Structural Communication and Web Based Instruction

Carlos Villalba

Carlos Villalba, M.Sc
Syracuse University
cavallal@syr.edu

Abstract
The paper first reviews earlier work on a methodology named Structural Communication that achieved some success in automating and individualizing intensive collaborative and creative discussion in a way that may compete with facilitated small-group methodologies. Then, the paper describes a methodology that combines some aspects of Structural Communication with interactive Web-based discussion to create an effective and efficient alternative to classroom-based case study discussions. A specific example of an online case discussion that was used in the study is presented and explained. Finally, some key research findings are summarized, suggesting that this hybrid methodology may be more effective than the facilitated small group for promoting creative ideas, as well as being more efficient and multipliable.

Resumo
O presente artigo, inicialmente revê experiências anteriores com a metodologia denominada Comunicação Estrutural, que alcançou sucesso na automatizar e individualizar discussões criativas e interativas intensivas de forma que compete com metodologias facilitadoras de pequenos grupos. Em seguida, o artigo descreve a metodologia que combina alguns aspectos da Comunicação Estrutural com Discussões baseadas na WEB, para criar uma alternativa efetiva e eficiente para discussões baseadas em estudo de caso. Um exemplo específico de um caso de discussão online que foi usada no estudo é apresentada e explicada. Finalmente, alguns resultados-chave de pesquisas são resumidos. Sugerindo que esta metodologia híbrida pode ser mais efetiva que pequenos grupos facilitados para promoverem?// ideias criativas, assim como sendo mais eficiente e multiplicável.

Resumen
En la primera parte de este articulo se revisan previos trabajos relacionados con una metodología denominada Comunicación Estructural que han alcanzado algún grado de éxito en la automatización e individualización de discusiones intensas, colaborativas y creativas en formas que puedan competir con las metodologías de facilitación con pequeños grupos. Luego, el artículo describe una metodología que combina algunos aspectos de la Comunicación Estructural con discusión interactiva a través de la Web para crear una alternativa eficiente y efectiva a las discusiones de estudio de caso llevadas en un salón de clase. Un ejemplo especifico de una de las discusiones de caso en-línea usada durante este estudio es presentada y explicada. Finalmente, se resumen algunos resultados claves de la investigación que sugieren que esta metodología híbrida puede ser mas efectiva que la de facilitación de pequeños grupos en la promoción de ideas creativas, y también más efectiva y multiplicable.

Structural Communication

Structural Communication (SC) is an instructional approach that provides a simulated dialogue between an author of instructional materials and the students. It has been called "an interactive technique for communicating understanding" (Egan, 1976). Understanding is "inferred if a student shows the ability to use knowledge appropriately in different contexts, and to organize knowledge elements in accordance with specified organizing principles" (Egan, 1972, p. 66). The technique was designed to encourage creative thinking in learners, allowing them to develop an understanding of a topic, not simply to memorize facts. Furthermore, Structural Communication was designed to promote learning for social action (Hodgson, 1972). The typical components of a Structural Communication unit are described below.

Intention	The opening statement, which defines what is to be studied, provides an overview, possibly an "advance organizer", and sometimes a rationale. It is used to provide a context.
Presentation	The

	material, experience, exercise, case study, etc. which supplies the essential facts and concepts of the domain being studied. This may be an existing text, a video, a case study, a simulation, or real-life experience, depending on the overall strategy of the exercise. This could also be any sort of computer-based instruction, including simulations.
Investigation	A set of problems for solution, which are designed to present the "intellectual challenge" that is an essential part of the Structural Communication methodology. These problems are interrelated and are open-ended to allow multiple responses and viewpoints. The purpose of the investigation section is for the learner to interact with the subject matter.
Response Matrix	A randomized array of items which summarize key parts, concepts or principles from the knowledge base that is being used and studied in the exercise. Often it resembles a "key point summary" of the Presentation. The student composes a response (outlines an essay) by selecting any number of these items as a "best" response to a given problem.
Discussion	The Discussion has two parts: a Discussion Guide and a set of Discussion Comments. The Guide is a set of if-then rules, which test the student's response for omission or inclusion of certain significant items, or combinations of items. The Comments are constructive statements that discuss in depth the rationale for including or excluding certain items.

A modified Structural Communication methodology with focus on collaborative learning

The research focus adopted by the author is on the effective implementation of group discussion, or "conversational", methodologies on electronic telecommunications networks. This focus is particularly important, as we know much less about how to converse effectively on electronic networks, than we do about electronic self-instruction. There is a long history and fairly developed technology of the design, development and delivery-at-a-distance of self-study materials. There is much less known about the running of effective group-discussion sessions at a distance (Chang, 1994). In the present study we were seeking ways around these limitations. In order to perform this research we developed a web based automated case discussion system using Authorware™. To do this, we turned to Structural Communication, originally developed in the United Kingdom in the late 60's and early 70's as a methodology for writing and presenting interactive print-based exercises. An adaptation of this methodology had shown itself to be effective for automating and individualizing small-group learning methods such as the Harvard Business Case methodology (Hodgson et. al. 1971). Later studies demonstrated the effectiveness of the methodology in reducing the amount of human facilitator or monitor interaction necessary in order to lead the exercise to a satisfactory conclusion (Romiszowski, 1990; Romiszowski & Chang, 1992; Chang, 1994).

The original SC methodology was redesigned in order to create a somewhat more constructivist and collaborative learning environment. Some of the most important features of the SC method, for example individualized learning of basic content and access to expert opinions, were maintained. However, the revised form provides open-ended discussion environments for students to share, argue, persuade, and negotiate their perspectives on the expert's feedback comments as well as on their own opinions. In the original method, the planned learning activity ends with reading the expert's comments. Since the revised method is designed for small group collaborative learning, from this point on, further learning activity occurs collaboratively with group members. After completing their work individually, students browse what each group member did. With a summary table as a guide, group members can access any item and read

the viewpoints and justifications of other group members. They are asked to react to each other's justifications and invited to indicate whether they agree or disagree with each other or with the instructor's viewpoint.

An illustrative example.

One area of application for Structural Communication (SC) exercises at Syracuse University has been in the Area of Instructional Design, Development and Evaluation, a master's and doctoral program that includes several courses on critical analysis and creative design of instructional methods, media and systems - ideal subject areas for SC. Since the late 1980's many SC exercises have been developed, some by faculty and others by the students themselves, on topics such as analysis and evaluation of training needs, overall course designs and detailed lesson plans. These were incorporated into regular courses as standard components of their design, most often as printed exercises followed by group discussion in class. Later some SC exercises were developed on the Macintosh platform, using Hypercard and were made available to the student community via the university campus computer clusters. These added the facility for online asynchronous discussion of individual opinions and viewpoints. With the appearance of the Internet, some of these early and well-tried exercises were migrated to the online environment., In the process, due to several factors peculiar to the university policy on campus computing, they also migrated from the Macintosh to the PC platform, which necessitated a total re-programming. This was done initially using the Authorware multimedia development software.

One of the exercises that was thus migrated is an interactive case study exercise that focuses on the skills of Human Performance Problem Analysis. This form of analysis is an important skill for the educational technologist or indeed for any education and training professional. It focuses on the identification of the multiple causes of inadequate performance in the job-context and separates those causes that may be impacted through training from those that cannot, in this way helping to avoid the expensive error of designing, developing and delivering totally unnecessary training programs. It has been estimated that as much as 70% of all corporate training courses give little or no return on investment in terms of improved job performance. This is because the root causes of inadequate performance are not entirely (or not at all) due to the lack of specific knowledge or skill on the part of the performers. Other causes, such as lack of motivation or inadequate job organization / environment / tools are very often mistaken for training needs (Gilbert, 1978). Several case study exercises have been developed to give practice in the analysis of typical performance problems and so develop the skills necessary to diagnose the root causes of performance deficiencies. One of these exercises was set in the imaginary context of a typical US university, where those responsible for faculty development have identified a problem associated with the lack of use of audiovisual teaching media, specifically the overhead projector. However, the case could be structured around any more recent item of teaching technology, for example, computer-delivered PowerPoint presentations. This case is here presented as an example of a typical SC exercise now designed to run on the Web and act as the initial component of a collaborative online methodology for case analysis and discussion.

The opening page of the exercise, shown here in Figure 1, presents seven actors all faculty members of the imaginary university. It also gives access to a lesson on the principles and procedures of Performance Problem Analysis, instructions on how to use the exercise and access to all the exercise components.

Figure 1. The opening page of the Overhead Projector case study exercise.

The seven graphic icons give access to transcripts of interviews of each of the faculty members, carried out by a performance analyst. Also, on the right side of the page, the student may click to access short resumes of each of the interviewees. This page gives the student access to all the available information that may be used in the process of analysis of the problem and proposal of a solution. The student commences study by clicking on the buttons of choice and reading the information presented in each secondary window that appears. Once the student is satisfied that all the possible causes of the problem have been identified, the button marked SOLUTION leads to the case discussion environment. It is this discussion environment that uses a modified Structural Communication environment.

The initial study material is the Presentation component of the exercise. It is the equivalent to the case material that, in a conventional publishing context may have been published as a book chapter. Indeed, there is no theoretical reason why the case material could not have been presented as a conventional text, to be studied online or offline as each student prefers. However, in this particular instance, the case material has been written in the form of a hypertext. This was done in order to illustrate to the student the manner in which information gathered from one source an interview with one of the faculty members may confirm and support, or may conflict with information from another. The use of a hypertext presentation enables the student to quickly see the need for cross-referencing multiple information sources and building an interconnected structure of information components as part of the process of problem analysis. The manner in which the information structure is studied is illustrated in Figure 2.
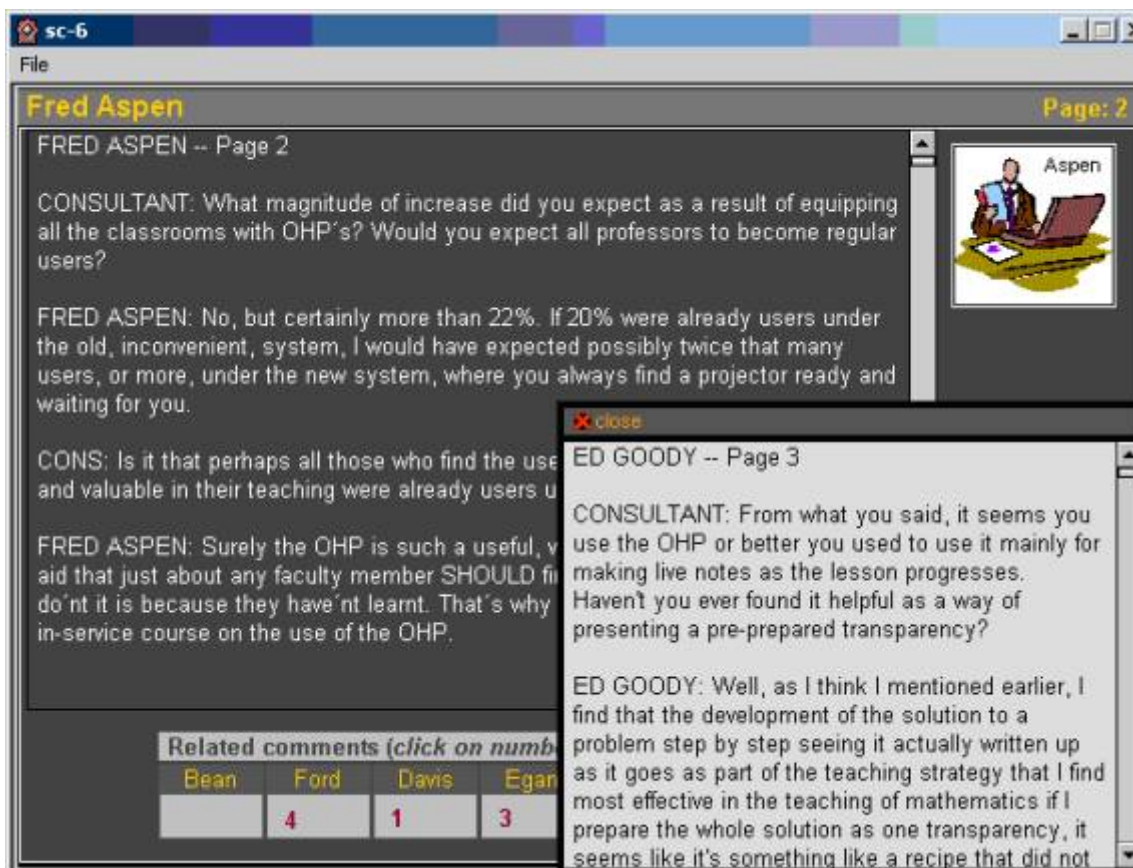
Figure 2. A typical information page in the case material database.

This figure shows the second of seven pages of transcript of the interview with Fred Aspen, who is the head of faculty development in this university, who has identified the supposed training need and has decided to offer workshops to the faculty on the use of overhead projectors. Each page of the transcript is hyper-linked to relevant pages in the transcripts of the other interviews. The local index provided at the bottom of each page allows the student to easily reach comments that other faculty members have made that are related to the one on the open page. These comments, when accessed, open up as a secondary window. Figure 2 shows the result of clicking on the link to the transcript of Ed Goody, a professor of mathematics who is expressing a view in conflict with Fred Aspen's.

Students, browsing in a purposeful manner through the hypertext quickly get a structured understanding of the many different viewpoints expressed by the faculty members. They must then evaluate these viewpoints, decide which of them are relevant and which are not, and thus make up their own mind regarding the real nature problem and its root causes. As the analytical skills of the students develop, they recognize more quickly which interview questions are relevant and which are not. This allows them to read only those parts of the hypertext that they deem to be relevant, thus reducing the time required to study the case material. They are, in effect, learning to ask the right questions.

When the student has gathered all the information that is deemed relevant, a click on the SOLUTION button presents the Response Matrix. This is really an array of items to be selected in constructing a response to the problem. The student should select the combination of items that best represent the student's proposed solution. The response matrix for the Overhead Projector case, shown in Figure 3, contains 20 items.

Figure 3. The Response Matrix.

There is no definition of the number of items to include in a response matrix. The items are dictated by the particular subject domain being studied and the author's view of what items should be included as possible choices for the problems that are being presented to the students. Often, the response matrix is just a list of the key events in a case, or the key concepts in a subject domain. For example, the twenty items in the example shown here are all methods that may be used to improve job performance some training-related and others not. The student would normally be familiar with these methods, as the SC exercise is preceded by the Presentation phase, which in this case involves the study of a well known model for performance problem analysis that is presented in a chapter of the book Designing Instructional Systems (Romiszowski, 1981). The issue is to select the mix of methods that will address all of the causes for the problem that were encountered in the study of the case material.

 Typically, a SC exercise will present three or more open-ended questions on different aspects of the domain, but the same response matrix would be used to respond to all questions. Thus, the array of items would include relevant response components for all the questions and, if the questions are reasonably different from each other, this guarantees a certain amount of redundancy - items that are irrelevant to a particular question without the need for invention of irrelevant distractors. A response matrix would rarely contain less than about 15 items, as this would imply that the problems being addressed are not all that complex and multifaceted as to require the use of the SC methodology. Also, the number rarely exceeds about thirty items to forty items, as this represents too much complexity in responding.

Students may select any number of items that they consider appropriate. The number of possible combinations is so large, running into millions, that it is rare for two students in any group to submit exactly the same response. However, the responses may be easily analyzed on the basis of the items that were included or excluded. The exercise then presents to each student a number of feedback messages, selected from a database of author's comments on the basis of the key items included or excluded. In the Syracuse model for online SC exercises, the students may comment the author's comments, typing their replies in a box provided in each feedback message. These student-generated comments are automatically stored in a central database and may be used in several ways:

- the instructor may respond directly to the student, elaborating on the initial feedback;

- the comments may be shared among all students and an online discussion may be initiated;

- frequently repeated comments may lead to a revision of the feedback messages, change in the response matrix items, or even a rewrite of the basic case material.

Once the student has read all the feedback comments that were automatically generated by the initial choices of response matrix items, and perhaps replied to some of them, the SC exercise presents a final summary of all the information that has been collected. This is presented in the format shown in Figure 4. Here the student has, on one page, a list of the particular inclusions/exclusions that generate feedback messages (there are 13 in our example) and an indication of the specific feedback messages that were relevant to that student's response. There is also a second chance to access the feedback messages - not only those that were recommended, but any of the others as well. In this second round, the student finds all the student-generated messages listed below the author's feedback. It is now possible to make further comments either on the original feedback or on specific student-generated comments. Thus, a threaded discussion is under way the threads having been pre-defined by the structure of the author's feedback. In our example, there are 13 discussion threads, accessible by the buttons in the right hand side of the final summary page. Thus the summary is not the end it is the beginning of further collaborative learning.

If you	Item	Review those marked	Feedback
Included	1.-Re-structure the job OR 18.-Re-plan the work methods/sequence		A
Included	3.-Re-assign/transfer OR 4.-Teach pre-requisites		B
Included	4.-Formal Instruction		C
Omitted	5.-On-job training	✗	D
Included	6.-"Telling/showing"		E
Included	7.-Plan practice / Re-train freq.		F
Omitted	8.-Supply a manual 9.-Supply job aids		G
Included	10.-Enlarge the job OR 11.-Enrich the job		H
Omitted	12.-Plan feedback of results good perf. OR 13.-Increase the rewards for good performance		I
Included	14.-Eliminate the rewards for poor performance OR 15.-Eliminate the punishing consequences		J
Included	16.-Increase punishment for non-performance		K
Omitted	17.-Re-plan the equipment or workspace	✗	L
Included	19.-Re-organize the responsabilities OR 20.-Re-organize the systems of management		M

Figure 4. The Final Summary page.

The Experiment

As the process continues, the pool of the students' discussion log grows. The web based automated case discussion system was designed to save every justification and discussion statement that students made. It also enables students to browse those reactions and opinions in a cumulative mode as the process continues. While they are performing these activities, the nature of their interaction varies along several dimensions. For example, they did, or did not, regularly access expert author's feedback comments to inform themselves on what the experts say. Similarly, they had posted, or not, their opinions and justifications in their own words. And of course, they all tended to differ in their initial selection of items from the response matrix.

The automatic collection of data by the central database enables all these, and other, variables to be tracked and measured automatically. However, the students who studied the SC case materials formally

as a part of their course work in the IDD&E program at Syracuse University, could generate further data that was not automatically collected by the exercise. They responded to questionnaires that were posted on the website together with the SC exercises. Also in class they applied their new skills to other examples of similar tasks, so it was possible to assess, somewhat subjectively, the amount of transfer of learning between the case examples used in the SC exercises and real-world performance problem analysis exercises.

The web based automated case discussion was delivered using two methods: a downloadable module that can be installed on an Microsoft Windows operating system, and a version embedded in a web page and accessible through the use of plug-in and compatible with both Windows™ and McIntosh™. Both versions, however, operate with a connection to the Web, so that all the data generated by the student interaction with the exercise was captured by the central server and stored in the database. The data presented below is a summary of the first experiences with the online use of the "Overhead Projector" case.

A total of 51 graduate students participated in this study, which involved the use of this Structural Communication exercise in the form of a case study of some problems related to a faculty development program in a hypothetical university college context. The students were asked to read a chapter of the set book (chapter 6 in Romiszowski, 1981) to create a common knowledge base on the domain under study, as part of the presentation section of the exercise. We incorporated the use of the case study technique as part of the investigation. In this section the students were asked to research and find clues and facts that could help them later on in the exercise to propose solutions to the problems presented. The solutions were proposed through the use of a specially developed response matrix. The response matrix was entirely based on the principles the students were supposed to learn after reading the presentation section and the chapter in the book.

Data Findings and Discussion

Qualitative analysis of the data collected by the web based automated case discussion system revealed two emerging themes: motivation and time. For the first theme, motivation, quantitative data from the evaluations corroborated the qualitative data. 74% of the students indicated that the exercise was highly motivating. This can be best summarized using one of the student's comments; Nice and easy to follow, it resembled an imaginary conversation with the instructor, which kept me on track. The motivation data, collected by means of online questionnaires, is presented in Figure 5.

As regards student motivation, there is little doubt that exercises organized in the form of Structural Communication are most effective. The students who participated in the study worked voluntarily and without recompense in the form of grade points throughout a whole semester with very low dropout rates. The students in earlier studies showed similar levels of motivation. This finding is important in the context of conversational CMC-type WBT in that the study materials placed in a publicly "open" WBT environment will survive and prosper, or alternatively wither and die, as a function of their ability to attract voluntary participation from a significant number of WWW navigators.
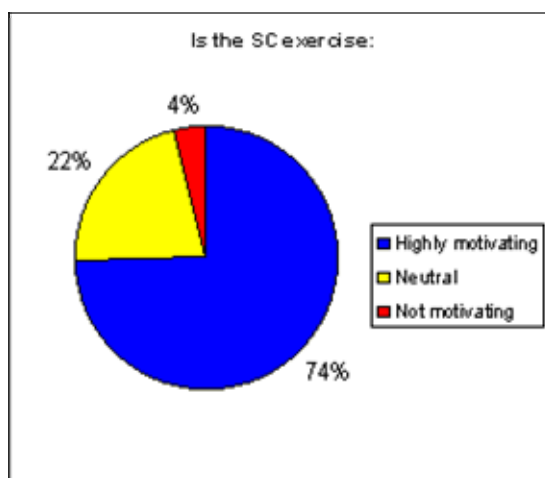

Figure 5. Motivation data

It may well be that the reasons for the high levels of motivation encountered in these studies are not entirely and uniquely a consequence of the SC format. As mentioned before, the quality of design of the

exercises themselves is probably a most critical factor. In Khan's recent collection of essays on Web-Based Instruction (Khan, 1997), two chapters are devoted to issues of motivation in WBI (Cornell & Martin, 1997; Duchastel, 1997). Both chapters review several well-known approaches and models for the design of motivational learning materials, such as ARCS (Keller, 1983). Well-known approaches take into consideration not only pedagogical principles they also take into account design principles and usability principles. A factor that contributes to the quality of the design of SC exercises is the use of the response matrix, which enhances considerably the usability of SC exercises. However, Structural Communication's unique mechanism of the response matrix is an approach that has been largely overlooked. The response matrix allows for easy and rapid responding to complex multi-faceted problems, at the same time allowing one to explore one's own and each others' cognitive structures in some detail. This is the inherent attractiveness of the methodology to the interested and reflective student.

We should not leave the question of motivation without also considering the motivation of the instructor or discussion facilitator. Cornell & Martin (1997) address the question of instructor motivation in Web-based learning. The authors mention seven reasons for lack of instructor motivation (as compared to twelve for student motivation) and, interestingly, this list of seven reasons does not include the avoidance of extra workload. However, experience and research suggest that CMC-delivered courses almost always involve significantly more instructor time than conventional courses. We therefore feel that one should add this eighth reason to the list. Furthermore, we believe that Structural Communication offers, at least in part, a solution to this eighth reason.

In discussions organized within a SC-based CMC environment, the problem of instructor overload is much reduced. The automatic generation of extensive and constructive feedback to students on the basis of the pattern of responses they select from the response matrix acts like a first-round live reaction from the instructor to specific aspects of the students' overall response. In practice, these automatically generated feedback messages satisfy well over 70% of the students' needs for clarification or orientation. The remaining 20% to 30% of feedback interactions generate second-round student responses in the form of electronic messages that pose supplementary questions or comments, usually at a deeper and more reflective level of discourse. The effects of this on the motivation of the instructor are twofold. First, the overall workload of responding to students (measured in terms of the number of messages to compose) is reduced by some 70%. Second, the messages to be responded are on issues that are often more interesting and always relatively original and non-repetitive.

Having touched on the issue of workload as it relates to the instructor/facilitator, we may mention our experience with the SC response-matrix mechanism as a device for the reduction of student workload. In selecting a subset of response elements from the universe represented by the items in the response-matrix, the student is in effect composing a complex, structured response to the problem under analysis. This is analogous to the preparation of an outline for an essay or live seminar presentation. The intellectual effort necessary to evaluate the relevance of each item of the matrix to the problem being studied is equivalent to that expended in planning an essay or presentation. However, the time and effort involved in writing an essay or preparing and delivering a presentation are saved. Figure 6 shows the time in minutes students spent working on the exercise.
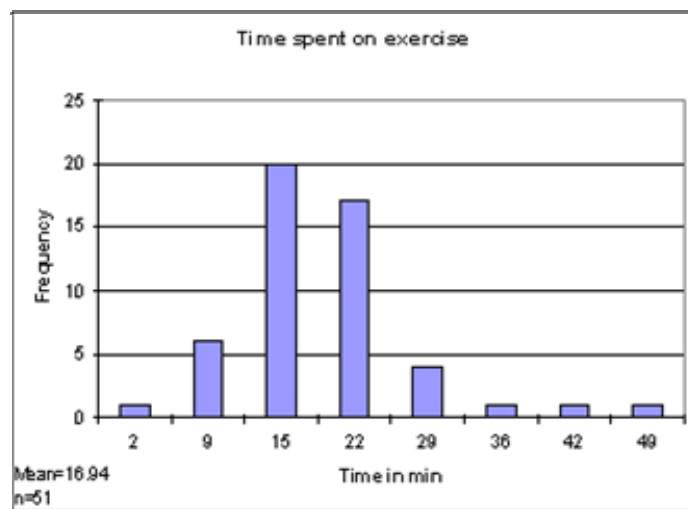

Figure 6. Recorded time spent on exercise

We have also observed that students spend more time, more productively, in the intellectual restructuring of ideas and the creation of their own knowledge structures than is often the case in conventional instruction. To be sure, students do restructure their ideas when they engage in free, unstructured, small-group discussion with their peers and teachers, but not with the frequency and depth of insight that seems to be generated in the SC environment. And, in our view, the relatively unstructured discussion lists that abound in current WBE environments, even the popular threaded discussions, are less effective in promoting creative idea-generation. Furthermore, they are more wasteful of student time than both the SC environment and the conventional small-group seminar presentation, in that every single contribution must be produced as an original typed message.

A further aspect that was of interest to the researchers was some insight into working of the response matrix as an instrument for generating a unique, but constructed, response. Given the prior experience with SC exercises in general and this specific exercise in particular (though in an earlier paper-based self-instructional format) we were aware that students tend to vary considerably in the response mix that they select. However, the online delivery of the exercise and the central collection of data enabled us to track this aspect automatically. Figure 7 shows the frequency of selection of each of the 20 response items by the group of 51 students in the experiment. It can be seen that there are five items that have been selected more often. These are five of the six items that according to the author's feedback should really be considered as parts of the overall solution. One may see this by comparing Figure 7 with Figure 4 and observing the items that have feedback comments associated to their OMISSION. The one other omission item number 8, which is the sixth in ranking in Figure 7. It scored lower than the other five, but this is understandable as item 8 (a reference manual) is associated with item 9 (a job aid) so that although it is possible to select both, it is more reasonable to select just one or the other. Pooling the scores of items 8 and 9 gives a total of 45 selections. Similarly, the other either/or omission items 12 and 13 give a total selection score of 47 when pooled. Thus, we see that the group as a whole responded reasonably well to the exercise, in that many of the students selected some or most of the important solution components.

However, these were not the only items selected - 19 out of the 20 items were selected a t least once and six items that, according to the author's feedback scripts, were not important, were in fact each selected by between 8 and 12 students. This data illustrates the variety of minority view responses existing in a group that on the whole did appear to resolve the problem reasonably well.
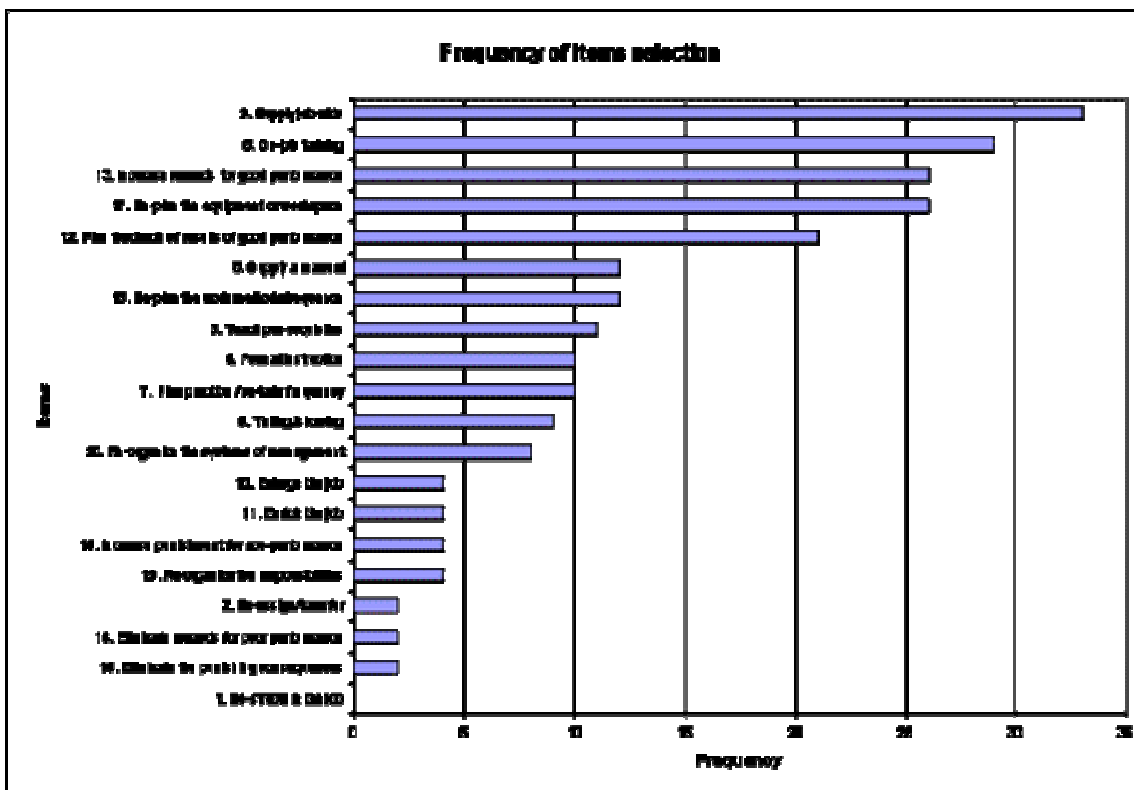

Figure 7. Frequency of Item Selection from the Response Matrix.

Further insights into the dynamics of the collaborative discussion part of the exercise may be gained from the comparison of Figures 4 and 7 with the data on the frequency of student-generated comments posted in the discussion areas, presented in Figure 8. First, it may be noted that the frequency of student

comments may be classified into three bands: under 5; 5 to 10; above 10. There are four of the discussion threads in each of these bands. It is also noticeable that the frequencies of selection (Figure 7) also seem to divide into three bands: below 5; 8 to 12; over 20. These two classifications "map" almost perfectly one on the other. This would suggest that the major part of the discussion on a particular item that developed occurred among those who had selected that item in the first place. However, the idea of the collaborative discussion component is more towards the encouragement of discussion between those who DID and those who did NOT choose certain items. It would seem that maybe the dynamics of the discussion, as currently set up, does not encourage the student participants adequately to step out beyond their originally formulated response. Students quite frequently posted justifications of why they had responded as they did, but they seldom entered (as contributors - they MAY have entered as readers, but this data was not captured) into the other discussion threads to see what other students had thought and said. Finally, it must be noted that the level of collaborative discussion activity was not exceptionally high, with a mean of just over two messages per participant during the exercise. Many students did not post comments at all. This contrasts with the high completion rate of the online questionnaires and positive motivation figures recorded. It would seem that many of the participants did not find the discussion component to be essential or useful.
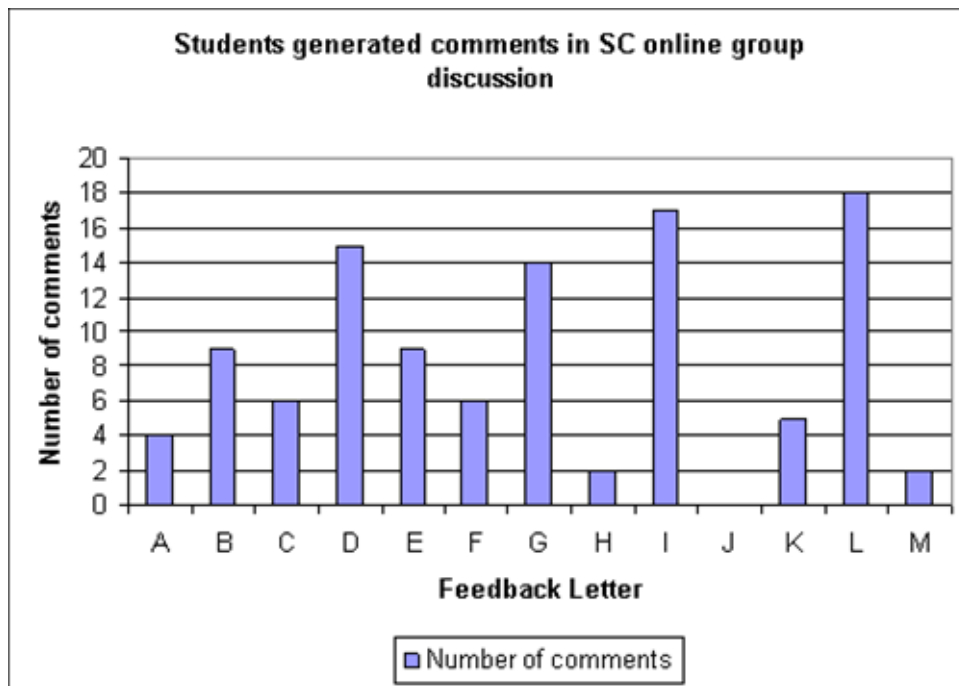

Figure 8. Frequency of student generated comments in each discussion thread.

The observations made here regarding the nature of the discussion that in reality developed in this exercise, are in strong contrast to the findings of earlier research, using SC exercises as a means of automating the study of Harvard Business Cases (Romiszowski & Chang, 1992; Chang, 1994) where it was found that the discussion developed to become the major element in the overasll exercise, involving most of the participants intensely and generating a significant number of creative contributions that went far beyond the case materials and author generated feedback built into the exercise. One may conclude, tentatively, that this difference between the results observed in these two studies may be more a function of the different nature of the content and objectives of the two subject domains, than the nature of the SC methodology itself. However, further research is required to shed more light on this issue.

Conclusion

It seems appropriate to close by stressing the importance of implementing effective, efficient and multipliable small group collaborative learning environments online. Learning research suggests that collaborative discussion activities, focussed on the generation and evaluation of creative ideas, are the modes of learning that are most effective for the attainment of higher order learning objectives associated with the development of critical thinking skills. These are the skills that are particularly important for the future generations of "knowledge workers". Most of the currently practiced modes of provision of such learning opportunities are not multipliable, because they rely on the constant participation of a skilled facilitator who can deal effectively with only a small number of participants at any one time. This limitation

applies equally to conventional, classroom-based, small-group learning methods and to most of the currently practiced online group discussion methods. Methodologies must be devised that are highly effective in promoting the development of critical thinking skills, but that do not rely on intensive management by facilitators. Otherwise, due to the difficulties and costs of arranging sufficient opportunities for facilitated small-group collaborative learning by conventional means, tomorrow's educational systems will offer "less and less of what learners need more and more". The approach described here, based on the Structural Communication methodology for the automation of the group facilitation process, seems to offer a solution to this paradoxical situation.

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Carlos Villalba, M.Sc., is from Venezuela. He is currently a Doctoral candidate in the Instructional Design, Development and Evaluation program at the School of Education, Syracuse University, USA.
He can be contacted through the following email address: cavallal@syr.edu