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Improving Usability in Decision Support Systems:
Practical Use of the Decision Enquiry Approach for Requirements Analysis

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Abstract: The function of Decision Support Systems (DSS) is to help their users to make more effective decisions by providing information in a way that actively assists the decision process. However despite widespread development and investment very few agricultural DSS in the UK have been taken up by end users. This paper describes the use of a method for requirements analysis based on Arinze's (1992) Decision Enquiry approach and on the use of workshops, in three agriculturally based DSS developments[1]. It concludes that the method provides a cost-effective and practical means of gathering information about the task of decision making, organising it and using it as the basis for design decisions and could usefully be applied in other sectors beyond agriculture. The approach is being widely used in UK agricultural DSS production and the next stage in the development of the methodology is the specification of design and evaluation procedures.

Key words: usability, decision support, decision enquiry, workshop, method

1. INTRODUCTION

'Usability is critical to the success of computer systems and products. Too many systems exist which are difficult to learn, complicated to operate, and are often under-used or misused.' Maguire (1997).

Decision Support Systems (DSS) are a branch of the Information Technology software family whose particular purpose is to offer aid to those

making decisions. DSS are intended to help users to make more effective decisions by providing information in a way that actively assists the decision process. Unlike expert systems, which are usually designed to supplant some aspect of an expert's role, DSS exist to complement and 'support' decision-makers rather than to replace them. DSS have been developed on many platforms in many industries and for a wide variety of uses, for example medicine (Plougmann et al., 2001) utilities (Lindquist et al, 1996), transport (Zografos et al., 2002), financial services (Zhou et al., 2001), and agriculture (Wong et al., 2001). They are usually based around a spreadsheet or simulation model, or a rule-base, or a combination of all three.

In UK agriculture, as in other countries, DSS have been promoted as a means of revitalising the knowledge transfer process in the wake of the removal of state funded advisory services. They seem to have plenty to offer to an industry that is desperately trying to make more cost effective and more environmentally sensitive decisions in the face of information overload. However, despite the potential and the investment very few systems in the UK have been taken up by end users. A previous paper has argued that the underlying reason for the lack of uptake is the absence of users in the design and development process (Parker & Sinclair, 2002).

Most professionals interested in the delivery of useful and usable systems believe the starting point has to be the user and that some form of user-centred design methodology should be employed in the development process. User-centred design is taken to be the involvement of users at all stages of system development from initial planning, through requirements analysis, into development and evaluation. This approach however has not been easy for DSS developers in agriculture to adopt, largely because of a lack of appropriate and practical methods. The author has argued (op cit.) that to produce usable and marketable DSS, small scale developers, like those in agriculture, need prescriptive, user-centred and DSS applicable methods that are easy and relatively inexpensive to adopt.

This paper describes the practical use of the requirements capture component of one such approach. Previous papers have described the development of the method within a UK agricultural project called DESSAC (Parker, 2001). The method worked well in DESSAC and the user interface developed as a result generated good usability feedback in pre-release user trials. DESSAC was however a well-funded project which ran over five years and there was no evidence that the approach would work in the smaller, shorter and resource restricted projects which are more characteristic of the industry. This paper therefore describes the practical application of the method within three current agricultural projects: PASSWORD, a DSS for pest and disease management in Oilseed Rape,

WMSS, weed management DSS and Slugs, a DSS for slug management in brassica and salad crops.

2. USER REQUIREMENTS ANALYSIS FOR AGRICULTURAL DSS

The method described in the paper is part of a suite of related approaches to the user-centred design and development of agricultural DSS (Parker, 1999). It is a method for the initial identification of user requirements for DSS and is based on two foundations, the Decision Enquiry approach to requirements capture developed by Arinze (1992) and the use of workshops as a cost-effective means of involving users in the design process. These will be discussed in brief before the method itself is outlined.

2.1 Decision enquiry or question-based approach

Arinze reasoned that the key information flow between the DSS and the user is the stream of requests from the user, i.e. the questions that the user asks of the system when using it to support decision making, and that these should therefore be the key determinant of the shape and form of the DSS. The data from the DESSAC project suggested that much of the crop protection decision task was indeed concerned with getting answers to questions about the weather, disease levels, product effectiveness etc. The focus on user questions, both from the observations of system failure and the observations of the decision making process, seemed therefore to support the Arinze argument.

Where Arinze's work is particularly useful to task analysis and requirements specification is the division of these questions or 'decision enquiries' (Arinze's term) into a functional taxonomy (op cit.). He argues that when decision-makers interact with a DSS they will invariably make an enquiry of one of three main types, labelled: state, action and projection enquiries.

State enquiries are made when the user is seeking information about the state of the world (or a model of it), i.e. enquiries about:

- entities (e.g. products, diseases)
- processes (e.g. pest and disease lifecycles, market behaviour)
- attitudes (e.g. buyer attitudes, consumer attitudes)
- policies (e.g. legislation, buyer policies)
- people (e.g. staff, customers, suppliers)

Action enquiries are requests for a plan of action to achieve a specified end state. This is a reverse 'what if' question, i.e. instead of what will

happen if I do this, an action enquiry asks how do I get to this pre-specified end-state. In this type of query, it is the function of the DSS to generate actions in response to the user's goal setting.

Projection enquiries are more commonly known as 'what if' enquiries. They are requests for an indication of outcome given a set of defined conditions e.g. 'How much will I lose if I delay the application of this spray for three days?'. The importance of this taxonomy is that it provides a direct link to specification. The identification of State enquiries tells the developer what data the user needs to have at hand, in DSS databases, linked programs or encyclopaedia, identification of action and projection enquiries provide a definition of the models that will be needed to support the user.

2,2 Workshops

What is the best and most cost effective method of involving users in design? Workshops, or focus groups, were adopted within the case study project for a number of reasons: their relative cheapness compared to interviews and co-opting methods, their use in human factors research and usability evaluations. Jordon (1998), and a history of successful use within agriculture (Norton & Mumford, 1993). Another reason for the use of workshop or focus groups is that the workshop participants "stimulate and encourage one another" (Bruseberg & McDonagh-Philip, 2002) and a short workshop can generate a wealth of information and consensus on issues of importance. Consensus on the most important issues is particularly useful to highly-cost restricted projects where hard decisions have to be made about priorities for research and development.

3. USER-CENTRED USER REQUIREMENTS METHOD FOR DSS

This section of the paper outlines the method used in the three agricultural DSS projects, WMSS, PASSWORD and Slugs. WMSS and Password are DSS for arable farmers and Slugs is a DSS for horticultural brassica and salad growers. The main distinction between the user groups for these systems is that arable farmers tend to focus on yield and gross margin while horticultural growers are forced by the nature of their product and their markets to focus on quality.

Each of these projects is LINK funded, i.e. partly government and partly industry funded, with a consortium made up of research and commercial partners, and has a heavy emphasis on basic biological research in addition to DSS development. All three projects were in the first year of

their three-four year life span at the time of the requirement's analysis and the funds available for the identification of user requirements were very limited in all three cases. While each of the three projects felt that the product they were developing was solidly based in a real need, expressed by the industry and supported by the industrial partners on the team, none had previously carried out any form of detailed requirements analysis. In all cases therefore there was an urgent need to identify a clear set of requirements to inform the biological and technological development, in as cost effective way as possible.

The workshops took place at different times but all within the 'slack' period for crop producers i.e. mid-November to mid-March. WMSS workshops took place in December 2000, PASSWORD in February 2001 and Slugs in March 2001. In each case the lead partner in the project arranged for invitations to take part to be sent to a large mailing list of appropriate producers, both farmers and those who provide advice to them on agronomic matters i.e. independent and distributor based consultants. Workshops for each project were planned to take place over two days, with two workshops per day, one in the morning and one in the afternoon. Separate sessions were held for farmers and consultants as previous experience suggested that these groups talked more freely in the company of their peers, without the complication of a commercial relationship.

The aim of these sessions were: to identify the sub-tasks or stages within the decision process, the questions asked within them and the sources of information currently used to inform the questions. Additional aims were to prioritise requirements and to provide answers to specific questions raised by the technical partners in the projects.

Topic	WMSS	PASSWORD	SLUGS	Mins (approx)
Introduction	✓	✓	✓	5
Aspects of decision making.				
Whether to act	✓	✓	✓	20
What type of action to take	✓			20
When to act	✓	✓	✓	20
What to apply	✓	✓	✓	20
Coffee break	✓	✓	✓	5
Additional support	✓	✓	✓	30
Most important problems	✓	✓		10
Availability of data	✓	✓	✓	20
Delivery mechanisms	✓	✓	✓	20
Questionnaire	✓	✓	✓	10
			Total	180

Table 1. Format of workshops

All of the workshops followed the same basic structure and took between 2 and 3 hours to run, flip charts and tape recordings were used to record the data. The structure and approximate timing of each is represented in Table 1. Eleven of the twelve planned sessions went ahead with 70 people in total taking part, roughly one-third farmers and two-thirds consultants. The Slug project workshops were less well attended because they were unavoidably delayed until late March when spring activities begin to demand attention.

After the participants had settled and the aims of the project and of the workshop were explained to them they were taken through the main stages or sub-tasks in the decision process. These sub-tasks were identified by the author prior to the workshops, on the basis of past experience. The subtasks are almost identical in the three groups and problem management can be said in all cases to include the decisions: whether to act, when to take action and what type of chemical to apply if action is needed and chemicals have been chosen. Only in the case of weed decision making (where cultivation is also an option) is there any real choice between chemicals and other options in intensive crop production.

The participants were asked to list the questions or issues that were most important at each stage i.e. what questions did they ask before they felt able to take the decision. Their answers were recorded on flip-charts and were visible during the discussions. After the questions were exhausted the participants were asked where they obtained the information to answer their queries. The aim of this section was to identify decision enquiries which could be translated via the Arinze taxonomy into concrete requirements for model and database components.

While the issues were fresh in their minds the participants were asked to split up into groups of two or three with a cup of coffee and identify areas in which they felt more support would be useful i.e. where information was either not readily available to answer their questions or was of poor quality. After about twenty minutes they were asked to re-convene and to report back to the group. Once again their suggestions were recorded on a flip-chart in plain view. The final part of this exercise was the ranking of the items in order of importance i.e. very important, important, useful or nice to have. The aim of this section was to identify the areas that the user group considered to be most important and therefore provide a concrete means of prioritising the work of the project.

In a related exercise the WMSS and PASSWORD groups were asked to identify the weeds or pests or diseases that they felt were most important to them, this was not seen as relevant to the Slug groups as few people are actually capable of distinguishing between slug species.

DSS are highly data driven and in order to identify the limitations under which the software would have to operate each group was asked the degree of access they had to observation and weather data. At the time of the workshops there was serious debate in all projects about the potential use of the Internet as a means of delivering DSS. The participants were asked what type of delivery mechanisms they might prefer for different elements of the support package they had defined. Finally participants were asked to complete a short questionnaire which contained specific questions raised by the technical partners and which obtained a more personal view of users willingness to invest in additional data gathering equipment or conduct more field level observations.

4. DATA ANALYSIS

The questions and issues generated in the decision-making session were divided into the three Arinze (1992) taxonomies, State, Action and Projection on the basis of best fit. The questions were placed in a table alongside the information used to answer them and the groups that suggested it as important. An example of this layout, showing a single decision element, taken from the WMSS weeds project, is provided in Table 2.

Decision element :	*Do I need to act?*				
Enquiry category :	*State:*	*Groups*			
Question	Information sources	1	2	3	4
What are the levels/population in the crop? E.g. good, bad, horrific; low, moderate, severe	Crop walking/observation Weed map, black-grass map Distribution Field history	✓		✓	✓

Table 2. Example of table for decision element data

In this example three of the WMSS groups said that when making the decision about whether to act against weeds they needed to find out what the levels were in the crop. One group did not specifically mention this question. The question is of the type 'state' because it relates to the current state of the 'system'. The information currently used to answer the question is listed in the second column. Of the data outlined only field history is available in digital format.

The collation of the questions relating to the different decision elements and the enquiry categories provided information about the broad task approach. The data from the next phase provided a starting point for the projects by identifying the perceived support needs of the users. The areas

suggested by the groups as requiring more support were collated by the author under headings selected on the basis of a perceived natural grouping. The raw data was made available to project partners to allow alternative groupings to be selected if necessary. In the event none of the groupings was changed. These headings were also tabulated and the ranking provided by each group listed. An averaging of these ranks provided a means to sort the suggestions in order of priority. Table 3 provides an example of the format used from the weeds project.

Need	Questions/notes	Groups 1	2	3	4	Rank Σ
Dose response information	Size, timing and weather? (In quarter doses is fine.) When can get away with 1/2 dose? How much will do the job? Consequences if wrong? Circumstances of trials data (to compare)? Impact on resistance? More info on broad leaf weeds	H	H	H	H	20
Adjuvants	Are any worth paying for? Impact of pH of water?		M	M		6
Support for impact of product on specific weeds	What is the impact of dose on weed size? When might a weed not be killed? What does moderate mean? 75%? What are scenarios when it works and when it doesn't work?			H		5

Table 3: Example of format used to summarise and rank support requirements

Other results e.g. those relating to availability of weather and observation data, the acceptability of web and PC delivery formats and other project specific questions were summarised and reported back to the projects in tabular and textual form.

5. CONCLUSIONS

The approach described above has been used in three different projects and performed equally well in all of them. It was simple to organise and run, the participants enjoyed taking part and, despite disappointing numbers in some cases, generated a wealth of information. Asking users to think in

terms of questions is a useful way to encourage them to think about the decision task. The responses are not however always phased in pure question format require some interpretation. Subsequent checking with those involved in the workshops described here did support the author's analysis. While the method is still not entirely free from this type of subjectivity it does provide a relatively formal and practical means of gathering information.

The approach is also easy to run. Two of the workshops sessions, in the PASSWORD project, were managed by non-human factors specialists. The general scope of the data resulting from these sessions matched that of the previous two sessions run by the author, however they were a little less detailed. This suggests that some workshop or meeting management skills are required to encourage discussion and elaboration.

In summary the decision enquiry/workshop approach provides a means of describing the task of decision making, of organising that description and using it as the basis for design decisions; and it can be used to ensure that tasks and functions are appropriately allocated within a decision support system. It is also widely applicable. There is nothing specific to agriculture about the approach, indeed the Arinze (1992) taxonomy originated in a mainstream business sector, and the author therefore believes its employment as described in this paper has general utility. By identifying the 'enquiries' or questions inherent in a decision making process, it becomes possible to state the users' requirements for data and for mathematical models, two key components of DSS. Because the designer knows that the system has to support the posing and answering of specific questions, this knowledge also guides the development of the interface. The collated set of user questions provides a ready source of evaluation criteria available from the design stage onwards.

This approach to requirements capture and specification is being promoted widely within UK agricultural DSS projects and will hopefully contribute to a big increase in the usability of the next generation of software. The next stage in the development of the methodology is the specification of design and evaluation procedures. Rapid prototype based activities in the context of workshops are likely to form the basis of this phase.

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