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Yuanqiong Wang
New Jersey Institute of Technology

Zheng Li
New Jersey Institute of Technology

Murray Turoff
New Jersey Institute of Technology

Starr Roxanne Hiltz
New Jersey Institute of Technology

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Yuanqiong Wang
New Jersey Institute of Technology
yxw9836@njit.edu

Zheng Li
New Jersey Institute of Technology
zxl8078@njit.edu

Murray Turoff
New Jersey Institute of Technology
turoff@njit.edu

Starr Roxanne Hiltz
New Jersey Institute of Technology
hiltz@adm.njit.edu

Abstract

This paper discusses the development of a Web-based collaborative Social Decision Support System (SDSS) Toolkit, and presents three case studies of its use by students in graduate level courses at New Jersey Institute of Technology (NJIT) to assess what they had learned together. The students were asked to collectively pool their interpretations of what they learned and see to what degree they had a consensus on the importance of topics covered in the course. The evaluation process and results are presented in this paper as a case study on how such a toolkit can be used in a collaborative learning environment. In the conclusion, possible enhancements and the future use of the toolkit as a learning tool are discussed.

Keywords: SDSS, list gathering tool, dynamic voting tool, course evaluation, collaborative learning, teacher enhancement, student assessments, CMC, CSCW, GDSS

Introduction

Collaboration among students in online courses as well as face-to-face courses enriches the learning experience, enhances the exchange of knowledge, and transforms a potentially solitary existence into an interactive journey (Benbunan-Fich, 2002; Hiltz, 1994; Lazarus, 2002; Leidner and Jarvenpaa, 1995). A useful collaborative learning tool will allow a class to engage in a structured discussion on a particular issue (Clark, 2000; Harasim et al, 1995; Turoff et al, 1995). Furthermore, a Web-based system gives great flexibility for both in-class teaching and distance learning. We have developed a Web-based Social Decision Support System (SDSS) Toolkit, which supports collaborative learning activities. This system has been used to poll students opinions on achieved course objectives in several graduate courses at New Jersey Institute of Technology. This paper describes three case studies of this exercise.

A Social Decision Support System (SDSS) is a type of inquiry system that supports the investigation of complex topics by large groups which hold many diverse and opposing views (Turoff, et al., 2002). The web-based collaborative SDSS Toolkit we developed includes two parts: a List Gathering Tool and a Dynamic Voting Tool.

The objective of developing such a toolkit is to help the individuals in the group to effectively produce, integrate, and synthesize their diverse views asynchronously (Turoff, et al., 2002). The SDSS Toolkit has many features to enhance the group process so that:

(a) All participants can come to respect and understand the differences caused by diverse values and interests of the contributing population,
(b) There can be a movement towards consensus on at least some of the issues involved.
(c) There is limited need for human facilitation of the meta-process of communication which is replaced by dynamic voting processes.

As a fundamental part of the SDSS toolkit, a List Gathering Tool helps group members to organize their ideas into a manageable list with clear structure. Group members can collaboratively build a list and organize the discussion as items in the list. Instead of using a simple post and reply structure in the general conferencing system, a contribution can be not only the users' original thoughts on a discussion topic, but also a suggested replacement for a number of other items on the list (e.g. consolidation), or a comment on an existing idea.

The Dynamic Voting Tool is not a simple tool that just provides majority voting or simple ranking, but integrates several major voting and scaling methods. It supports "yes/no", rank order, Likert scales, semantic differential scaling methods, and different voting methods such as plurality voting and approval voting. The major feature of the Dynamic Voting Tool is to provide human dynamic voting. That is, during a group process, group users can change their minds and change their votes repeatedly until specified criteria are met.

Evaluating whether the teaching objectives have been met at the end of the course can help the instructors to improve their teaching, and help the students to review the course material, hence further understand the course subject. Such an end-of-course exercise is itself a form of computer-mediated collaborative learning (Alavi, 1994). Most course evaluations have been focused on the instructor's teaching behaviors, such as being an organized presenter of information or being fair-minded in grading, and the students' performance. And often times, the evaluation on the instructor's ability was based on a standard student survey questionnaire, either paper-based (Achtemeier, et. al 2003; Hmieleski, 2000; Hmieleski, et. al 2000) or online survey, while the evaluation on the students' perceptions was based on a final exam at the end of the semester. However, very few prior studies were found that compared the teaching objectives and students' perceptions of the course contents. According to Brown and his colleagues (1989), the gap between the client experiences and professional perceptions of client experiences will highly influence clients' evaluation on the service. Therefore, finding the gap between students' perceptions and instructors' teaching objectives can help teaching staff to improve their teaching.

Since Spring 2002, we have been using the SDSS Toolkit to evaluate what students learned from several graduate level courses, including three face-to-face sections and three online sections, at NJIT. These exercises were trials for us to examine whether the students' perceptions of the course are the same as the course objectives designed by the instructor. It can also show us if a large distributed group could use this sort of software asynchronously to efficiently agree on a list of items, including multiple rewordings as a large group contributed to the quality of the resulting list, and a preference rating for the items on the list that represented the collective intelligence of the group.

Course Background

At NJIT, we have been employing group communication software to deliver distance-learning courses and to enhance face-to-face classes since the early 1980's. Currently, most graduate level courses in the Information Systems Department are delivered through face-to-face lectures combined with online activities. Students registered in a face-to-face section are encouraged to use a computer conferencing system to further discuss the course topics, in addition to listening to the lectures in class. Most of the courses are also offered online, combining lectures on CD ROM with discussions and collaborative assignments in the same conferencing system.

Three graduate level courses in the Information Systems Department at NJIT-- Management of Information Systems (CIS 679), Evaluation of Information System (CIS 675), and Design of Interactive Systems (CIS 732) -- were utilized in these case studies.

As a pilot study of this exercise, in spring 2002, students from CIS 679 used the SDSS Toolkit to come up with a rank ordered list of the most important things they had learned from the course. This course, offered by Murray Turoff, is an elective taken by graduate students in the Master's program in IS and in some other programs, including Computer Science and Management. It is also required for the Ph.D. students in IS. About half the course focuses on the task of managing software development projects for applications in an organization (Turoff et. al, 2000). There was one section of face-to-face students and one section of a distance version both utilizing a conference system (WebBoard) as a merged class.

In Fall 2002, students from two sections of CIS 675 and two sections of CIS 732 participated in the same exercise. CIS 675, offered by Starr Roxanne Hiltz and Yuanqiong Wang, is required for all graduate students in IS. The course focuses on how to use both quantitative and qualitative methods to evaluate an information system from the users' points of view. One section was delivered face-to-face combined with online activity, and another was delivered online. CIS 732, offered by Murray Turoff, is an elective for all the graduate students in IS and Computer Science. The course focuses on the design of interactive systems and human computer interfaces. There was also one face-to-face section and one section of a distance version both utilizing a conference system (WebBoard) as a discussion medium.

A summary of the courses which were included in this case study is shown in Table 1 below and includes the total students in each class and the number who participated in the post-course evaluation exercise reported here.

Table 1. Courses in the Case Study

Course Section	Delivery Mode	No. of Students	Time
Management of Information Systems (CIS 679- 101 and 851)	Face-to-Face + Online activities + Distance section	38 (28 participated)	Spring 2002
Design of Interactive Systems (CIS 732- 101 and 851)	Face-to-Face + Online activities + Distance section	23 (16 participated)	Fall 2002
Evaluation of Information Systems (CIS 675-101)	Face-to-Face + Online activities	27 (15 participated)	Fall 2002
Evaluation of Information Systems (CIS 675-851)	Online only	27 (20 participated)	Fall 2002

Web-Based SDSS Toolkit

The Web-based SDSS Toolkit includes two parts: a List Gathering Tool and a Dynamic Voting Tool, as briefly described in the first section. This toolkit was developed by the first two authors of this paper as part of their Ph.D. dissertations (Wang, 2003; Li, 2003). Unlike most online "voting" systems, the Web-based SDSS toolkit allows participants to actually collaboratively formulate the statements to be voted on in a well designed, structured way.

As Turoff et. al (1996) suggested, the heart of a group decision process such as the Delphi process, brainstorming, or Nominal Group Technique (Blanning, and Reinig, 2002; Dennis, Valacich, and Nunamaker, 1991), is the structure that relates all the contributions made by the individuals in the group and which produces a group view or perspective. In a computer-based Delphi, the structure is one that reflects continuous operation and contributions. The List Gathering Tool tries to help a group of users to collaboratively pull their ideas together, and provides a structure to organize those ideas into a list. Using this tool, users can propose their original ideas as root items in a list. During the discussion period, other users can make comments on the root items, and they can suggest better wording for the root items posted by other group members. After better wording is suggested, all group members can vote on it to decide whether the original item should be replaced by the modification suggested. When a certain pre-determined threshold (e.g. more than 50% of group members voted "yes" to the modification) has been reached, or if the group manager decides to do the replacement (depending on the system setting), the original root item will be replaced by the modification. Figure 1 illustrates the list-gathering process.

When the group members feel that they have reached a point of apparent agreement on wording, or a certain timeline is met, a voting session is made available by using the Voting Tool. Note that in the current version used for this study, consolidation of items could be suggested via suggestions to modify an item, but there is no explicit method to combine two or more items into one. In the results, we found that there were a number of places where some of the items overlapped. This has led to the following revision: participants will also be allowed to propose the deletion of a contributed item. This too will trigger the same yes/no voting process where a majority of all the active participants voting yes can cause the item to be deleted.

As with the proposal to substitute a better wording the original author can accept the suggested change anytime before a majority vote is obtained. It is also possible for the monitor of the process to perform the same function. However, the objective is to encourage the group to operate without the need of human facilitation intervention.

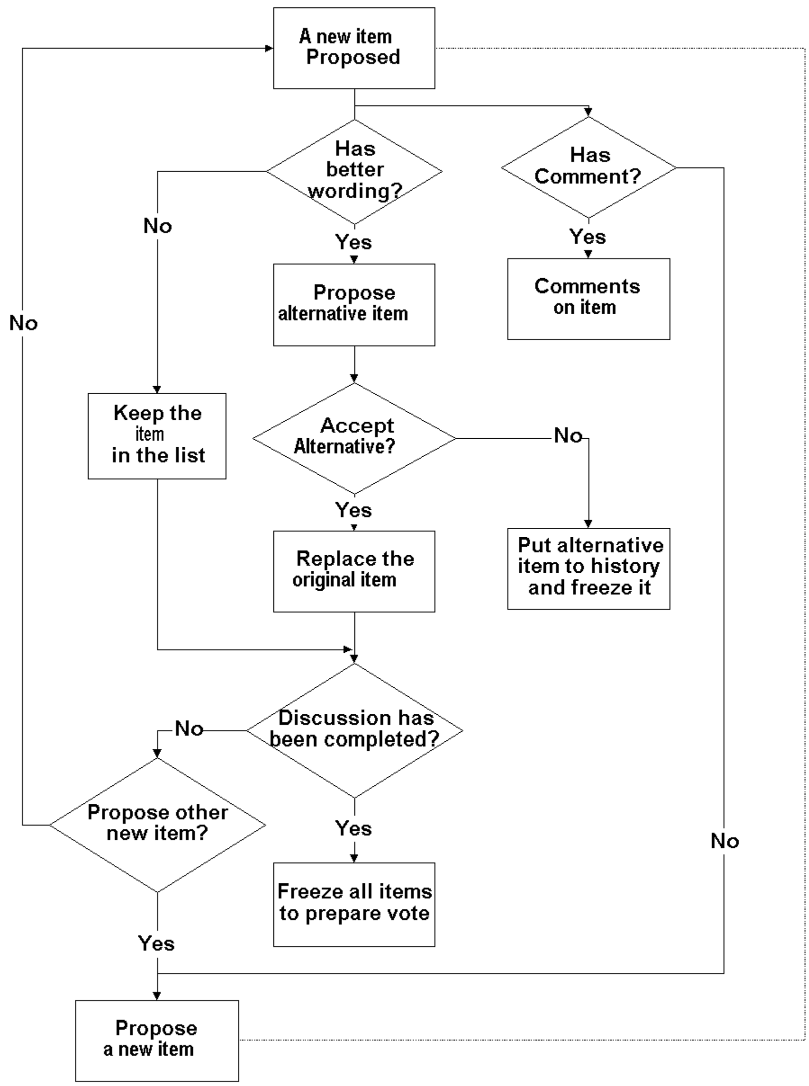


Figure 1. List Gathering Process Model

Evaluation Procedure

At the end of the semester, the course evaluation exercise was distributed as an optional assignment for the students who took the course. The whole process lasted two weeks. It has two phases. First, the students used the SDSS Toolkit to collectively generate their ideas in the form of a list of what they had learned from the course. And then they used rank order voting to see to what degree they had a consensus on the importance to them of the topics or skills. Students who participated in all the phases of this exercise could earn three extra credit points. A total of 115 students from the three courses (CIS 679, CIS 675, and CIS 732) did the exercise.

Phase One: Using the List Gathering Tool to List Items

In this case study, we created a topic for students in each course, e.g. topic “CIS 679 Exercise” for CIS 679. Under the topic, we created one list called “Things learned” as the workspace for students to do the exercise. The students were asked to suggest a concise statement of what they felt was the single most important thing they learned in the course. If someone else had already entered it, then the student needed to come up with something next in importance that no one had previously entered.

If students wanted to present a rationale on why they thought their item was important they could put in a separate comment to the root item to state their justification and where it occurred in the material of the course. The students were free to comment on any root item in the list and that comment could be classified as "Pro", "Con", or just an impartial "Neutral" comment.

The students could propose what they thought was a better wording of the root item which is called a "modification". If more than half of the class voted “Yes” to the modification it automatically replaced the original.

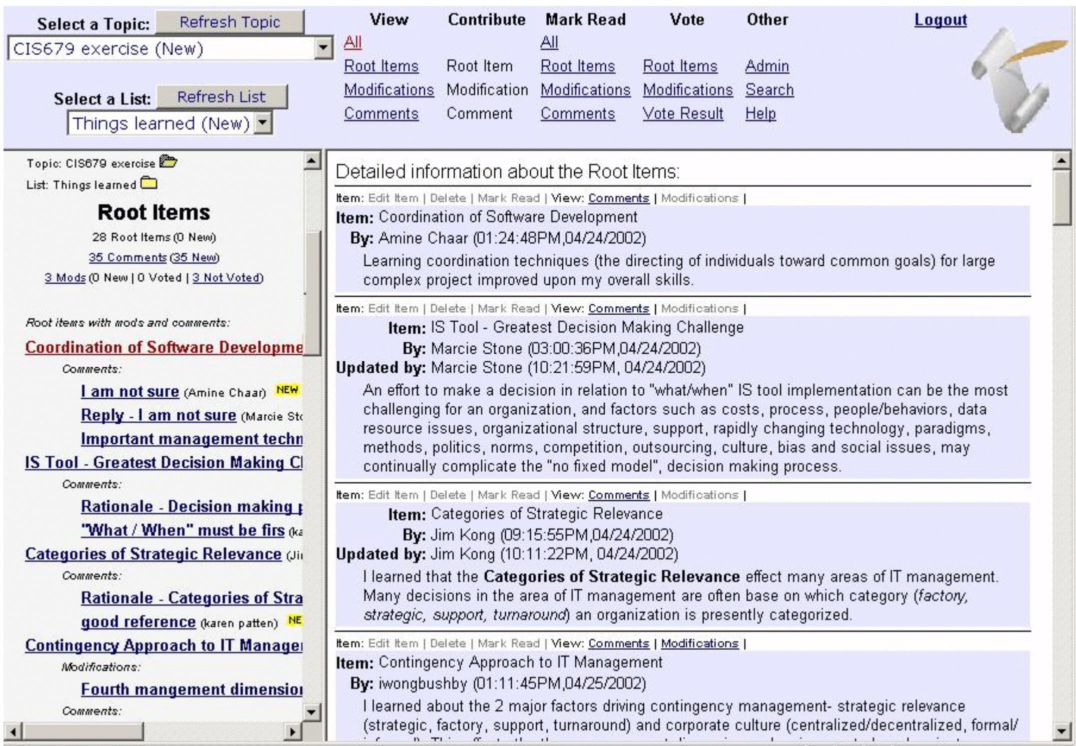


Figure 2. List Gathering Tool

Figure 2 illustrates the interface and the process through which students contributed their ideas about what they had learned from the course. The left frame is the index to what may be viewed in the right frame. The controls and menus are in the frame area across the top. The system allows for the collection of multiple lists within a single exercise.

Phase Two: Using the Voting Tool to Vote on the List Items

Once the class seemed to have most of the ideas in place and all the modifications voted on, a rank order voting procedure was triggered for all the items on the list. Students input ranks for the items based on their importance. As the result, the system calculated all the votes and established a rank ordered list of items for the class as a whole.

Evaluation Results

Table 2 shows the summary of the results of the exercise in each course. Figure 3 shows the final list of items for each course, in the form of the "top ten things learned." For example, as the result of the exercise, the students in CIS 679 produced 28 root items, 3 modifications (Mods), and 35 comments. In total, 24 students voted on the 28 root items using rank order voting. The items were listed in rank order as determined by an algorithm using Thurstone's law (Thurstone, 1927; Li et. al, 2000) which results in a single group scale providing meaningful interval measures of differences in preference. Two items for which half the group preferred A to B and half preferred B to A would occur at the same point on the scale. The top ten list items ranked by the students in CIS 679 were (As shown in Fig.3a):

Data Display: | Data Table | Bar Chart | Horizontal Bar | Line | Pie Chart | Raw Data | View Comments

List Name: Things learned from CIS679 (Round 1)

Voting Method: Rank Order Voting

Voting Period: *06/May/2002* to *25/May/2002*

Display Voting Result

Count only the last vote if a voter voted multiple times

Data Table: Thurstone's Law Result

Data Calculation: | Thurstone's Law | Borda Count | Condorcet | Mean   Distributions of Votes

Rank Order	Item (Discription)	Thurstone's Law	Dis. Above	Dis. Below	25% point	50% point	75% point	Total Votes	Vote Change
1	Runaway Projects	16.50	0	9.72	6.76	4.50	4.11	24	2
2	Categories of Strategic Relevance	6.78	9.72	0.02	6.65	4.11	2.09	24	2
3	Coordination of Software Development	6.76	0.02	0.11	6.65	4.18	2.10	24	2
4	IS Tool - Greatest Decision Making Challenge	6.65	0.11	0.51	6.14	4.11	2.10	24	2
5	Significance of 'people' issues	6.14	0.51	0.96	4.26	3.04	2.76	24	2
6	Risk management during the life of a project	5.18	0.96	0.68	5.18	3.92	2.42	24	2
7	Project management	4.50	0.68	0.24	4.26	3.48	2.27	24	2
8	Managements trade offs	4.26	0.24	0.08	5.18	2.53	2.27	24	2
9	Managing Change	4.18	0.08	0.07	6.65	3.04	2.27	24	2
10	Contingency Approach to IT Management	4.11	0.07	0.19	6.65	3.92	1.89	24	2

Figure 3a. Voting Result (Partial) for CIS 679

Data Display: | Data Table | Bar Chart | Horizontal Bar | Line | Pie Chart | Raw Data | View Comments   My History

List Name: Things learned (Round 1)

Voting Method: Rank Order voting

Voting Period: 05/Dec/2002 to 11/Feb/2003

Display Voting Result

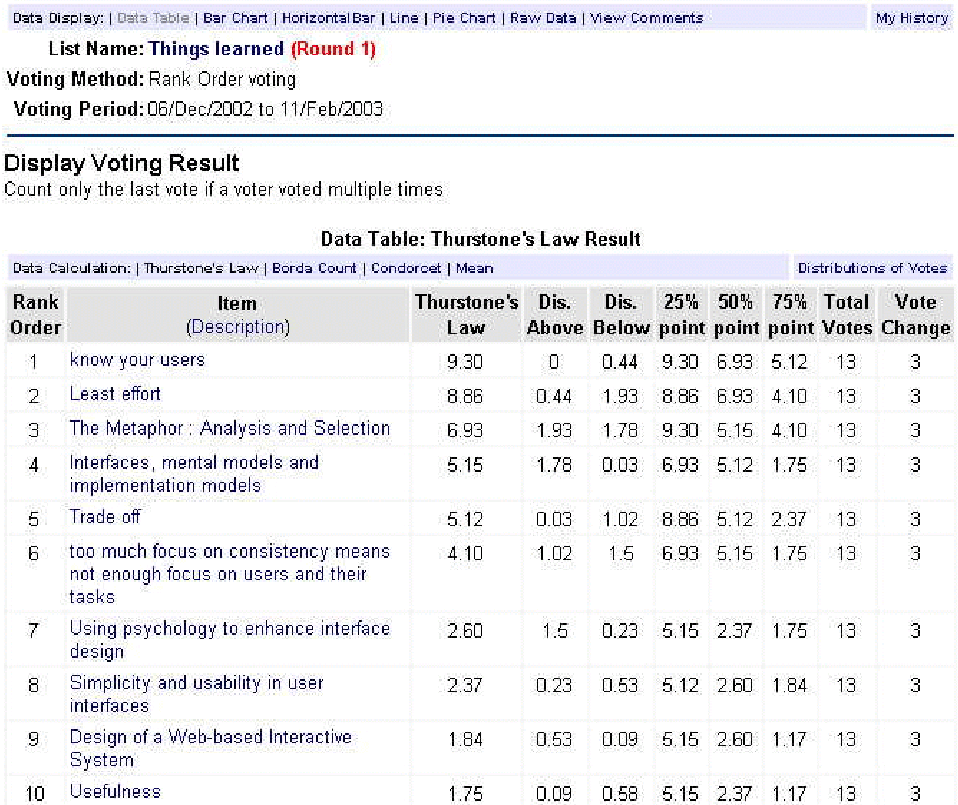
Count only the last vote if a voter voted multiple times

Data Table: Thurstone's Law Result

Data Calculation: | Thurstone's Law | Borda Count | Condorcet | Mean   Distributions of Votes

Rank Order	Item (Description)	Thurstone's Law	Dis. Above	Dis. Below	25% point	50% point	75% point	Total Votes	Vote Change
1	How to conduct Experimental research?	32.96	0	12.19	20.77	10.58	9.57	29	18
2	Practicality of Protocol Analysis	20.77	12.19	1.31	12.39	9.24	7.57	29	17
3	Statistical Methodology for evaluating significance	19.46	1.31	2.86	16.48	9.57	7.25	29	18
4	Essential ordered Steps in Conducting an Experiment	16.60	2.86	0.12	12.39	8.67	7.57	29	18
5	Protocol Analysis - Learning the cognition process	16.48	0.12	4.09	16.48	9.57	6.08	29	18
6	Survey Methodology	12.39	4.09	0	12.39	9.24	4.02	29	18
6	Methodology of Questionnaire Construction for IS surveys	12.39	0	1.72	10.67	9.24	6.97	29	18
8	Understanding Qualitative Methods	10.67	1.72	0.09	10.58	7.25	5.96	29	18
9	Experimental methods applied in IS study	10.58	0.09	0.51	16.60	8.67	4.84	29	18
10	Evaluation of Information Systems is a Formal Scientific Process	10.07	0.51	0.5	10.67	7.25	4.84	29	17

Figure 3b. Voting Result (Partial) for CIS 675



Data Display: | Data Table | Bar Chart | Horizontal Bar | Line | Pie Chart | Raw Data | View Comments | My History

List Name: Things learned (Round 1)
Voting Method: Rank Order voting
Voting Period: 06/Dec/2002 to 11/Feb/2003

Display Voting Result
Count only the last vote if a voter voted multiple times

Data Table: Thurstone's Law Result

Data Calculation: | Thurstone's Law | Borda Count | Condorcet | Mean | Distributions of Votes

Rank Order	Item (Description)	Thurstone's Law	Dis. Above	Dis. Below	25% point	50% point	75% point	Total Votes	Vote Change
1	know your users	9.30	0	0.44	9.30	6.93	5.12	13	3
2	Least effort	8.86	0.44	1.93	8.86	6.93	4.10	13	3
3	The Metaphor : Analysis and Selection	6.93	1.93	1.78	9.30	5.15	4.10	13	3
4	Interfaces, mental models and implementation models	5.15	1.78	0.03	6.93	5.12	1.75	13	3
5	Trade off	5.12	0.03	1.02	8.86	5.12	2.37	13	3
6	too much focus on consistency means not enough focus on users and their tasks	4.10	1.02	1.5	6.93	5.15	1.75	13	3
7	Using psychology to enhance interface design	2.60	1.5	0.23	5.15	2.37	1.75	13	3
8	Simplicity and usability in user interfaces	2.37	0.23	0.53	5.12	2.60	1.84	13	3
9	Design of a Web-based Interactive System	1.84	0.53	0.09	5.15	2.60	1.17	13	3
10	Usefulness	1.75	0.09	0.58	5.15	2.37	1.17	13	3

Figure 3c. Voting Result (Partial) for CIS 732

Table 2. Results Summary

Course	No. Students Participating	No. Root	No. Mods	No. Comments	No. Votes
CIS 679	28	28	3	35	24
CIS 675	35	42	3	60	29
CIS 732	16	15	5	46	13

With the Dynamic Voting Tool, one can visualize the relative comparison of alternative results on the same data set, which may present opposing different views of the group results. For example, rank order results can be calculated by different methods, such as Thurstone's Law, Borda Count, Cordorcet's Law, mean/average, distributions of votes in terms of the ranks, or simply the raw data (i.e. individual votes). One can choose to display the data in a data table or graphically (e.g. bar chart, horizontal bar, line, or pie chart).

In Figure 3, Thurstone's Law results are displayed in a data table. Thurstone's Law is a data analysis method used for both rank order or paired comparison data (Thurstone, 1927; Li et. al, 2001). It has the very unique feature of being able to transform a set of individual rank order data or comparative preference data to a single composite group interval scale result. Therefore, one can identify not only the rank order of the group result, but the meaningful distances between list items.

The rank ordered list from each course showed the perceived class achievements of the students. The instructors used these results to check whether the items proposed by the students match the original course objective in the instructors' mind.

Feedback from Instructors

Since three of the authors were also the instructors who participated in this case study, this section represents their attempt to take on the role of a "user" of the system.

The lead instructor for CIS 675, Roxanne Hiltz, felt that the top items represented the most important topics in the course, but only if several of the items were combined. For example, questionnaire construction and sample survey methodology were covered in two separate items tied for rank 6, and also mentioned in an item ranked as number 21; if they had been combined, the combined ranking might have been higher. The qualitative methods taught, including protocol analysis or the "thinking out loud" method, were described in separate list items ranked as numbers 2, 5, 8, 24 and 26. A real "surprise" was the very low ranking of the importance of learning how to understand published research articles in information systems. This skill was listed in the course objectives in the syllabus as one of the "top five" but was listed and ranked only as number 41 out of 42 by the students. Apparently they do not value the ability to read and understand journal research articles in Information Systems as much as the instructor does. Alternatively, it may be that the students felt the prior course “Principles of Information Systems” (CIS677) had covered that topic to a point where they did not need added skill in this area except for the understanding of professional evaluation studies.

For CIS 679, the students contributed all the items the professor expected during phase one. However, the final rank ordered list was a surprise to the professor. For example, not only was “Runaway Project” ranked No.1, but also its Thurstone’s Law results were about two times higher than the No.2 item. A runaway project is one for which the cost is at least twice as much as originally planned. Upon reading the comments made on the item it was observed that this topic became an organization factor or metaphor around which the students associated much of the lecture material dealing with the problems of the development process. So even though only two lecture hours was spent upon this topic as an introduction to the development process, it provided a cognitive framework for the organization of an additional 15 hours of lecture. This was a total surprise to the professor. We also note that items 7 to 10 had considerable overlap and many similarities. However, the fact that the scale values are all very close to one another is an expression of this similarity of the items which is a natural result of the Thurstone's scaling process. If an equal number rank A higher than B to those who rank B higher than A, the two items would have the same scale value.

In CIS 732 the top ten items are more equally distributed along the range of the scale values and the items are more distinct and dissimilar in nature. This was a more likely result from a smaller class where each member was asked to contribute only one item. In the future the proposal change to allow deletions should help to minimize the occurrence to overlapping items through the combination of the deletion and replacement process to allow minimization of duplication for the group results.

The important finding from this application of the technology is that instructors may well discover insights about the course they are teaching that are not easy to otherwise determine. It also appears to be very beneficial to the students as is evident in the comments on the proposed items which get to be very interesting insights into the ways the students assess what they have learned.

Summary and Discussion

These class exercises gave us an opportunity to explore the use of the SDSS Toolkit in an asynchronous distributed learning environment. It shows us how we can utilize the new SDSS Toolkit to enhance learning for both face-to-face and distance learning classes. Assessing the achieved course objectives helps not only the students to review what they have learned, but also the instructors, to improve their future teaching. The exercise turned out to be very successful.

However, the results also indicate the need for an explicit process to combine or consolidate initially separate items on the list. In keeping with the spirit of making each operation very straightforward and simple, it was felt that adding the deletion proposal to the rewording proposal and having them each work exactly the same way would keep the tool very easy to use. The design of this asynchronous communication process for large groups is in the spirit of an online "Roberts-rules-order." The fact that each member may address any motion or proposal at any time is the key to allowing asynchronous operation for large groups. How participants voted is not identified and comments may be entered anonymously so that the system can support a complete Delphi process (Linstone and Turoff, 1975). The Delphi method may be utilized as a learning tool for collaborative class exercises.

For this kind of exercise, with the addition of a consolidation mechanism, multiple rounds of discussion and voting will help students to arrive at a final list of items with few duplications. Due to the time constraints of the case studies reported here which occurred during the last two weeks of the course, we could only conduct one round of discussion and voting.

This system can also be used by all the students in a class to continuously explore pragmatic issues in a particular course such as tradeoffs in the design of an information system or an interface. For any course with pragmatic content, this would be an interesting way to have the students collectively pool their interpretations of what they are learning and see to what degree they have a consensus on pragmatic issues in the course. Many instructors have expressed interests in utilizing this toolkit in their teaching, and several courses are using the toolkit as a class exercise now. We intend to place this software in the public domain before the end of 2003.

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