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Evaluating a Computer Program with a Structured Expert Review Process

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Evaluating a Computer Program with a Structured Expert Review Process

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ABSTRACT

A structured expert review process was implemented to evaluate the technical content and usability of a program on aeration system design for grain storages. Technical evaluation was used to determine if the computer program generated solutions similar to expert solutions. Other aspects of the evaluation focused on measures of ease of use, effectiveness of information conveyance and usefulness of solution. The evaluation procedure and questionnaires are described and results from the evaluation of an aeration system design program are summarized.

The evaluation process served to validate the aeration system design program, generate suggestions for improving the program, identify areas for further research and advance aeration system design technology by bringing together experts representing the range of practice. The review process was beneficial and could be adapted for use with other decision support programs.

INTRODUCTION

Increased availability of microcomputers in agricultural sectors has led to development of microcomputer programs for agricultural extension purposes. These software programs typically fit into the category of decision support tools. Decision support programs imitate an expert by involving a client in a problem solving situation, often providing a recommendation in response to a client's request for help in making a decision. Programs have been developed to make recommendations on such diverse topics as feed rations for dairy cattle, "pik and roll" strategies for corn marketing and aeration system designs for grain storages.

Text and graphic delivery methods have been used by program developers. Text presentation methods have been the most common, but some recent programs have utilized the graphic capabilities of microcomputers to convey information. Regardless of the presentation method, a program must effectively communicate with a user to insure that the user's responses are appropriate. An expert developing a decision support program must be concerned with both the technical content and usability of a program. If a program was evaluated, the results could be used to verify the program's theoretical and practical value, to determine if the program is ready for distribution, to document the publication value of the program and to obtain recognition for the work involved in developing the program.

How can a decision support program be evaluated to insure its integrity and usefulness? A number of approaches to evaluation are possible. Experts could review the decision support program to determine its validity and similarity to expert advice; the performance or output of the program could be checked for economic, mechanical or managerial feasibility; or users could evaluate the user interface for acceptability and the program solution for implementation. In this study, determining the validity of the program was the highest priority, so an expert review approach was used.

House (1980) described the use of an expert review procedure as a basic evaluation tool. Random error is a potential problem in a review process, but can be counteracted by increasing the number of judgments with a group of judges or experts (Mumpower and Anderson, 1983).

Concurrent, construct and content validity tests can be used to ascertain overall validity (Borg and Gall, 1979). Concurrent validity is determined by relating a test to a criterion measure administered about the same time (Borg and Gall, 1979). In other words, in solving the same problem, how well do the results of the computer program and the expert reviewers correspond? Construct validity is the extent to which logical and theoretically consistent constructs are represented (Borg and Gall, 1979). In application, what procedures, equations and rules of thumb do the experts use and how do these compare with the logical structure of the computer program? Content validity is the degree to which items or components, in this case the questions asked of a user, are pertinent to solving the problem for which the program was designed (Borg and Gall, 1979). For example, are the questions asked by the computer program typically asked by experts, is the information to answer the question readily available to the user and are the questions worded adequately.

The term "sensitivity", as used in this study, differs from sensitivity of an agricultural model which relates to the degree of response to a range of inputs. In this study, sensitivity refers to the degree to which a user with poor or incomplete information can use a program and still generate an acceptable solution. In other words, does the program adequately define terms which may be vague to

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a user and does it educate a user or recommend a response to a question, if needed?

Warwick and Liniger (1975) described the two basic goals of questionnaire design as follows: (a) to obtain information relevant to the purposes of the survey and (b) to collect the information with maximal reliability and validity. To accomplish the first goal of relevance, each question should have an explicit rationale for why it is asked and how the response will be used. The second goal of accuracy requires that questions be properly worded. In wording questions, it is critical to make sure that the particular issue which the researcher has in mind is the same issue to which the respondent gives an answer (Payne, 1951). A first step in developing questions it to search for questions on the same topic that have been asked by other researchers (Sudman and Bradburn, 1982). Borrowing from other researchers is also applicable in the design of questionnaires. Dillman (1978) described a total design method for questionnaires which included detailed recommendations for questionnaire design. Although Dillman's method was intended for mail surveys, components of this method including questionnaire organization, question wording, response formatting and upper and lower case character usage are applicable to expert review methods.

The objective of this study was to implement a structured expert review process to evaluate the technical content and usability of an agricultural engineering program which generates custom designs for grain aeration systems.

EVALUATION PROCEDURE

The first step in the evaluation procedure was to formulate the evaluation objectives. The objectives were selected for evaluation of the aeration system design program described by Watson (1987) and are applicable to other decision support programs. The evaluation consisted of technical and usability components. Objectives of the technical evaluation were to measure concurrent validity, construct validity, content validity and sensitivity. Objectives of the usability evaluation were to measure the general "ease of use" of the program, effectiveness of information conveyance and usefulness of the solution. These objectives were used to guide development of five questionnaires used in the review process.

Measuring concurrent validity requires a criterion measure. Two examples problems were prepared for the aeration system design program. Reviewers were asked to complete the problems using their usual procedures, before the hands-on phase of the evaluation. Worksheets were prepared to allow the reviewers to easily record their problem solutions and to allow the program developers to conveniently compare results. During the hands-on phase of the evaluation, the reviewers used the computer program to solve the same example problems. The reviewers' solutions to the example problems were the criterion measure for the concurrent validity of the program.

The first questionnaire was prepared to measure concurrent validity and required reviewers to rate differences in solutions generated by the program and their own solutions (Fig. 1). Seven categories of problem

AERATION SYSTEM DESIGN FOR FLAT GRAIN STORAGES
Rating of Design Results

Reviewer: SUMMARY

Please rate the design results produced by the aeration design program based on the magnitude of difference between your results and the program results. Consider the case studies you used with the program and check the appropriate box. The rating categories of the differences are none, minor, moderate and substantial.

	DIFFERENCES			
Design result	**None**	**Minor**	**Moderate**	**Substantial**
1. number of ducts	4	3	2	0
2. placement of ducts	1	2	5	1
3. duct diameter	3	3	2	1
4. duct length	1	2	6	0
5. number of fans	2	1	2	3
6. fan size	2	2	2	2
7. connector size	2	4	2	1

If you checked the categories of *moderate* or *substantial* for any of the above items, please complete one of the attached rating explanation sheets for each item receiving a *moderate* or *substantial* rating.

Fig. 1—Questionnaire for rating differences in reviewers' and program's solutions.

AERATION SYSTEM DESIGN FOR FLAT GRAIN STORAGES
Explanation of Moderate or Substantial Rating

Reviewer: SUMMARY

Circle the category rated *moderate* or *substantial* which is being explained on this sheet:

number of ducts
duct diameter
number of fans
connector size
placement of ducts
duct length
fan size

For the category you circled above, what do you think caused the difference between your results and program's results?

ducts placed close to wall in shallow storage
used 1.5 air path ratio for all ducts
tarp covered pile effect of widthwise placement not considered by program
using a spacing > depth of grain over duct
used 1.5 air path ratio for all ducts
disregarded outside 3-5 ft; depth - use evenly spaced ducts for convenience

Do you think the program should be changed? YES 3 NO 3

If yes, how would you recommend the program be changed?

disregard grain depths <= 4' (<= 3')
allow expert to change air path ratio
option for tarp covered pile

Fig. 2—Questionnaire for explaining "moderate" or "substantial" difference rating.

AERATION SYSTEM DESIGN FOR FLAT GRAIN STORAGES
Review of Design Guidelines

Reviewer: SUMMARY

This section of the evaluation requests your opinions regarding design factors used in the aeration system design program. Please, indicate whether or not you agree with the following factors. If you disagree, indicate your preferred value in the space provided.

Design Factor	Value	Agree?	If no, your value
1. air path ratio for middle ducts	1.5	8 YES NO 0	
2. minimum grain depth on wall to be considered deep (ft) (related to 3 and 4 below)	5	7 YES NO 1	4
3. air path ratio to outside with shallow grain depth	2.0	8 YES NO 0	
4. air path ratio to outside with deep grain depth	1.8	8 YES NO 0	
5. maximum length of plastic aeration tube from fan (ft)	60	1 YES NO 6	75 80 80 100 100 press chart
6. maximum length of metal aeration tube from fan (ft)	80	4 YES NO 3	100 100 100
7. minimum static pressure for fan sizing (in. water)	0.5	8 YES NO 0	
8. static pressure of connector (in. water)	0.25	6 YES NO 1	curve data
9. static pressure of turn in connector or duct (in. water)	0.25	5 YES NO 2	0.5 10-15% total sp
10. minimum bushels to design aeration system (bu)	3000	6 YES NO 2	no minimum no minimum
11. minimum peak grain depth to design aeration system (ft)	6	8 YES NO 0	
12. minimum distance from duct to wall parallel to duct (ft)	3	5 YES NO 3	5-6' 5' 6'

Fig. 3—Questionnaire on problem-solving guidelines.

AERATION SYSTEM DESIGN FOR FLAT GRAIN STORAGES
Review of Response Screens

Reviewer: SUMMARY

Please evaluate the information the program requests of the user. All items asked on one screen are grouped together. Circle your response to the four questions for each response screen. The four questions are:

Is this information you typically ask of a client?
Is this information readily available to the client?
Is the question worded adequately?
Is the help information sufficient to assist a client in answering the question?

Response screen	Typical question	Information readily available	Worded adequately	Help information sufficient
1. client information	8 YES NO 0	8 YES NO 0	8 YES NO 0	7 YES NO 1
2. grain type	8 YES NO 0	8 YES NO 0	8 YES NO 0	8 YES NO 0
3. new structure	8 YES NO 0	8 YES NO 0	8 YES NO 0	8 YES NO 0
4. construction type	6 YES NO 2	8 YES NO 0	8 YES NO 0	8 YES NO 0
5. post spacing	6 YES NO 2	8 YES NO 0	8 YES NO 0	8 YES NO 0
6. structure liner	4 YES NO 4	5 YES NO 0	5 YES NO 3	7 YES NO 1
7. storage size	8 YES NO 0	8 YES NO 0	8 YES NO 0	8 YES NO 0
8. grain depths on walls	8 YES NO 0	8 YES NO 0	6 YES NO 2	8 YES NO 0
9. maximum piling height	8 YES NO 0	7 YES NO 1	5 YES NO 3	6 YES NO 2
10. number of ducts	6 YES NO 2	6 YES NO 2	8 YES NO 0	5 YES NO 3
11. duct type	8 YES NO 0	6 YES NO 2	7 YES NO 1	5 YES NO 3
12. duct direction	8 YES NO 0	8 YES NO 0	7 YES NO 1	6 YES NO 2
13. fan type	5 YES NO 3	7 YES NO 1	7 YES NO 1	6 YES NO 2
14. fan arrangement	6 YES NO 2	8 YES NO 0	5 YES NO 3	3 YES NO 4
15. airflow rate	8 YES NO 0	8 YES NO 0	5 YES NO 3	5 YES NO 3

Space if provided on the following page for your comments.

Fig. 4—Questionnaire on response screens.

solutions were included on the questionnaire, with instructions for the reviewer to rate differences as "none", "minor", "moderate", or "substantial". Only ratings of "moderate" or "substantial" were considered to question the concurrent validity of the program.

Aeration system design is an example of a subject area in which diverse recommendations exist in the literature for some steps in the design process and recommendations are vague for other steps. As a result, different experts may use different recommendations in their design process. An explanation of any differences in problem solutions was needed to adequately interpret the reviewers' responses. The second questionnaire was prepared to measure concurrent validity and required reviewers to explain why they rated a program solution as a "moderate" or "substantial" difference from their own and to make any recommendations for modifying the program (Fig. 2.).

Measurement of construct validity consisted of interpreting the results of the concurrent validity questionnaires and a third questionnaire which required reviewers to record their agreement or disagreement with design recommendations used in the program (Fig. 3). A "moderate" or "substantial" difference rating on the concurrent validity questionnaire could be associated with differences in choice of design guidelines between expert reviewers and the program, thus raising doubts about the construct validity.

A fourth questionnaire was prepared to measure both content validity and sensitivity (Fig. 4). This questionnaire required reviewers to respond "yes" or "no" to the following questions about each response screen of the program: (a) "Is this information you typically ask of a client?"; (b)"Is this information readily available to the client?"; (c)"Is the question worded adequately?" and (d)"Is the help information sufficient to assist a client in answering the question?". The first three questions addressed content validity and the fourth question addressed sensitivity.

A fifth questionnaire was prepared to measure the usability of the program (Fig. 5). This questionnaire required reviewers to rate the user interface for "ease of use", effectiveness of information conveyance and usefulness of the design drawing and management recommendations components of the solution. Reviewers were also asked to respond to some general questions about their reactions to the program and the review process.

Nine experts evaluated the aeration system design program. Five reviewers were associated with extension work in agricultural engineering at universities and four were associated with aeration system component manufacturers. Hands-on evaluations were scheduled for 3 h plus a luncheon. The evaluation period included a brief introduction to the design problem and the computer program. Once the introduction was complete, the reviewers proceeded to use the program to solve the example problems, experiment with the program and complete the five questionnaires.

AERATION SYSTEM DESIGN FOR FLAT GRAIN STORAGES
Usability Evaluation

Reviewer: **SUMMARY**

Please respond to the following questions to help us evaluate the usability of the program.

USER INTERFACE

1. How convenient are the keys used for the special key commands in the program?
   VERY SOMEWHAT A LITTLE NOT VERY
   8 0 0 0
2. After using the program once, how comfortable were you with the key operations?
   VERY SOMEWHAT A LITTLE NOT VERY
   7 1 0 0
3. What changes would you make to the key operations?

   update capability for quick change of responses

   have program go to next screen after 'enter' key hit

   change highlight & selection on choice screen

4. How acceptable is the speed of program execution?
   VERY SOMEWHAT A LITTLE NOT VERY
   5 3 0 0
5. Generally speaking, how easy was the program to use?
   VERY SOMEWHAT A LITTLE NOT VERY
   8 0 0 0
6. Based on the operation of the key commands and the appearance of information on the screen, do you think the following groups of people could use a program such as this one (not including technical aspects) after a few minutes of training?
   a) beginning microcomputer user 8 YES NO 0
   b) average county agent 8 YES NO 0
   c) average farmer 8 YES NO 0

INFORMATION CONVEYANCE

7. How effective are the text and illustrations in conveying the appropriate points?
   VERY SOMEWHAT A LITTLE NOT VERY
   7 1 0 0
8. In general, how well does the text convey the appropriate information?
   VERY SOMEWHAT A LITTLE NOT VERY
   6 2 0 0
9. Would the illustrations associated with the response screens be helpful to:
   a) you or other expert 6 YES NO 1
   b) average county agent 7 YES NO 0
   c) average farmer 7 YES NO 0
10. How useful are the illustrations for:
    a) involving a user in the design process?
    VERY SOMEWHAT A LITTLE NOT VERY
    3 4 0 0
    b) helping the user to consider different options or new ideas?
    VERY SOMEWHAT A LITTLE NOT VERY
    3 2 1 1
    c) amplifying the meaning of the text?
    VERY SOMEWHAT A LITTLE NOT VERY
    4 3 0 0
11. Considering the response screens in general, how important are the illustrations to the accuracy of communication with the user?
    VERY SOMEWHAT A LITTLE NOT VERY
    5 2 0 0

DESIGN DRAWING

12. How usable are the design drawing and component specification list for a client to:
    a) purchase components of an aeration system?
    VERY SOMEWHAT A LITTLE NOT VERY
    5 2 0 0
    b) install an aeration system?
    VERY SOMEWHAT A LITTLE NOT VERY
    5 2 0 0
13. How would you change the design drawing?

    symbol for solid vs. perforated w/ legend

    put duct diameter on drawing; show footage of pipe not just location

    BP should be related to direction; print plan w/ client information

    heavier line for building; use modular lengths; drawing displayed longer

14. How would you change the component specification listing?

    change connec tor size to solid duct size; change duct to perforated duct

    add total hp & number of fans; add warming/cooling time

    standard lengths and sizes

    draw line under each duct size across page

MANAGEMENT RECOMMENDATIONS

15. How important are management recommendations in a program of this type?
    VERY SOMEWHAT A LITTLE NOT VERY
    7 0 0 1
16. How helpful, to a client, are the management recommendations generated by the program?
    VERY HELPFUL SOMEWHAT HELPFUL NOT HELPFUL
    5 2 0
17. How effectively are the management recommendations communicated?
    VERY GOOD GOOD AVERAGE BELOW AVERAGE
    3 4 0 0
18. Generally, is the correct emphasis placed on critical recommendations?
    YES, DEFINITELY YES, MOSTLY NO
    1 6 1
    If No, how would you change the emphasis?

    moisture/temp of grain - continuous or intermittent operation

    fan run time; exhaust area; bird-rodents; ventilation area

    number them add -more- & -end- at end of pages; insect control

19. How similar are the recommendations provided to ones you commonly make?
    VERY SOMEWHAT A LITTLE NOT VERY
    0 6 1 1
20. What changes, additions or deletions would you make to the management recommendations?

    time/temp/moisture; fan run time; exhaust area; insect control

    downward airflow recommended

GENERAL

21. Would this program be useful to you in the practice of designing aeration systems?
    YES, AS IS YES, W/ CHANGES NO
    2 6 0
22. Would you recommend this program for use in the pratice of designing aeration systems by:
    a) county agents 4 YES, AS IS 4 YES, W/ CHANGES 0 NO
    b) farmers 4 YES, AS IS 3 YES, W/ CHANGES 1 NO
    c) aeration equipment suppliers 2 YES, AS IS 6 YES, W/ CHANGES 0 NO
23. Did participation in this technical evaluation cause you to think about the problem of aeration system design differently?
    YES NO
    4 4
24. As a result of participating in this technical evaluation would you consider changes to your current aeration system design procedure?
    YES NO
    6 2
    If Yes, what changes would you consider?

    change air path ratio for ducts near side wall

    consider using varying air path ratios

    use air path ratios per your design method

    determining length of connector; fan in middle of duct

25. Please use the space provided below to make any additional comments on the usability of this program.

    print recommendations on screen; run w/o AutoCAD & Synthesis

    add other products such as potatoes

    allow other than rectangular storages - polygons

    maximum side wall grain depth > 20'

    change plastic to HDPE and max. lengths to 80'

    calculate static pressure thru conduit vs .25 or have option to override default

    for expert users allow more flexibility in design parameters

    allow vertical fan placement

    very impressed; very good and easy to use; will improve with use

    it serves audience you identify; good program

Fig. 5—Questionnaire for usability evaluation.

The evaluation procedure progressed under the direction of the researchers. When possible, two people familiar with the program directed reviewers during the evaluation process. Discussion of differences between the reviewers' and the program's solutions to example problems was encouraged and was important to provide accurate information for the reviewers to explain the cause of a "moderate" or " substantial" difference rating and for the researchers to interpret the reviewer responses. Notes of the reviewers' pertinent comments were made. The luncheon provided a relaxed environment for discussing the program and the subject area.

Responses to the questionnaires for technical and usability evaluation were quantified and summarized. An insufficient number of reviews was conducted to perform statistical analysis on the results. The program developers were required to objectively examine the results to determine the validity and usability of the program and the implications for modifying the program.

EVALUATION RESULTS

Utilizing outside experts in the technical evaluation process was beneficial, as reviewers were cooperative and shared their technical expertise in aeration system design. Watson (1987) described the results of the evaluation of the aeration system design program in detail. Results of the technical and usability evaluations are summarized here and are an example of results from an expert review process.

Technical Evaluation

Reviewers' ratings of design results and explanation of "moderate" or "substantial" difference ratings were used to measure concurrent validity. Three of the seven categories of design results received more ratings of "moderate" or "substantial" differences than "none" or "minor". A difference in one design result category was usually related to differences in other design result categories. The program developers studied the difference ratings and their interdependancies and traced the differences between the reviewers' and the program's solutions to two areas of design guidelines: the method for placing ducts and the method for determining the length of a duct. In the first case, two methods which produce dissimilar results were prominent in the design literature. In the second case, the design literature was vague on an appropriate guideline. In both cases the variation among reviewers was as substantial as the differences between the reviewers and the program. Discussion with reviewers resulted in some agreement about guidelines that were vague in the literature. Other design guidelines were identified as needing further research. Considering the variation among experts, concurrent validity was ascertained.

Construct validity was measured based on the reviewers' agreement or disagreement with key design guidelines used in the program. The reviewers agreed with the values used in the program with one exception. For the maximum length of plastic aeration tubing from a fan, reviewers preferred longer lengths than those used by the program. The program developers interpreted this as a minor difference given the lack of information available in literature, thus, the construct validity was deemed acceptable.

Content validity of the program was measured by reviewers' responses to questions about the response screens in the program. In general, the reviewers said that the questions in the program were typical of questions they asked, the information to answer the questions was readily available to the clients and the questions were worded adequately. Some reviewers did not typically address the related issues of post spacing or structure liners. Questions on equipment type or arrangement were excluded by some reviewers since they usually made these decisions for clients. Reviewers suggested improvements to the wording of questions or the illustrations for seven of the response screens. Reviewers made several suggestions about the content of the program but their approval was evident, thus content validity was ascertained.

Sensitivity of the program was measured by the reviewers' opinions of the adequacy of the "help" information available to a program user. The reviewers generally responded that the "help" information was sufficient. One exception was the "help" information available for fan arrangement. Variations of the three options presented to a user were possible, which led to some confusion for the reviewers. Sensitivity, as the term is used in this study, was acceptable.

Reviewers' suggestions from the evaluation process were scrutinized for possible incorporation into the program. The guideline for the maximum length of plastic aeration tubing from a fan was changed due to a consensus among the reviewers. Some suggestions for changes to the content of response screens were also incorporated. Other suggestions were specific to an individual reviewer's preference and should only be changed if the reviewer were to become the program developer.

Usability Evaluation

The reviewers rated their perception of the usability of the program. Ratings were requested for user interface, information conveyance, design drawing, management recommendations and general categories.

Reviewers rated the user interface very easy to use. All reviewers agreed that beginning microcomputer users, county agents and farmers could use a program with this type of user interface. Some suggestions for improvement were made.

Information conveyance with text and graphics was rated very effective by the reviewers. Reviewers responded that the illustrations would be helpful to other experts, county agents and farmers. The illustrations were rated somewhat useful for (a) involving a user in the design process, (b) considering different options and (c) amplifying the meaning of the text. The illustrations were rated very important to the accuracy of communication with the user. The design drawing was rated very useful for purchasing components and installing an aeration system. The management recommendations were rated very helpful to a client and reviewers felt that the recommendations were communicated well.

Half of the reviewers responding reported that the

technical evaluation process caused them to think about the problem of aeration system design differently, and six indicated that they would consider changes to their current aeration system design procedure. Most of these reviewers were considering changes to one or more design guidelines. Reviewers agreed that the program (as is or with changes) would be helpful to them in the process of designing aeration systems. They also would recommend it to county agents, farmers and aeration equipment suppliers. One reviewer said the evaluation process did not cause him to think about aeration system design differently, but he would use the program to design more accurately and to quickly try different alternatives.

SUMMARY

Evaluation of a decision support computer program is important for a program developer to verify a program's theoretical and practical value and usefulness for potential users. A structured expert review process was implemented to evaluate the technical content and usability of an aeration system design program. Technical evaluation objectives were to determine concurrent validity, construct validity, content validity and sensitivity. Usability objectives were to measure ease of use, conveyance of information and usefulness of solution. Example problems and questionnaires were prepared and completed by nine experts who participated in the review process.

Through the evaluation of the aeration system design program, the validity of the program was verified and a number of suggestions to improve the program were generated. Reviewers were cooperative and shared their expertise in the subject area. Although not among the original objectives, the evaluation helped advance aeration system design technology by bringing together experts representing the range of practice and identifying areas for further research. The review process was beneficial and could be adapted for use with other decision support programs.

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