ENVIRONMENTAL SOFTWARE SYSTEMS

Environmental Risk Assessment Systems

SECOND EDITION

IFIP TC 5 WG 5.11

6th International Symposium on Environmental Software Systems

(ISESS 2005)

May 24-27, 2005, Sesimbra, Portugal

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SECOND EDITION, Version 2
Edited by Ralf Denzer
Environmental Informatics Group, Germany **March 2015**

Available at:

https://www.researchgate.net/publication/274499320_Environmental_Software_Systems_Volume_6_Second_Edition

ENVIRONMENTAL SOFTWARE SYSTEMS, Volume 6
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This volume contains a newly compiled version of the Proceedings of the 6th International Symposium on Environmental Software Systems 2005 (ISESS 2005), published by the International Federation for Information Processing (IFIP) under ISBN 3-901882-21-9.

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Gaiberg, March 2015

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ISBN: 3-901882-21-9 **IFIP Conference Series**

ENVIRONMENTAL SOFTWARE SYSTEMS, Volume 6

Environmental Risk Assessment Systems

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- open conferences;
- working conferences.

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ISBN: 3-901882-21-9 IFIP Conference Series

Consumer Decision Support for Product Selection

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Abstract

Understanding the long-term impacts of present choices is of growing importance to citizens and governments in today's world. Individual consumers have not received a great deal of support in their efforts to make these assessments for the products that they consume regularly.

Consumers may not agree on the relative importance of all of the possible attributes that a product may have, yet each distinct attribute contributes to the precision with which any one consumer can make a choose. Instead of an automated approach that might recommend selections and limit user involvement, an interactive system appears more promising for increasing awareness. Knowing the basis for consumer decisions can help a decision support tool to better structure and present information for its user, and it may also help to target impact information to specific consumer groups, by expressing it in the terms that matter most to those groups.

This paper presents an analysis of a user study of a decision support tool, in terms of its effectiveness in helping users find the products that match their value judgments and what may be done to improve performance.

1. Introduction

This paper presents an analysis of a user study of a suite of tools based on those from the United States Environmental Protection Agency (EPA) Environmentally Preferable Purchasing Pilot Project (EPPPP). Users of the tool suite are able to make comparisons between products on the basis of eight attributes, namely: skin irritation, food chain exposure, air pollution potential, contains fragrance, contains dye, package contains recycled materials, product is a concentrate, and product reduces exposure to concentrate. Participants were asked to rate the importance of each attribute in their own decision-making. Participants were also asked to indicate which attributes they felt were missing. These two sets of self-reported information enabled a comparison between the product that best met their stated preferences, according to the importance placed on each attribute, and the product they chose using the tool suite.

To accomplish this, the participants were classified into two clusters, based on both sets of attribute importance data, and an ideal product was found for each group. Although some people were able to choose this ideal product, many were not.

Impact analysis, as part of ISO 14040, groups and quantifies resource use and emission data into a number of impact categories that can then be weighted for importance. This information must then be made available in a way that is well-suited for interpretation by the target audience. Both the categories of importance and the means to communicate the data to individual consumers must be addressed. Different consumers will likely have different opinions about the importance of any information and would apply different weights to the associated impact category, but every individual should be provided with the ability to decide on the weighting best suited to one's self. For example, although not everyone agrees about whether information about genetically modified food ingredients should be mandatory on labels, it is clearly an important impact category for some consumers. To be most effective, this impact information must also be presented based on the units of individual consumption.

Although some may discount the need for action because uncertainty remains about climate change, evidence is much clearer about the impact of vehicle emissions on air quality and health (Blake et al., 2004). Ordinary citizens need to have this information, and have it presented in ways that allow them to make connections to their daily lives. In considering a tool that will provide access to this information, three separate but related issues are clear: how individuals will interact with and gain access to the information; what information is presented; and how that information is presented. In order to understand how these issues are handled in other situations, an examination of current tools was undertaken.

The rest of this paper is organized as follows. Section 2 presents a look at the United States' EPA's EPPPP, and shows samples from the three tools within the suite. Section 3 discusses the user study that was conducted at the University of Regina. Section 4 presents an analysis of the study and Section 5 provides a discussion and an outline of future work.

2. Decision support systems

The potential of consumer decision support systems to effectively support the consumer decision-making process is real. This is especially true when considering environmental decision support systems that pertain to household products purchased and consumed frequently. If implemented with care, these systems can effectively allow individual consumers, governments, and industry groups to rate their personal impacts. This will open the potential for more eco-effective decisions-making when purchasing/consuming, regulating, and/or producing these products.

One might first seek environmental information about a product on the web through Google, or a similar search engine. Table 1 lists the top five results from a "cleaning products environmental information" query in Google. Of the information available through these URLs, much is inappropriate for direct application to the task of choosing amongst several cleaning products, even though EMS (#2 in Table 1) did provide a list of instructions on how to create eco-friendly cleaning product alternatives, there was no data to permit a comparison amongst products.

1. EPP Cleaning Products, Environmentally Preferable Product Information: the Commonwealth of Massachusetts environmentally preferable products procurement program with information about environmentally preferable cleaning products (http://www.state.ma.us/osd/enviro/products/cleaning.htm).
2. EMS – Environmentally Friendly Alternatives to Commercial Cleaning Products: Eco-friendly tips and advice for alternative choices (http://www.ems.org/household_cleaners/alternatives.html).
3. EPA - Environmentally Preferable Purchasing: a guide for federal purchasers. (http://www.epa.gov/oppt/epp/documents/clean/cleaning.htm)
4. The Soap and Detergent Association: facts about cleaning product disposal (http://www.cleaning101.com/environment/facts/).
5. WorldWise General Information: general cleaning product information (http://www.worldwise.com/cleanprod.html).

Table 1: Top 5 search results for "cleaning products environmental information" query in Google (Search Performed in March 2005).

Generally speaking however, providing quality information in such systems has increasingly become an issue due to the quantity of confusing and misleading information available (EPC 2002). This is particularly true when considering environmental issues. As well, due to the large quantity of information available, especially on the World Wide Web, deciphering the quality among the quantity proves a difficult task (Berndt, 2001). It should also be noted that the appropriate quantity of information should also be considered, i.e. if not enough information is represented in the system, the system will also prove less effective (O'Keefe and McEachern).

Design issues, such as interface layout, must also be considered (Wittenberg et al., 2001). For instance, if the data is displayed in large tables navigation might prove difficult to users when exploring the system information. As well, user needs assessment must be considered, i.e. finding out what people care about and require in their choices (Schwitzer, 2002). Other issues that should be considered include linking decision making to community involvement, i.e. in the form of social networks relating other consumer experiences, as well as the general lack of standards and regulations thus increasing consumer confusion, etc. (ANPED, 2001).

3. User Study

A total of 48 undergraduate students enrolled in undergraduate Computer Science courses were recruited for this study through the Computer Science Department participant pool, which rewarded student participation with a research credit (bonus mark) to be applied towards a qualifying class.

The participants completed a pre-task questionnaire, completed a set of tasks using the tools from the EPPPP suite, and then completed a post-task questionnaire. The study was intended to discover how well people could use the various decision support tools within the EPPPP suite. The tools allowed for sorting by a single attribute with no filtering (Figure 1), sorting by multiple attributes by priority and acceptable attribute levels (Figure 2), and sorting by assign weights in scoring formula (Figure 3). Each tool in the suite presents information in a tabular format. The difference between the three tools is in how they allow the user to organize and filter the products based on the attributes.

The Single Attribute Ranking Tool allows the user to organize the table of data based on one attribute at a time. Initially, the list of products is presented in alphabetical order. The user is able to sort the list according to any one of the environmental attributes. Since this tool only allows the sorting by one attribute at a time, it directly supports the task of selecting a product based on one attribute (i.e., which product has the lowest food chain exposure?). However, it does not support tasks involving more than one attribute (i.e., Which product has the lowest air pollution potential and the lowest skin irritation?). In these situations, the user must sort the list according to one attribute, and then scan for the other attribute values. The selection of the attribute to sort by determines precedence in sorting, which may not be apparent to the user.

The Multiple Attribute Ranking Tool allows the user to organize the table of data based as many as four attributes at a time, as well as filter the table based on the selection of a minimum acceptable level for each attribute. If the user selects only one attribute to sort by, and no filtering, the result is identical to the Single Attribute Ranking Tool. Selecting multiple attributes when ranking, and entering filtering information allows the user to answer complex questions such as “which products cause minimal air pollution and produce a small amount of air pollution or less?” However, since the sorting of the data and the filtering of the data are done separately, users may have difficulty converting their goals into commands to be executed. In this case, the user may experience a large gulf of execution (Norman, 1988) which is meant to indicate the cognitive gap between conception of a goal and its realization through the appropriate computer commands.

The Weighted Attribute Ranking Tool allows the user to select filters for each of the attributes, and enter weights for the ranking of the data. A higher value supplied for the weight of an attribute will result in that attribute having a bigger impact on the sorting of the data. If the user enters equal values for the weights, the result is identical to the Multiple Attribute Ranking Tool. By allowing users to enter different weight values, they have the ability to indicate that one attribute is more important than another when organizing the data. While the sorting and filtering are provided together in this tool, users who are not familiar with weighted averages may have some difficulty in deciding an appropriate weight to enter.

From the website (EPA, 2004), only the single attribute tool was functioning. The interfaces for the multiple and weighted attribute tools worked, but no response was received when “Submit” was pressed. Also, real-valued data was discretized differently between the multiple and weighted attribute tools. These shortcomings were corrected in a local version of the tools that was used to perform a usability study.

The tools were intended for institutional users, but the study was conducted on the basis of consumers using the tool. This approach was justified because not all purchasers are expert in all areas where they are required to make decisions. The reason for an evaluation of the EPPPP was to assess the effectiveness of an existing decision support tool, and so establish a benchmark for future evaluations of decision support tools for product purchasing and procurement.

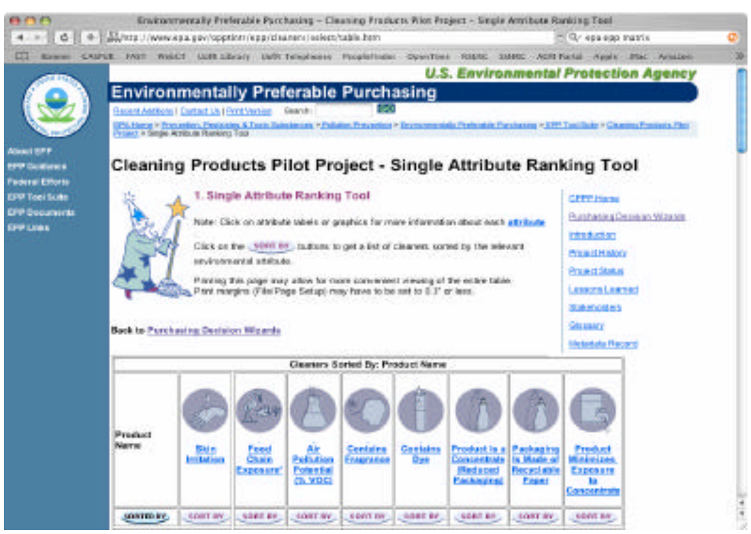

Figure 1. Sort by Single Attribute

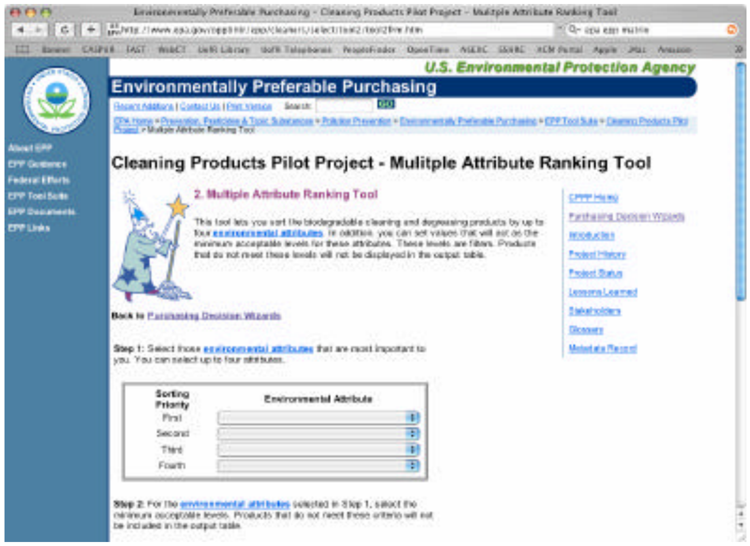

Figure 2. Sorting by multiple attributes by priority and acceptable attribute levels.

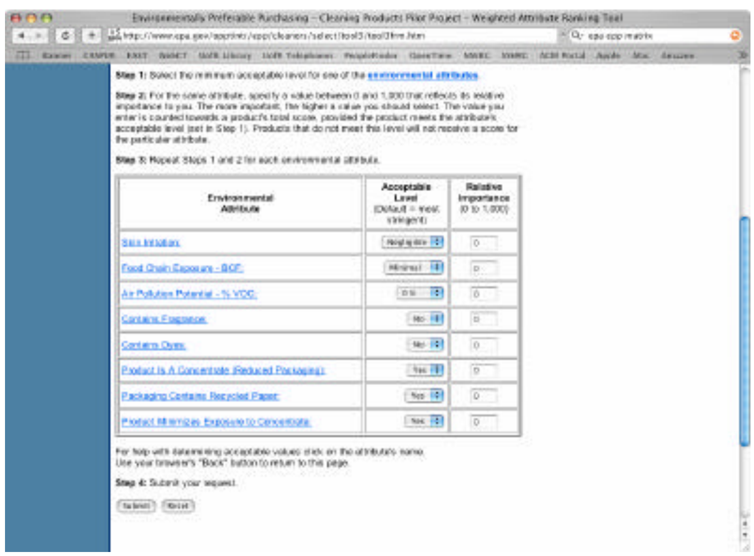

Figure 3. Sorting by assign weights in scoring formula

We did this by giving each participant 3 tasks to perform using each tool. Per tool, participants were asked to complete tasks involving specifically 1, 2, and 3 attributes. The participants were divided into

6 groups of 8. Within each group, the order of the 3 tools was varied. The questions that comprised the tasks are given in Table 2. Response time for all questions was recorded, and the responses were graded for correctness. In the post-task questionnaire, participants were asked to rate their use of the various software tools; to rank the importance of available attributes; and to state any missing attributes that would also be important.

Please indicate the product(s) which best satisfy the questions below. For some questions, there may be more than one correct answer. In these cases, indicate all products that satisfy the question.

Please speak aloud as much as you like and ask any questions that you have about the interface.

Single Attribute Ranking Tool

1. Which products cause strong *skin irritation*?
2. Of the products that have an *air pollution potential* of less than 3% VOC, which *contains dye*?
3. Which product(s) meet the following criteria:
    a. exempt from *food chain exposure*
    b. does not *contain fragrance*
    c. *product is a concentrate*

Multiple Attribute Ranking Tool

1. Of the products that reported *food chain exposure*, which have the highest value
2. Of the products that cause slight or less *skin irritation*, which *contains fragrance*?
3. Which product(s) meet the following criteria:
    d. no *air pollution potential*
    e. does not *contain dye*
    f. *packaging is made of recyclable paper*

Weighted Attribute Ranking Tool

1. Of the products that have *air pollution potential*, which has the least?
2. Of the products that are exempt from *food chain exposure*, which have *packaging made of recyclable paper*?
3. Which product(s) meet the following criteria:
    a. negligible-slight *skin irritation*
    b. does not *contain dye*
    c. *product minimizes exposure to concentrate*

Table 2. User Task Questions

4. Analysis

In our analysis user groups were formed based on how they ranked various attributes. The 8 attributes represented in the tools were ranked, as were other environmental attributes. Of the participants 2, of the 48, did not evaluate the importance of all attributes, and their data was excluded from further consideration. The attribute ranking values ranged between *unimportant* to *very important*. To focus on user preferences, rankings of *very important* were set to '1'; others set to '0'. Concerning the attributes users thought were missing, those that they mentioned were missing were set to '1' and '0' otherwise (a variable was created for the missing attribute if it was mentioned once). Hierarchical clustering was used to determine the number of clusters to use. After the number of clusters were formulated we used the k-means procedure in SPSS to form 2 groups, where k = 2. The final centers for the 2 clusters are presented in Table 3. The missing attributes were not used to make any decisions within any of the tools. However, it is instructive to consider their relative importance to the available attributes in the decision support tools.

Furthermore, in order to assess the performance of these 2 groups with respect to their ideal products, each of the 29 products for which data was available was assigned coordinates. These were computed from the cluster centers for each group, using the following formula. The net effect of this calculation is to give the most value to high-ranking attributes when determining relative positions.

$$X = 1^{st}\text{ ranked attribute value} * 1000 + 3^{rd}\text{ ranked attribute value} * 100 \\ + 5^{th}\text{ ranked attribute value} * 10 + 7^{th}\text{ ranked attribute value}$$

$$Y = 2^{nd}\text{ ranked attribute value} * 1000 + 4^{th}\text{ ranked attribute value} * 100 \\ + 6^{th}\text{ ranked attribute value} * 10 + 8^{th}\text{ ranked attribute value}$$

The attribute values were arranged so that a lower value for any attribute would mean a more environmentally preferable alternative. With the coordinates for each product established, according to the formulas tailored for each cluster, the Euclidean distance was calculated from each product point to the origin (optimal point). These distances were used to determine the ideal product for each cluster.

In Cluster 1, with 15 valid product choices, the mean rank of the selected product was 4.83, In Cluster 2, with 20 valid product choices, the mean rank of the selected product was 7.13. Of the 35 who expressed a preference for a product they would purchase for themselves, 5 picked the ideal product for their cluster. However, there were only 29 products all together. Table 3 indicates that the supplied attributes were more adequate for users in Cluster 1 than users in Cluster 2. This is reinforced by the performance results.

Although these results are encouraging, they still leave much to be desired. Users may not assign the intended meaning to given attributes, and this may lead to errors. For example, any relationship between *product is a concentrate* and *product minimizes exposure to concentrate* was not seen my many users.

Cluster 1 (N=19)	Cluster 2 (N=27)
Air pollution potential (1.0)	(M) Price (0.63)
Skin irritation (0.74)	Skin irritation (0.33)
Is a concentrate (0.53)	(M) Effectiveness (0.30)
Package contains recycled material (0.53)	Air pollution potential (0.26)
Food chain exposure (0.42)	(M) Cost (0.15)
Contains fragrance (0.32)	Food chain exposure (0.11)
(M) Price (0.26)	Package contains recycled material (0.11)
Contains dye (0.16)	Reduces exposure to concentrate (0.11)
Reduces exposure to concentrate (0.16)	(M) Animal testing used (0.11)
(M) Purpose (0.11)	Contains fragrance (0.07)
(M) Cost (0.05)	Is a concentrate (0.07)
(M) Abrasiveness (0.05)	(M) Flammable (0.07)
(M) Biodegradable (0.05)	(M) Manufacturer location (0.04)
(M) Toxicity (0.05)	(M) Brand (0.04)
	(M) Size (0.04)
	(M) User reviews or ratings (0.04)
	(M) Toxicity (0.04)
	(M) Efficiency (0.04)
	(M) Ingestion effects (0.04)
	Contains dye (0.0)

Table 3. Cluster centers for each cluster, ordered in descending order of importance. Notice that for cluster 2, the most important (missing) attribute is price. Intermingled with the 8 available attributes for cluster 2, there are 12 missing attributes. In contrast, for cluster 1 there is only 1 missing attribute amongst the 8 available .

5. Conclusion

Aside from a need to better understanding users' relationship to attributes given in a decision support system, there are also improvements to be made to the interfaces to such decision support tools so that they do not encourage errors from users. Strategies for personalization of the interface and the attributes by which the information is filtered seems an important direction for future efforts. More analysis of user behaviour is required, but the outlook is promising.

Acknowledgments

This work was supported by the Centre for Sustainable Communities at the University of Regina, and by the Natural Sciences and Engineering Research Council of Canada. We thank Orland Hoeber and Melissa Buhler for assistance with the user study.

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