becomes a group decision.

3.3 Applications

The educational purposes of DDT are varied, but there are four specific fields where it can be used:

3.3.1 Remote Practicals

As mentioned above, when practicals involve a large number of students, DDT is especially useful for enabling decisions to be reached from home. For example, students can configure multiple routers and switches in a remote networked lab. If the practical involves numerous solutions, then the students will have to discover these solutions for themselves and decide which must be tried first, what work to carry out (e.g., how to configure the equipment) and how to distribute the tasks. With a limited number of students the discussion involved can be done by emails, chatrooms and so on. But with large groups, such as the whole class, it could become unmanageable. With DDT, decisions can be taken easily. The advantages of complex practicals are that students can learn much more with less effort since complexity involves a higher degree of challenge and the work is distributed among more students.

TABLE 2
Functionality of the Debating Tool

User Actions	Results
Send opinions →	Argue/learn from classmates
Send proposals →	Keep a structured debate
Vote proposals →	General opinion of the group → Decision made by the group
See own contributions →	Proposals pending to be voted

3.3.2 Seminars

Seminars, in which participants debate preselected topics, are a classic methodology of quality teaching [10]. When students discuss areas of study, they discover associations between elements, solve misunderstandings, and extend their knowledge beyond the texts. Classic debates can be organised by the teacher in the classroom or lecture hall. The teacher can chair the discussion in order to move things forward towards conclusions or to take decisions. If students do not participate he or she can ask them directly, but time is limited and only one student can speak at once. In large classes many students will be left out. In a web forum, by contrast, everybody can contribute, but they can easily become tangled and this leads to discouragement. Something that motivates students to participate is therefore required. With DDT, students are prompted to argue and progress in a structured way since they have an objective (the decision to make). As in web forums, everybody can participate, and, the tree hierarchy offers a clear debate structure that encourages students to contribute. In addition, the teacher can guide the debate if he or she wants (participating as an anonymous contributor), for example inserting suitable proposals that have been overlooked or to inserting inappropriate ones with the aim of drawing attention to unforeseen drawbacks.

Seminars can be set up in different ways, for example by means of a general title such as "Solutions to global warming" or "What would be the perfect network protocol be like?" This kind of discussion has the advantage of collecting a wide range of ideas from students, but the drawback of possibly distracting them from the specific area of focus. In order to avoid this, the teacher can initiate the debate with some key proposals that will act as headings, thus helping to successfully guide the debate.

Another kind of discussion is problem solving. The classic "case study" approach belongs to this category. For example, students read a list of symptoms and use DDT to discuss

which disease is most probable. Students have the opportunity to show their partial agreement (vote percentage) for different diagnoses, making DDT very useful for this purpose. In addition, a new heading like "treatment" could be proposed in the same debate, where students can discuss about the right therapy. The outcome will reflect the feelings of the debate group. The teacher could assess each item and obtain marks for the students measuring the error margin automatically. This differs from classic evaluating techniques [6], [15], [25], which cannot take advantage of the confidence degree linked to votes. In other technical degrees, problems to solve could be, for instance, control methods for a defined system, fixing a misconfigured network, or the items needed in a home automation system, and so on. This kind of discussion will need some information to define the problem, but students will not require any guidance.

3.3.3 Groupwork

In certain subjects, expertise must be acquired by means of practical activities, typically consisting of projects involving large numbers of students. DDT is suitable for continuously making multiple decisions (any proposal with more than 50 percent positive votes is considered accepted) and can deal with large groups. DDT allows a larger number of projects to be carried out with a larger number of students, and a greater area of study can also be covered.

3.3.4 Quality Assurance Testing

At the end of each semester, the Quality Assurance Department at the University of Huelva issues a student satisfaction questionnaire in order to evaluate teaching services. The questionnaire is composed of a fixed set of questions that can be scored on a five point Likert scale. For example, aspects like teacher punctuality or whether his or her explanations are clear are measured. Nevertheless, any virtues or defects that are not included in the questions cannot be rated. In other words, students can measure certain aspects, but cannot give their full opinion, such as suggestions or criticisms of the teaching methods. Thus, if a topic is very hard and needs more time, if a practical exercise is dull because everybody already knows how to solve it, or if the teacher speaks too fast, none of these aspects shows up. One solution to this might be to receive anonymous emails or notes, but the problem here is that the rest of the students cannot express their agreement with others' opinions. As a result, it is not possible to know whether an opinion is a generally held opinion or just a criticism from an angry student. The same obtains for suggestions for improvements.

DDT allows reviews and suggestions to be freely gathered. Moreover, due to the voting system, it is possible to see how many students agree with a proposed criticism and filter out the angry ones. The same can be applied to improvement suggestions.

4 Empirical Results

This section is aimed at showing the capabilities and goodness of DDT developed across different scenarios. To this end, we followed a research based on testing DDT with real case studies: i) one session debate, ii) large project and iii) quality control of teaching. The test were conducted in three different courses over two academic years (2012/13 and 2013/14). The applications above for which DDT was used were chosen in accordance with the opportunities and necessities of each subject. In this section we detail those that were used and evaluated.

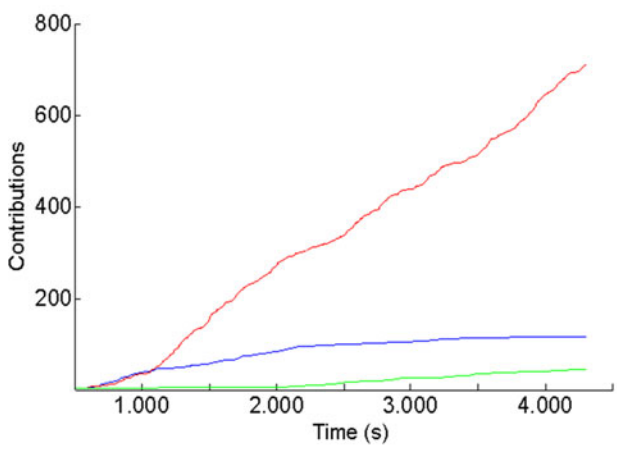
4.1 Debates

This case study was carried out with a group of 21 students in the fourth year of a Computer Engineering degree. Although the outcomes cannot be generalized, they serve as preliminary results. The title of the debate was: "What ten network vulnerabilities are most likely to afflict a small company?" In addition, the students were informed that they should collate the most likely vulnerabilities into a fast automatic vulnerability assessment test. The quicker the test, the less time will be required for an employee to run it and the cheaper it will be for the company. Nevertheless, if the test does not detect anything, it will create distrust. If vulnerabilities show up then the company will pay for a more exhaustive service. From the point of view of the business, finding the best balance was key, and the students were encouraged to vote for the ideal selection. This was a way to avoid dispersion in a general and open debate. Students could employ all their knowledge to search for solutions, but the single objective reasonably constrained the right answers.

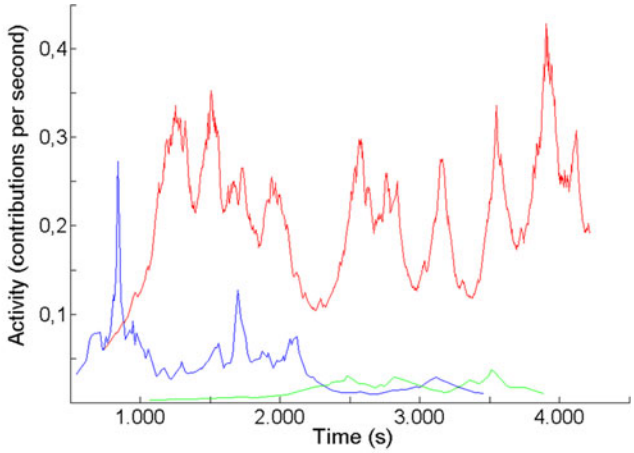
The students had an hour and a quarter to make their contributions and used the computers of a lab without talking to each other. Fig. 6a shows the temporal distribution of the experience in terms of proposals, opinions and votes. Each line depicts the sum of all contributions sent from the beginning to any particular point in time measured in seconds, as defined in abscissa. Horizontal lines indicate when no more contributions were sent. Fig. 6b represents the students' activity over time. In other words, it stands for the number of contributions per second for each type of contribution. Although the outcomes cannot be generalized to all the case studies, these graphs are representative of other debates where proposals typically grow rapidly at the beginning and slowly at the end. As shown, opinions and votes remain relatively steady over time in comparison with proposals. One point that shows up from these charts is that most of the proposals are sent in the first 30 min. (85.3 percent); and this happens in a complex debate. This suggests that more straightforward debates could be carried out more quickly, and that more than one debate could be opened in the same class session.

Fig. 7 corresponds to Whisker plot boxes representing the students' degree of participation with respect to proposals (left), votes (centre) and opinions (right). It is notable that with the exception of giving opinions, all students contributed across the range of categories. In numerical terms, they sent at least one proposal and ten votes; indeed, the average was in fact much higher (5.5 proposals, 33.4 votes, and 2 opinions). These results contrast sharply with oral debates where quite a few students might not participate in any form due to several reasons (e.g., a large number of students in the class, too much information to debate in a short time, teachers' control over student talk, etc.) and consequently the teacher has little idea of their level of knowledge [5].

Another aspect of interest evaluated was whether the most active students in the classroom were also the most



(a) Accumulated contributions in terms of proposals blue), votes (red) and opinions (green).



(b) Activity index of proposals (blue), votes (red) and opinions (green).

Fig. 6. Temporary development of the debate.

active using DDT. Fig. 8 shows how this aspect was measured. On the one hand, the students were classified in ascending order in terms of their oral participation in the classroom. This was valuated according to right answers to questions put by the teacher. Students could choose to be asked or not by signing up to a list at the beginning of the class. This way, the oral participation was voluntary and weighed by attention each student paid. Then the oral participation was calculated in the interval [0, 1]; where '1' was assigned to the most active student and '0' to the least. On the other, a measure of participation in debate was devised. First the following participation index α (1) was computed for every student:

$$\alpha = \sum_{i=1}^{3} w_i \cdot n_i, \tag{1}$$

where n_i is the number of contributions with respect to proposals ($i = 1$), votes ($i = 2$) and opinions ($i = 3$). The coefficient w_i stands for the weighting given to each kind of contribution. In this case, the selected values were 5 for proposals and opinions, and 1 for votes. These values derive from an estimation of the time a student has to invest in each kind of contribution relative to the others. Once this index had been calculated for every student, it was possible to find the maximum ($\alpha_{\max}$) and minimum ($\alpha_{\min}$) values. Taking these two parameters, a normalized rate α^* (2) can then be defined as:

$$\alpha^* = \frac{(\alpha - \alpha_{\min})}{(\alpha_{\max} - \alpha_{\min})}. \tag{2}$$

This debate participation index, taking values from 0 to 1, is similar to the oral participation measure and represents the degree of involvement for each student relative to their classmates. The chart in Fig. 8 represents the relationship between these two measures for each student.

Supposedly, if a student were very active in the class, he or she might be expected to be the same in the debate, and vice versa. However, the chart indicates that there is no correlation between the students' spoken and written participation (Pearson's correlation coefficient is $\rho = 0.24$). This suggests that there are students who tend to avoid oral participation but are much more active via a computer. It may be the case, then, that web debates of this type have the capacity to foment the participation of these students in a way which other types of activities are unable.

The final aspect measured was the performance of DDT for awarding grades on the basis of student contributions.

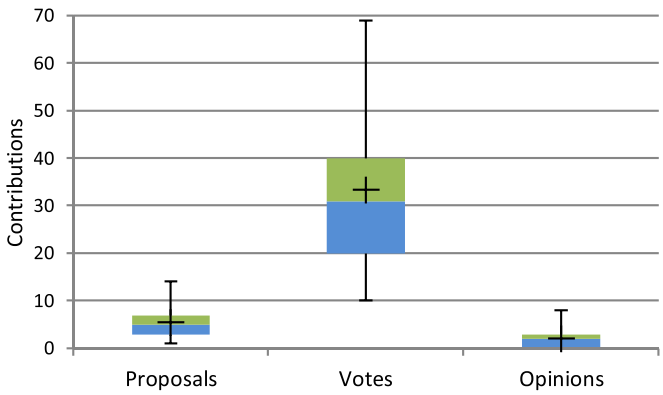


Fig. 7. Measure of participation in terms of proposals, votes, and opinions for a group of 21 students.

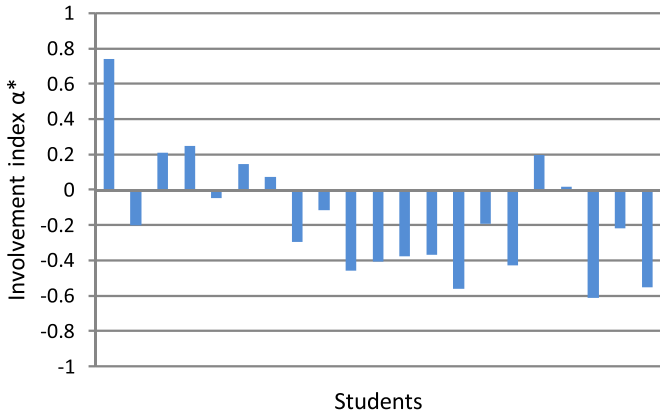


Fig. 8. Student debate involvement (α^*) for a group of 21 students ordered according to their oral participation.

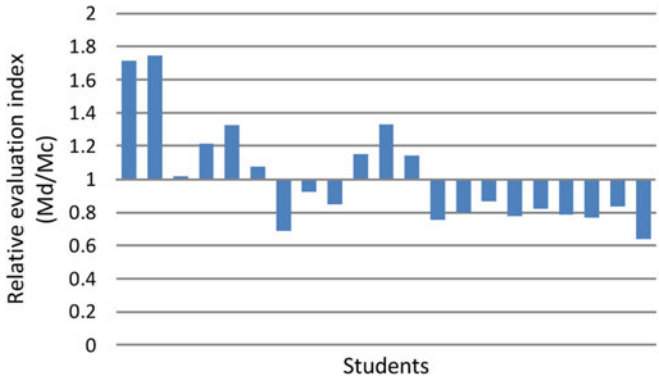


Fig. 9. Relation between debate marks and classroom marks (Md/Mc) for 21 students placed in *x*-axis in ascending order by Mc. Higer Mc marks to the right.

The procedure followed was for the teacher to rate all proposals on a scale from 0 to 10. The rating system was based on how near each proposal was to the knowledge limits, from five for obvious or lazy proposals, to ten for proposals that went beyond the topics covered in the classroom. Values under five were also given for wrong proposals. Once all the proposals were rated, which took just a few minutes, the system calculated all the students' grades on the basis of the scores their proposals had received. In this way, it is very quick and easy to calculate marks for all the students.

The question remains, however, of how accurate DDT is for measuring students' level of achievement. For this purpose, the students' grades calculated by DDT (Md) were divided by the grades they had previously been awarded in class (Mc). The results are shown in Fig. 9, where the *X*-axis aligns students in ascending order by classroom marks. If the resultant quotient is 1, it means that the marks are equal. The further the quotient is from 1, the greater the discrepancy in the marks. The expected values were close to 1, which would imply that the more able students in the classroom also achieved a high score in the debate, and likewise with the lower-achieving students. Nevertheless, as can be seen in the graph, the marks obtained contradict this hypothesis ($\rho = -0.32$ comparing Md with Mc). An interpretation of such values could be that debate grades include a kind of abilities which are distinct from pure knowledge. This idea is supported by the fact that the students had full access to their notes, books and the Internet during the debate. Possibly, the ability to manage information and the available time efficiently is one of them.

4.2 Projects

The goal of this case study was to evaluate DDT for use in group work in cases where teams cannot physically meet (e.g., remote practicals) or when groups are too large, which can occur, for example, in project development. The next set of charts comes from this kind of work. The experience was carried out by three teams of students, totalling over 36 members, after a week's work from home. In this case, the students belonged to the second year of Computer Engineering degree, and their objective was to determine the communication facilities of a business (i.e., network, devices and configuration), which are skills of the subject "Network Fundamentals". The teams were randomly formed.

Fig. 10 shows a snapshot of the use of DDT. The columns depict the number of students who sent a number of contributions within the intervals specified along the *X*-axis. Each interval has three columns: votes, proposals, and opinions.

A result of these graphs is the low use of the forums; in other words, students sent few opinions. In fact, some

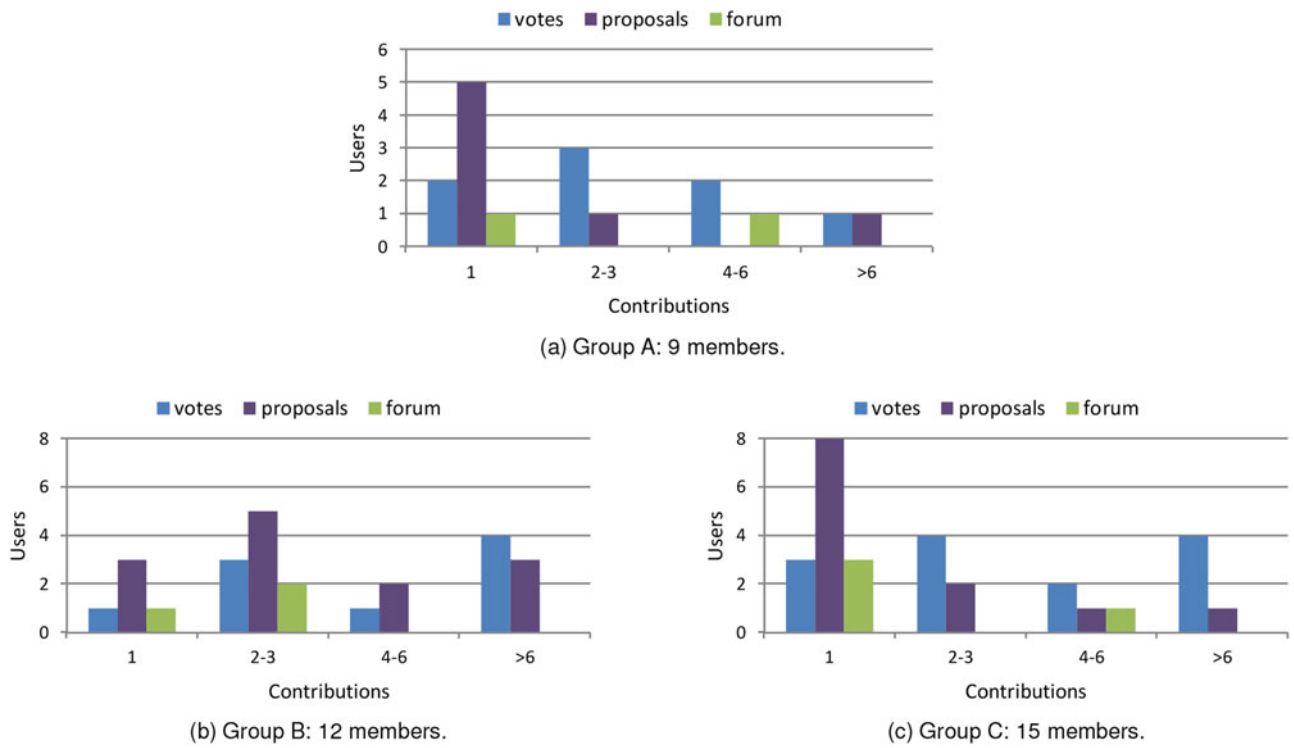


Fig. 10. Degree of participation measured in three teams with differing numbers of students: 9(a), 12(b), and 15(c).

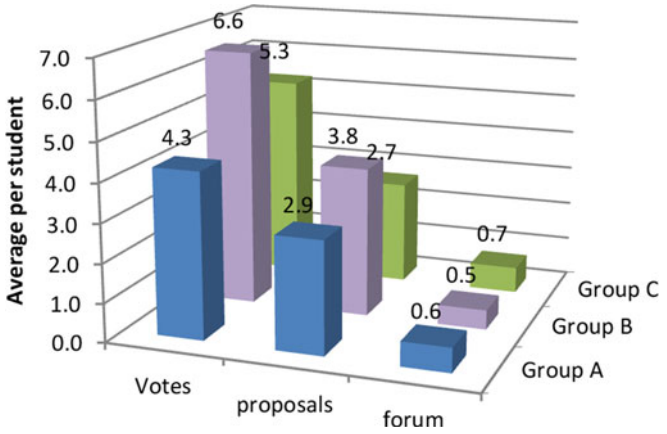


Fig. 11. Average number of contributions per student.

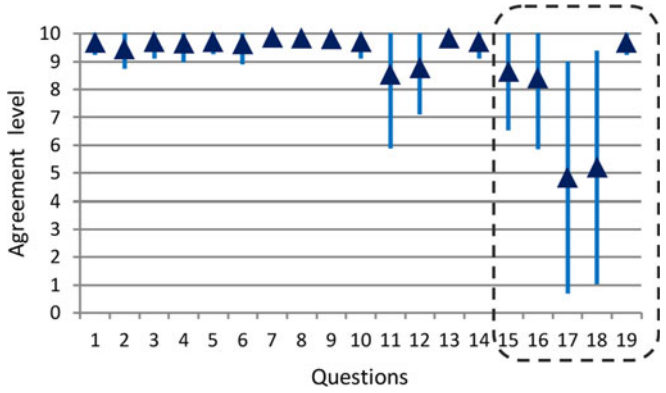


Fig. 12. Quality assurance test: average scores (10 = totally agree, 0 = totally opposed) extended with standard deviation. Questions 1-14 from university QA questionnaire; questions 15-19, inside dashed line, added by students.

proposals were written with the aim of communicating ideas instead of putting something to the vote, thus appropriating the role of the forum. This could be due to the low visibility of the forums. The solution may be to provide warning signals in the proposal tree when new opinions are added.

Results suggested that the self-ordering system was largely successful. Two of the groups reached 3 levels of nesting and the other one 4. However, some proposals were placed in the wrong position. The average percentage of correctly placed proposals was 72 percent. Unexpectedly, the reason for the misplacements was not a lack of understanding DDT, rather the students choose upper nesting levels to ensure the visibility of their proposals.

Fig. 11 depicts the average number of contributions per student for the three groups after a week of debate, where the contributions are votes, proposals and forum opinions. Comparing these average values with the group size, the correlation coefficients are $\rho = 0.43$, $\rho = -0.17$ and $\rho = 0.24$ for votes, proposals and opinions respectively. This points that students do not change their level of participation because of the group size.

After the experience, students were invited to submit their impressions about DDT either orally or anonymously by e-mail. A negative aspect that they mentioned was, surprisingly, the flexibility of the time. As the students had all week to post their contributions to the project, some of them did it at the beginning and some at the end. This caused a certain frustration amongst the early posters, who wanted to start their tasks as soon as possible. Quite a few students expected to receive answers to their contributions in a day or two, as they were accustomed to in other forums, but waited in vain. These two drawbacks could restrict student uptake of DDT. The solutions to these problems could be:

i) to reduce the timescale for using DDT,
ii) to demand a higher degree of commitment from the students,
iii) to provide a tutorial to encourage correct usage.

4.3 Quality Assurance Questionnaires

This educational experience was carried out by the same student group of Section 4.1, but working from home within an extended period of two weeks. The students were instructed to exchange login and password to ensure their privacy. In this trial, the questions from a quality assurance test were incorporated into DDT as proposals, and the voting panel attached to every question was used to measure student agreement or satisfaction index. Up to this point, DDT operated in the same way as the classic paper version. The two improvements it provided for quality assurance tests were the abilities to introduce new issues or evaluations from any student, and to measure these via the voting system. In this way, angry criticism and isolated opinions could be filtered out.

In order to evaluate the effectiveness of DDT in these two respects, several parameters were calculated. Students posted five new issues (treated in DDT as new proposals), which represented the 26.3 percent of the total number of questions proposed. The degree of agreement on these issues is shown in Fig. 12. The average level (triangle) is depicted on a segment of twice the length of the standard deviation. Questions 1-14 were issued by the university, while questions 15-19 were proposed by students. Some of these questions (15, 16, and 19) achieved the same dispersion as those proposed by the university, that is, there was a high degree of agreement. In other words, the students had proposed unconsidered issues on which they tended to agree, suggesting that these could be aspects of the subject or the teaching process demanding attention. However, not all evaluations met with general agreement. Issues 17 and 18 are clear examples of that. The resulting high deviation implies a wide range in the voting, and these questions therefore provide little consensus on their relevance for improving teaching.

These results suggest that DDT is responsible for generating new perspectives and refine those aspects that are truly important for students, which is ideal for being exploited by teachers in an educational context. The fact that DDT is, so far as we are aware, the only one capable of receiving anonymous opinions and, simultaneously, calculating the degree to which the whole community agrees with them, can be regarded as a success. At the moment, the main goal has been to verify that these features work irrespective of the degree to which they work. The empirical results suggest that not only is DDT useful, but its features are desirable and used, too.

In addition, a classic opinion poll was carried out. The twelve statements comprising the poll are listed in Table 3,

TABLE 3
Evaluation Questionnaire on the Student's Opinion

Q	List of Statements
1	The tool is difficult to use
2	When the group has to take a decision, the tool is better than a classic forum
3	When the group has to take a decision, the tool is better than a meeting
4	When the group has to take a decision, the tool is better than other means of communication (email, chat, etc.)
5	The tool is useful for elaborating projects
6	The tool is useful for self-conducted quality assurance tests of the subject and the teacher
7	The tool is useful for achieving rapid agreements needed in remote practices
8	The tool is useful to encourage debates about the topics learned in the classroom
9	The tool needs more improvements in order to be practical
10	The tool is a good contribution to teaching
11	The tool is useful in areas outside teaching
12	The tool does not work and should be given up

with the results depicted in Fig. 13. The *X*-axis represents the statements from 1-12, while the *Y*-axis shows the degree of student agreement with each one. A value of ten indicates total agreement and '0' total disagreement. The format corresponds to Whisker plot boxes.

The analysis of the graph suggests the following points. Students find DDT easy to use (Q1), and it does not need many improvements (Q9). Students think that DDT is better than other tools (Q2, Q4), but it is not clear whether it outperforms an in-person meeting (Q3). Fig. 13 shows how controversial the question is. Most of the students are indecisive (intervals Q1 to Q3 are very short and centred on the value 5), but there is both total agreement and disagreement with this question. This suggests that trials using both methods would be worth carrying out to clarify the issue. Statements Q5 to Q8 try to measure in which context DDT is more appropriate. The general opinion regards all the applications positively, returning similar scores except in the fifth question, focusing on benefits in projects. There are some negative opinions but most of these are over five (Fig. 13). A possible factor here is that the number of group members is not specified in this question. Therefore, the answer will be less enthusiastic if students are thinking of small groups, which are the most common. The most extreme values are returned in Q6 and Q12. Students appreciated that DDT

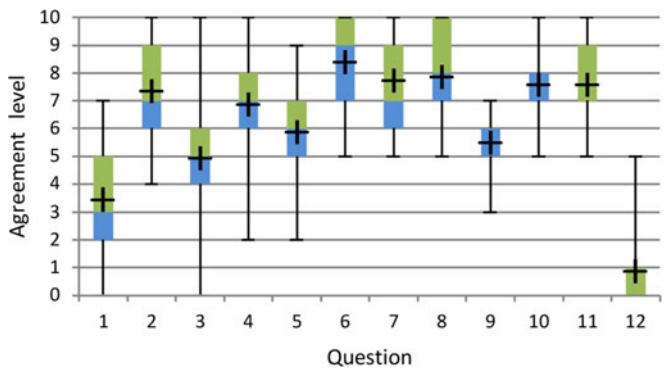


Fig. 13. Students' opinion of DDT. Each question in Table 3 is referenced by its number along the *X*-axis.

TABLE 4
DDT Benefits

Area	Benefits
Quality Assurance Tests	Allows students to add issues freely. Filters out isolated opinions. Capable of receiving proposals for improvements.
Debates	Achieves full students' participation (less certain in spoken debates). Persuasion by leadership or oratory is avoided. Critical thinking and argument through knowledge are encouraged. Easy to evaluate and record. Measures knowledge level of the whole class. Faster than oral debates; permits multiple short debates in the same class period Places students at their knowledge frontier.
Work in groups	All students contribute to decisions (avoids steering by individual). Motivates search for solutions to task. The larger the group, the more useful the tool.
Remote Labs	Allows large-scale practicals involving numerous student contributions. All lab resources can be used simultaneously. Work is shared, and hence reduced, but knowledge is greater.
General	No moderator is needed; users are in charge. Intuitive arrangement; debate is self-ordered. Easy to use; similar to classical forums. Multiple questions or proposals incorporated naturally. Available at any time, from any place. It is a web tool.

brings special benefits when quality assurance tests are required (sixth question). Finally, questions Q10 to Q12 evaluate the general impression of DDT, which is also positive. The final question is formulated negatively; the extremely low score implies that students are in favour of using and developing DDT in the future.

5 Conclusions and Future Work

It is well known that debates and group work are valuable methodological resources for teaching in universities. However, there are limitations to traditional face-to-face configurations which could successfully be overcome through the use of web tools. Such tools enable students to participate from home, increase the level of involvement, and can organize large numbers of contributions. Until now, to the best of our knowledge, there is no software available that allows students to participate in educational debates and to contribute to decision-making via the Internet. DDT provides these two services, needs no moderators and is easy to use across a wide range of applications related to the learning process (e.g., one session debates, large projects and surveys for quality control of teaching). A summary of the benefits of DDT is presented in Table 4.

The paper described a comprehensive study involving different courses. The methodology carried out through case studies consisted in employing DDT with teams and in class debates. Although the analysis is limited to these target scenarios -but extensible to others- and the results could

not be generalized, we obtained several educational outcomes. Results showed that students experienced an overall positive response to DDT, as a way to anonymously expose proposals, opinions and votes. As an alternative to other educational activities it motivated students that were reluctant to participate verbally. DDT also demonstrated to be useful to develop other valuable skills (e.g., critical reflection, discussion with peers and social strategies), as well as managing and structuring knowledge. Nonetheless, its best contribution was in quality tests where students revealed other demanded aspects about teaching and proposed their preferred solutions.

DDT is continuously growing. Since the background idea—in whichever application—is to let students manage on their own, our immediate efforts are focused on improving the tool's appearance and utility, but keeping its strategy. In fact, the students involved offered a lot of suggestions to improve the aspect, the behaviour, and other features. Some of them were about structuring the time: to limit the period for sending proposals, to sequence voting and arguing time, etc. Others were about organizing the debate, as a button to relocate proposals equivalent to the voting method (to vote 'no' to the misplaced proposal and 'yes' to the same one in a better place). Teachers who used DDT were interested in how to measure and represent the results. In this sense, there are currently works in the line of providing a set of tools to extract all data for graphical analysis and reporting through a Business Intelligence (BI) approach by using MicroStrategy software. At this moment, DDT is being integrated with an IdP (Identity Provider) by means of "SimpleSAML" free software with the aim of incorporating it to educational platforms like Moodle. This means a huge potential by taking advantage of the platform resources. For example: students could autonomously open their own debates for teamwork, debate evaluation would be moved to global marks in an easy way, and teachers could automatically create class groups.

Moreover, DDT can also be used out of the teaching field. One application would be opinion polls, which is useful in advertising, journalism, social research, politics, etc. Other application would be decisions making. For example a board of directors who have to travel continuously. Other examples include neighbour meetings, sport clubs, labour unions, and whenever a human group has a high level of members.

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