ADVANCED TECHNOLOGY AND KNOWLEDGE TRANSFER*

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Abstract

This paper reports on a specific project, employing new technological capabilities to better transfer expert knowledge. The specific project considered for the paper is the World Initiative for Soy in Human Health (WISHH), a Multi Organization Enterprise promoting the use of soy and soy products in humanitarian and development aid around the world. VisIT, which stands for Visualization of Information Technology, is a potentially powerful organizational tool. It is compared against the traditional technology in the WISHH setting. An evaluation experiment was conducted with undergraduate students enrolled in agriculture and consumer economics and management courses in January and February 2002. The paper provides the summary results of the effectiveness of the use of that technology to transfer expert knowledge.

Introduction

This paper reports on the evaluation of the use of alternative knowledge transfer tools that organize information and aid in the transfer of multidimensional technical information from experts to non experts and decision makers. The study evaluates the expert maps created for a specific Multi Organizational Enterprise, namely, the World Initiative for Soy in Human Health (WISHH) through a visualization tool – VisIT (Visualization of Information Technology). The research hypothesis is that the use of graphical tools leads to a better understanding of complex issues among the audience.

The food and agriculture sector today is complex consisting of various entities with differing interests responding to rapidly changing external stimuli. The outlook of

agribusiness managers not only involves local decisions and markets but also includes global perspectives and uncertain future trends of the market. Managers are bombarded with problems and issues that cross organizational, industrial, geographical and public-private boundaries. These multidimensional problems require the input and expertise of people in various disciplines and with diverse experiences.

At the same time, the technological revolution has made it possible to integrate information that pertains to multidimensional viewpoints of an issue. Technology is allowing individual "expert" knowledge to be transformed into knowledge that is commonly available. With broad missions and interaction of managers, experts and groups that exhibit different cultures, assumptions, priorities and goals, the task of decision making has become very complex. Decision makers not only need to face the challenges of a complex environment but also need to recognize the opportunities for future advancement and growth. The primary purpose of this research project is to evaluate alternative means to organize information to provide the complex view of an issue to the audience and enhance knowledge transfer.

This research project was developed to evaluate the usefulness of the visualization approach as compared to traditional technologies available in the specific setting of WISHH. An evaluation experiment was conducted with two hundred and twenty four undergraduate students enrolled in two courses in agricultural economics and management at the University of Illinois, Urbana-Champaign.

Research Goals

This research study investigates whether knowledge transfer of complex issues can be improved by using graphical aids such as the expert map developed with the use of a new visualization software – VISualization of Information Technology (VisIT). The study evaluates the performance and the perception of use of alternative tools to organize and present expert information.

Problem Context

Although the approach applied here has general applicability, the expert map and experiment are developed for a specific purpose. The purpose is to enhance and evaluate the knowledge creation and dissemination abilities of a specific organization, namely, the World Initiative for Soy in Human Health (WISHH). The objective of WISHH is to increase the international consumption of soy proteins by humans, especially in the developing countries, to satisfy the growing nutritional needs in these areas.

WISHH is working with government agencies and Private Volunteer Organizations (PVO) to promote the use of soy and soy products in humanitarian and development aid projects. It is a partnership among Illinois soybean growers, processors, health consultants and the University of Illinois. WISHH is seeking to work with PVOs to introduce soybeans and soy products into markets where soy has not traditionally been available. It looks for opportunities around the world for the use of soy. WISHH aims at becoming the clearinghouse for knowledge about soy and nutrition in development. WISHH is a complex organization with a number of entities. Participants in WISHH

include representatives from farm organizations, processors, private volunteer organizations, government, academia and consulting.

The audience for WISHH relevant knowledge includes its participants as well as other people and organizations, ranging from US government agencies, the World Food Program, and farmers to consumers of soy foods in developing countries. The WISHH support team must be able to effectively respond to specific, straightforward questions, such as: Can the use of soy protein enhance the well being of individuals in an HIV/AIDS effected community in southern Africa? How should soy protein be best used to meet economic and cultural constraints in that setting? Meaningfully responding to such questions, however, requires input from several disciplines (health, nutrition, planning and economics) as well as insights based on experience (food preparation, government regulation, and food logistics and aid distribution).

Knowledge Transfer Tools

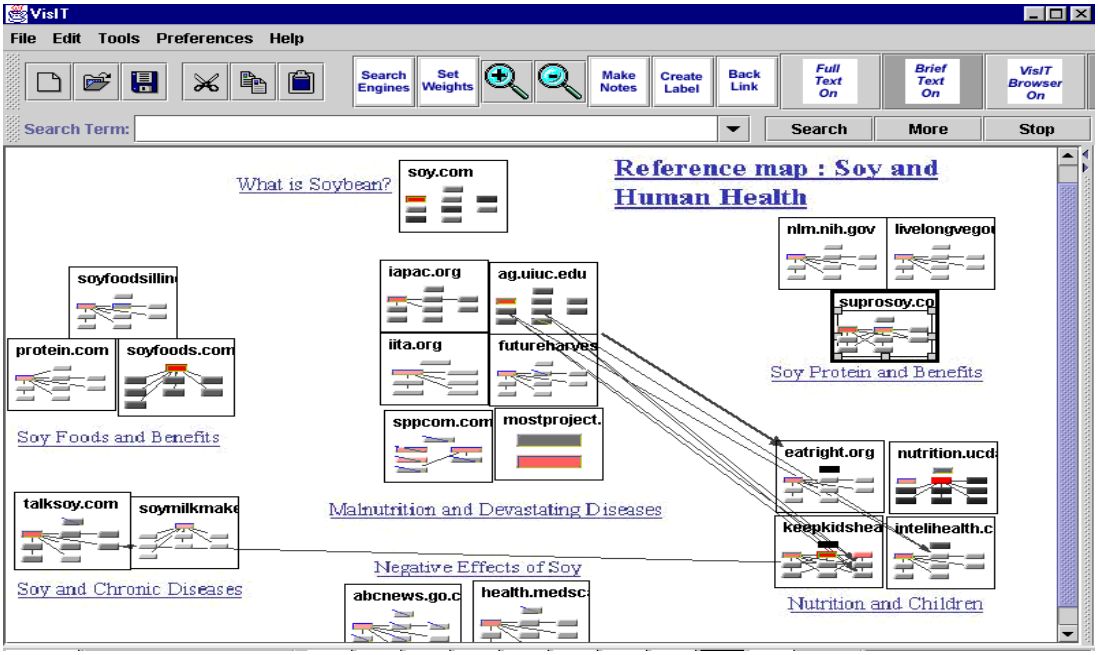
In recent years, most organizations have created websites that contain information about the organization as well as other issues dealt with by the organization. Usually various "links" are provided to access the various sources of information. Historically, this information is provided through a linear listing of URLs. The information retrieval in this case takes place through word based interfaces. However, "there is not a one to one correspondence between words and meanings", even in subjects with their own technical jargon such as law (Rose & Belew, 1991). "This is especially problematic for a domain novice user who is exploring a specific subject area and has only vague notions of what

the technical words or the controlled vocabulary used by the information retrieval system mean. In fact, with the advent of the Internet, word based accessing problems have increased (e.g. relevance and set magnitude problems exacerbated by the Internet's sheer size and lack of structure)" (Cole *et al,* 2002).

Instead of presenting word-based linear lists, visual representation of the information space can have many advantages. One definition of visualization is:

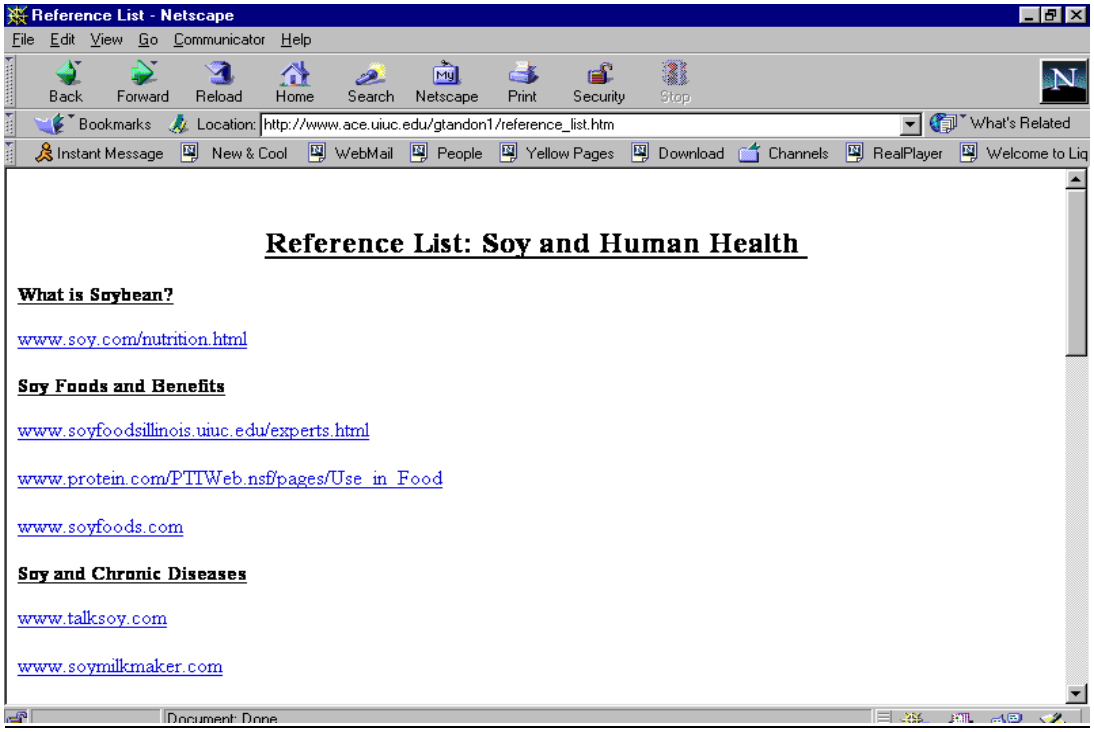
> "….the visual representation of a domain space using graphics, images, and animated sequences as well as sound augmentation to present data and the structure and dynamics behavior of large and complex data sets that represent systems, events, processes and objects (Williams, Sachats & Morse, 1995, p.163)"

To explore the potential of using visualization tools to organize information as compared to linear lists, a reference map and a list were created using the same sources of information. The reference map was created using software called Visualization of Information Technology (VisIT). It was developed at the Beckman Institute at the University of Illinois, Urbana Champaign (For more information refer to Levin and Kauwell, 1999). It is a potentially powerful organizational tool, which provides an Internet based graphical learning environment. Instead of lengthy lists, VisIT displays search results through an interactive graphical user interface, which can be saved, further manipulated and linked. The figure below illustrates the screen shot of the reference map created by VisIT.



The map above has linkages shown by arrows which were automatically created if one website provided a link to another website. A grouping of arrows to one website gives a visual clue to the user that this may be a good source to start their information search. Second, the boxes are color coded. A red or pink box refers to direct hits and gray to black refers to other pages on the website which may or may not be useful. Darker colors indicate higher relevance ranking. Whenever a cursor is placed on a box helpful comments are displayed to give the user a better idea on what the website is about.

The linear list was created using the commonly known Hypertext Markup Language (HTML). This list represents the traditional search list obtained from information retrieval tasks or the way most websites organize their information resources. The figure below depicts the screen shot of the reference list.



The list illustrated above had similar information resources and was grouped in the same way as in the VisIT map. A white background and no graphics were used in the map as well as the list to reduce the bias caused by other graphics or colors.

Experimentation

This study employs a survey conducted in three stages along with a case study-based experiment conducted in a controlled environment. A comparative study is done with two randomly selected groups – one using traditional HTML technology and the other using reference maps created by VisIT. The participants of this study are undergraduate students of the Agriculture and Consumer Economics Department at University of Illinois, Urbana-Champaign. The students have been used to represent the audience that the WISHH organization wishes to serve. The age, culture and life experience factors are not considered in the study so as to negate the effects of those factors.

All the information was collected in an electronic format. Computerized self administered questionnaires were used to collect the information in the first two questionnaires. The students were given a week to complete these questionnaires. The demographics questionnaire collected basic information about age, year in school, gender, ethnicity and rural or urban background. Second, this questionnaire asked self-evaluation questions regarding the student's information and knowledge about soybeans, nutrition, and the nutrition situation in developing countries. These three subjects were the basis of the issue used to create expert maps. The questionnaire then had two questions that evaluated the information seeking behavior of the students. The last section of the demographic questionnaire had questions to determine the students' familiarity with the web. This was electronically submitted by the students.

The second part of the survey used the Index of Learning Styles questionnaire prepared by Richard M. Felder and Barbara Soloman at North Carolina State University. This is a 44-item questionnaire used to measure the respondent learning styles. The web version is available on their website. The respondents were required to go to the given web address and complete the questionnaire. The questionnaire then automatically scored the student on their learning styles on four scales. The respondents submitted a print out of the output of the learning styles questionnaire.

Next, the students were provided a "Globalization Case Study" about a fictitious company called "Agrotech, Inc." The students were introduced to the company and its

products. The reader was a new employee at the company. He/she was assigned a project to find out more information about WISHH and the issues handled by this organization so that his/her boss could make a presentation to the senior managers of the company about further investment in this project. The case study also gave background information about the soybean industry in the United States.

The controlled experiment took place in ACES[1] Library, Information and Alumni Center in groups of 20 to 25 students in the same room. Two undergraduate classes participated in the survey. For one class, students were randomly assigned to complete the task either using VisIT or HTML based linear lists. For the other class, entire discussion sections were randomly assigned to either use VisIT or HTML based linear lists. The experiment was completed on three separate days.

The lab in which the experiments took placed was equipped with similar computers. The VisIT reference map had been downloaded and tested on all computers. All the computers had the exact image of the reference map or the reference list, (which was on ordinary HTML web page). The students were given a copy of the Globalization Case Study (GCS) Task statement, which clearly explained the task required of the students. The surveyor was present during each controlled experiment and gave instructions to the students about the task and other technical aspects of the experiment. The students were given 50 minutes to complete the task.

[1] Agriculture, Consumer Economics and Environmental Sciences

The third survey collected qualitative data as well as self evaluated quantitative data about the tool, process, task and the answer. The questionnaire consisted of the following five tasks:

1. Cut and Paste the 6 sentences that you identified during the web search as being most relevant to your task.
2. In your own words, provide a brief summary using not more than 4-5 sentences.
3. What problems did you encounter while doing the search task?
4. Which one website did you find the most useful for your task?
5. What, if provided more, would help you to answer the question better?

The qualitative data was analyzed using a content analysis approach forming a codebook for each of the five different types of qualitative data. These data, along with the quantitative data, were analyzed to evaluate the introduction of the two different information presentation stimuli.

Results and Analysis

Data collection took place in January and February of 2002. Data was collected through the surveys on the Internet. There were three parts of the survey. The first part of the survey collected basic demographics. The second part of the survey required the completion of the learning styles questionnaire on the North Carolina State University web page. The third part of the survey required participation in the actual case study and experiment. In this third part, the students were divided into two groups –

Group 1: Used no Visualization Aid

Group 2: Used Visualization aid – VISIT expert Map.

A total of 224 students participated in the survey. Out of these, 197 students completed all three parts of the survey, which is an 87.9 % response rate. Table 1 below describes the demographic mix of the respondents. The respondents on average were less than 20 years of age. The gender mix is female dominated. However there is no gender effects hypothesized. The group is largely white with predominantly a rural background.

Table 1: Respondent Demographics

Category	Sub Category	% of Total
Age (Mean)		19.3 Years
Year in College	Freshman	50.3%
	Sophomore	18.8%
	Junior	23.4%
	Senior	7.6%
Gender		
	Male	41.1%
	Female	58.9%
Ethnicity		
	Hispanic	1.5%
	Black	2.0%
	White	92.9%
	Asian or Pacific Islander	2.5%
	Other	1.0%
Background		
	Rural	66.5%
	Urban	33.5%

The respondents were also asked to self evaluate themselves in domain knowledge of soybeans, nutrition and developing countries. Similarly, the learning styles questionnaire provided four scores on the learning styles scales for the respondents. Learning styles were measured in the following four scales:

Active /Reflective

Sensing/Intuitive

Visual/Verbal

Sequential/Global

The data for the domain knowledge and learning styles was collected for all the respondents and analyzed along with their responses to the task assigned. This analysis did not add significant changes or additions to the results. (Tandon, 2002).

In the third survey the respondents were required to complete the assigned task and then evaluate the use of the reference tool provided to them. They were asked to self evaluate the following:

1. Assess the list of websites provided relative to the following characteristics: Useful, Effective, Informative, and Well Structured.
2. Assess the task you were assigned relative to the following characteristics: Complicated, Clear and Well Structured.
3. Assess the process you used to complete the assigned task relative to the following characteristics: Simple, Need More Time.

4. How satisfied are you relative to your completion of the task? : Satisfaction, Like or dislike, did a good job or bad job, Content or disappointed with completion of the task.

These variables were measured on a 7 point Likert scale. The means of the above responses were evaluated for significant differences between the two experiment groups – Traditional users and VisIT users. The means with significant differences between them are presented in Table 2 below.

Table 2: Significant Difference of Means Between Traditional and VisIT Users

Variable	Group	Mean	F	Sig.
Informative*	Traditional	2.07	7.00	0.01
	VisIT	2.56		
Complicated*	Traditional	2.44	5.76	0.02
	VisIT	2.86		
Simple*	Traditional	2.43	4.57	0.03
	VisIT	2.78		
Need more time**	Traditional	5.73	3.79	0.05
	VisIT	5.35		

Table 2 above shows that significant differences between the two groups were found for the variables informative, complicated, simple and need more time. Traditional users (without VisIT) found the reference list given to them more informative than VisIT users. Similarly, traditional users found the task less complicated than VisIT users, the process used to complete the task simpler than VisIT users and had more than enough time to complete the task as compared to VisIT users.

* This was measured in the Likert Scale of 1 to 7 with 1 being more informative, simple and less complicated while 7 being less informative, simple and more complicated

** This was measured in the Likert Scale of 1 to 7 with 1 being need more time and 7 being more than enough time.

The other part of the experiment required the respondents to complete the assigned task. The task required the students to search for the relevant information (evidence) from the sources provided to them and then summarize this information in their own words. They also were asked what problems they encountered in the search process and what more could have been provided for them to perform better. They provided the URL of the one website which they used the most.

The understanding and learning of the students was measured by evaluating the answers given by the students in their own words. This understanding and learning was the knowledge transfer that actually took place after using the information sources given to the students. The qualitative data was coded using content analysis. To judge which reference tool helped the users to understand the complex issues faced by the WISHH organization experts and audience, the following criteria was used:

1) Degree of Importance and Applicability – This measures how broadly the information obtained by the users can be applied and its significance to the task assigned. Fewer references to unrelated subject matter lead to a higher degree of importance and applicability of the answer. A higher degree of importance leads to a "better" answer or "superior understanding".

2) Degree of Diversity – This factor measures variety and the range of issues covered by the respondents in the answer. A more equal distribution of frequencies among the various issues leads to a more diverse answer. More diversity leads to a "better" answer.

Using the above criteria, the answers of the students were evaluated, coded and analyzed. Table 3 below gives the percentage of frequencies for the sentences cut and pasted by the respondents as the most relevant to their task, by the two types of users – Traditional and VisIT.

Table 3: Percentage of Frequencies for the Answer for "Cut and Paste sentences that you identified during the web search as being most relevant to your task."

Category	Traditional users	VisIT users
# of Valid Respondents	102	95
1. Diseases	34.5%	34.3%
2. People (-ve)	15.7%	14.0%
3. People (+ve)	4.7%	6.8%
4. Developing Country	7.7%	4.9%
5. Soybeans Composition	11.9%	13.1%
6. Nutrition and Protein	10.0%	11.1%
7. Unrelated	5.3%	2.0%
8. Other	2.0%	2.2%
9. Soy Foods	2.1%	3.3%
10. FDA	3.8%	4.3%
11. HIV	1.5%	1.6%
12. Neutral	0.9%	1.9%

The table above illustrates that VisIT (reference map) users had a higher degree of diversity in the responses as compared to traditional users (reference list). VisIT users had a higher number references to important elements such as FDA and HIV/AIDS and fewer references to unrelated items and other factors. VisIT users also had references to developed countries and how WISHH can be a part of the company agenda in developed countries. Traditional users, on the other hand, exhibited a greater degree of distortion regarding unrelated factors and other items such as ease of use. They had less diversity as

most of the references were concentrated on the major issues related with soy, ignoring small but important parts such as FDA and HIV/AIDS which were especially relevant to WISHH.

This pattern was repeated in the second task assigned to the students, summarizing the findings in their own words. Table 4 illustrates a similar pattern. The analysis shows that VisIT users had a higher diversity and higher degree of applicability and importance in their responses as compared to traditional linear list users. This means that VisIT users had a higher level of understanding and learning regarding the complex issue managed by WISHH.

Table 4: Percentage of Frequencies for the Answer "In Your Own Words"

Category	Traditional users	VisIT users
# of Valid Respondents	102	95
1. General	19.07%	21.73%
2.Advantages	18.81%	21.73%
3. Positive	15.72%	15.97%
4. Negative	10.05%	9.27%
5. Developing Country	18.30%	13.74%
6. Composition	4.38%	5.11%
7. Unrelated	5.41%	2.56%
8. Other	1.29%	0.96%
9. Ease of Use	3.87%	2.56%
10. HIV/AIDS	1.80%	2.24%
11.FDA	0.26%	1.28%
12. Developed Country	1.03%	2.88%

During the search process, VisIT users had a higher number of technically related problems while traditional users faced information related problems. Traditional users found it more difficult to locate specific information. Similarly, traditional users indicated that more information related to sources and task guidance could have helped them in the completion of the task while VisIT users indicated that more task guidance and technical information about the tool could have helped them more in the completion of the task. Traditional users used fewer information sources (or websites) as compared to VisIT users.

Discussion

In this project, evaluation of the use of a knowledge transfer technology involved two main methods. First, the users were asked to self evaluate their experience of the use of the tool. Second, the users used the tool to complete an assigned task which was then analyzed to compare the performance of the users of the two different tools. In this project the two methods provide different and contradictory answers to the use of an advanced knowledge transfer technology.

The respondents, who used the visual knowledge transfer tool, were able to better understand the complex issues associated with the World Initiative for Soy in Human Health. These respondents had a higher diversity in their responses and a higher degree of applicability of their answers as compared to respondents who used the traditional linear lists. The traditional lists users did not use all the information sources given to them and their problems were mostly information related. This means that even though the

information was given to them, they did not attempt to search thoroughly and look at all aspects of the issue. In contrast, the respondents who used the visual reference map used more of the resources that were given to them and incorporated various aspects of the complex issue of soy and human health in their answers.

On the other hand, the VisIT users found the tool complex and were not satisfied with the answers as compared to the traditional linear list users. Even though the understanding and learning of the complex issues increased by using visual tools such as VisIT, the users did not like the VisIT tool. The traditional linear list users did not understand the complex issue very well, but they were more comfortable with the technology and their own answers.

There are two main implications of this research. First, the way information is organized influences knowledge transfer. This study demonstrates that visual tools can enhance the understanding of complex issues. Traditional linear lists do not tend to given an overview of the whole complex issue to the users leading to concentration on either irrelevant subjects or only the major concerns of the issue. Thus, if the goal of an information source is to just present the information, then traditional technologies are the preferable way to present this information. On the other hand, if the goal of a source of information is to enhance understanding and knowledge transfer, for example in a knowledge management system, the information should be organized using flexible, powerful yet simple visualization tools such as VisIT.

The second major implication of the research is that even though some technologies such as VisIT help to achieve the goal and have the potential to assist completing our tasks more easily, they may not be used. The self-evaluated perceptions of the use of the tool included some variables that are used in individual decision-making. An individual decides to use a new technology or product only if the user finds it useful and is satisfied by it. If the user does not find it satisfactory, however advanced is the technology and however good results it obtains, it will not be adopted.

This is related to the "Qwerty Myth". According to the popular story, August Dvorky at the University of Washington patented a new typewriter layout, which was vastly superior to the existing Qwerty keyboards. The time taken to learn this type of keyboard was reduced and the speed of typing also was faster. But the Dvorky typewriter was not accepted in the market even with its superior qualities. According to Liebowitz and Margolis, 1990 "an established standard can persist over a challenger, even where all users prefer a world dominated by the challenger, if the users are unable to coordinate their choices."

In this case the standard is the linear HTML based lists available on the Internet and the challenger is the VisIT organization of information sources. The visual tool has superior results in understanding as compared to the linear lists approach but the users are not satisfied with it. This implies that users will not adopt this tool because they perceived that they did not have a good experience with it. Thus, it is important for the developers of VisIT and similar visualization tools to understand the market and their potential users.

Summary

The primary purpose of this research project is to evaluate the use of alternative means to organize information to provide the complex view of an issue to the audience and enhance knowledge transfer. This research investigates whether knowledge transfer of complex issues can be improved by using graphical aids. The specific areas of study evaluate the performance and the perception of use of alternative tools to organize and present information.

An experiment was conducted in the specific setting of the World Initiative of Soy in Human Health, an organization that deals with various complex issues. A visualization tool called VisIT was used to develop a visual reference map of Internet sources about soy and human health. Students in Agriculture and Consumer Economics at the University of Illinois, Urbana-Champaign participated in the experiment in which they used either the reference map or the traditional HTML based linear list to complete the assigned task. A total of 224 students participated in the survey. Both qualitative and quantitative data were analyzed to interpret the use of the two different reference tools. The quantitative responses measured the perception of the use of the tool by the user while the qualitative responses evaluated and explored the actual use of the tool by the user.

The analysis of the result demonstrate that even though the use of the visual based tool (VisIT map) led the users to have a superior understanding of the complex issue and enhanced knowledge transfer, the users were not as satisfied with its use. On the other hand, the users were more satisfied with the traditional technologies used to present expert information even though their understanding of complex issues was inferior.

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