The Yarn and Knitwear Designer/Technologist Relationship.

(Interface usability design)

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This paper will briefly discuss the development of the YarnCAD (3D yarn and knitted fabric simulation) system. The different approach taken by this group can be summed up quite simply. **When a fabric is to be designed and then produced it is first necessary to choose a suitable yarn with the required aesthetic and mechanical properties. It is therefore logical that if an accurate computer simulation of a fabric is to be produced, we should begin with the accurate simulation of the component yarn.** As with all simple statements of concept, the implications of this statement are far reaching. Only by getting CAD for yarn simulation right will CAD for Fabric simulation be accurate. From the earliest stages of development, one of the demands from design and manufacturing companies was for yarn simulations to be included. However, as most of the systems had been developed using 2D fabric simulations then the only option was to superimpose scanned in or painted 2D yarn images on top of the simulated fabric structure.

This study examined the relationship between the textile designer and technologist and how the design of the YarnCAD system has to accommodateThe possible areas of misunderstanding/misinterpretation.

An experiment was designed requiring individuals to use the system to design their own yarn and then to try to simulate a given real yarn. The methodology used to capture and analyse the data obtained is known as 'Protocol Dialogue Analysis' or 'Think Aloud Method'. This simply means that the subject is asked to articulate their thoughts as they carry out the task. Twelve participants took part in this exercise, each having a design or textile technology background and education. This results in many pages of statements which have to be refined and coded in order to discover trends in problems, misunderstandings, misinformation, poor navigation etc in the system.

Introduction

The aim of this project was to support collaboration between textile designers and textile technologists, by identifying the communication problem between them, then providing solutions and support systems to be used in different ways by individual users even those who have different levels of textile knowledge, so that both textile designers and textile technologists can make use of CAD systems in an appropriate way to tackle systemic problems of the design process by giving different contributors access to the information and expertise of their colleagues.

The support CAD system allows designers to develop comprehensive and compatible specifications which are consistent with their design ideas. The communication problems could be resolved by reliable specifications of the support system, such as database of information on fibre and fabric properties, as well as any available expertise and historical data. This can have wider consequences for the design process, as designers and technicians respect each others expertise, they might also respect each other's opinion in other issues and treat each other with higher regard.

A number of valuable papers have been written (Eckert, C. et al 1994,1998,2004) about the knitwear design process, the communication problems between technologists and designers and the use of a CAD support system to obviate these. However, these papers did not attempt to identify the parameters involved at the technology gap or to suggest possible CAD interface solutions to ameliorate these problems. This paper will attempt to do so though it must be realised that this is a précis of a detailed study (Hsieh, W-H. 2007). The yarnCAD software package was used as the vehicle upon which the study of the designer/technologist interface could be undertaken and this tool will now be briefly introduced.

The YarnCAD System

The YarnCAD system is a computer tool that helps in narrowing the gap between the textile designer and technologist in their joint work on producing new yarn. The designer expresses his ideas about new yarn in a form of visual image whereas the technologist thinks in terms of technical specification of yarns and fabrics. The existing approach to developing new products involves a repetitive and time consuming process of yarn and fabric sampling until the required resemblance between the initial image and produced yarn is found. The main advantage of the YarnCAD system is that idea realisation and yarn parameters assessment can be brought forward within the design process without the need for expensive yarn production. This is achieved by generating realistic 3D images of yarn and fabric, designed from the initial technical specification of spinning process, yarn and fabric.

YarnCAD system consists of four major components:

- The user interface
- The mathematical models used for simulating different types of yarns and knitted fabrics
- The graphic engine for yarn/fabric visualisation
- The yarn data base

The user interface is based upon a standard Windows Multiple Document Interface (MDI) where each document window presents a 3D graphical image of the yarn or fabric. The interface gives the user maximum flexibility in manipulating the yarn and fabric parameters and any change immediately affects the image.
Parameters defining the yarn are entered via a sequence of dialogues. The user selects the type of yarn (e.g. knitting, weaving), the manufacturing process (e.g. woollen, worsted), the yarn effects (e.g. plain, slub), and the type of knitted fabric (plain single jersey or 1+1 rib). Strands are added or removed as desired from the list. The set of parameters that are individually editable for each strand includes colour, count, twist level and direction, fibre type, coefficient and spectrum of unevenness, and some others specific for different types of yarn. The sample of knitted fabric is defined by its size and stitch density in horizontal and vertical directions. The full specification of yarn and fabric can be printed out together with its image, or stored via a standard filing system.

Designing a New Yarn

* To start designing a new yarn or fabric choose *File→New* item in the Main Menu or click *New* icon in the Tool Bar and then input the necessary data using the dialogue boxes. The system enables single, 2-, 3-, and 4-ply straight yarns and slub yarn to be simulated.

The design process starts from *Yarn Production* dialogue (Figure1.) where the yarn type can be chosen from the options *Knitting*, *Weaving*, *Crepe*, *Braided Knitting*, and *Braided Weaving*, and the spinning process can be set to *Woollen*, *Worsted*, or *Cotton* from the *Process* list.

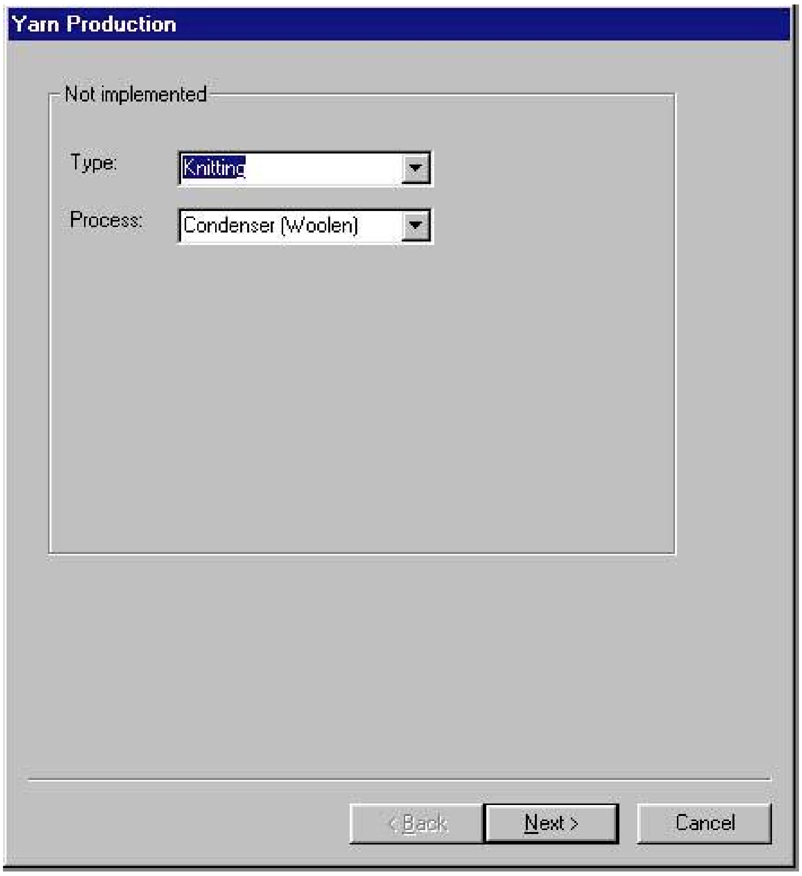

Figure 1. *Yarn Production* Dialogue

Click *Next* which brings the *Yarn Effects* dialogue (Figure2.). Options define yarn type and visual effects on the yarn surface. From the *Special Effect* list four choices are available: *Straight* yarn, *Plain Loop and Fabric*, *Rib Loop and Fabric*, and *Slub* yarn. It is advisable to start from the straight or slub yarn and then to put it into the knitted fabric sample.

Yarn surface can be presented in four different appearances using the set of four buttons: *Smooth*, *Medium*, *Ribbed*, and *Auto*. The last one enables the yarn surface to be presented differently depending on the image magnification.

When parameters in this dialogue are set, click *Next* to proceed with the designing process. It is possible to return to the previous dialogue by clicking *Back*.

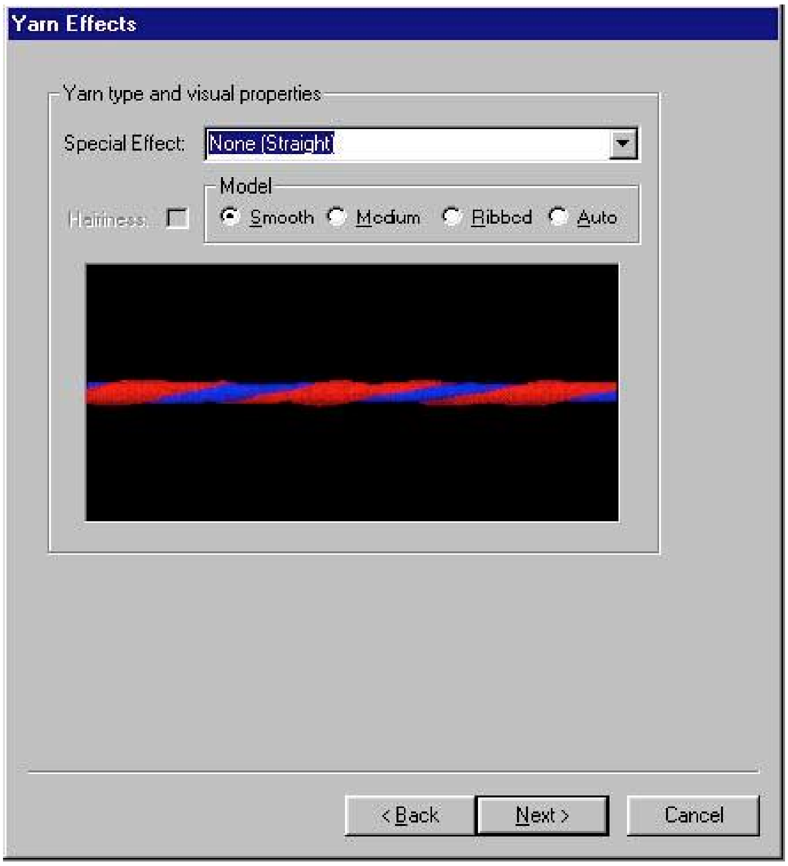

Figure 2. *Yarn Effects* Dialogue

If the *Straight Yarn* option was chosen at the *Yarn Effects* dialogue, the *Strands* dialogue (Figure2.) appears on the Main Window.

The dialogue box consists of two parts. The upper part labelled *Yarn* determines twist level and direction for the plied yarn, whereas the lower part labelled *Strands* determines properties of each individual strand.

By default, the dialogue starts with two strands. Strands can be removed or added by clicking *Cut Strand* or *Add Strand* buttons. It is possible to remove any particular strand by firstly clicking on the strand number. Maximum available number of strands in the yarn is four.

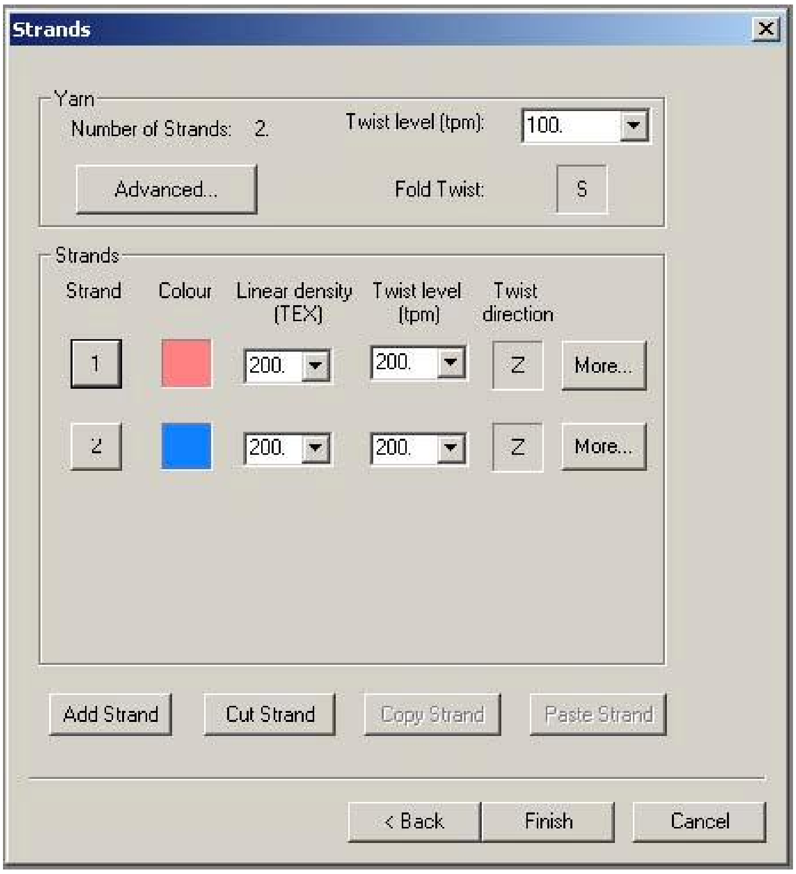

Figure 3. *Strands* Dialogue

For each strand the following parameters should be set: colour, linear density in tex, twist level in twists per meter, and twist direction (S or Z). For the more experienced designer it is recommended to use *More* button which brings *More Strand Properties* dialogue.

Strand colour can be set by clicking the coloured area next to the strand number. This initiates the *Colour* dialogue where the colour of the strand can be chosen from the palette of 48 pre-designed colours or from 16.7 million colours by clicking *Define Custom Colours* button.

Yarn linear density and twist level can be determined either from the list of pre-set values or by entering appropriate number into the box (Figure 3.).

Yarn twist direction can be set to Z or S direction using *Twist Direction* button.

When all individual yarn strands are determined, it is necessary to set twist level and direction for the plied yarn using upper part of *Strands* dialogue (Figure 3.) which is similar in its functionality to the lower part.

Advanced option of *Strands* dialogue (Figure 3.) determines specific parameters of the two-ply yarn production described in Appendix.

Click *Finish* button and the 3D image of the yarn with the specified properties will be presented in the window labelled *YarnPa1* (Figure 4.). If instead the *Back* button was clicked then the *Yarn Effects* dialogue would be presented.

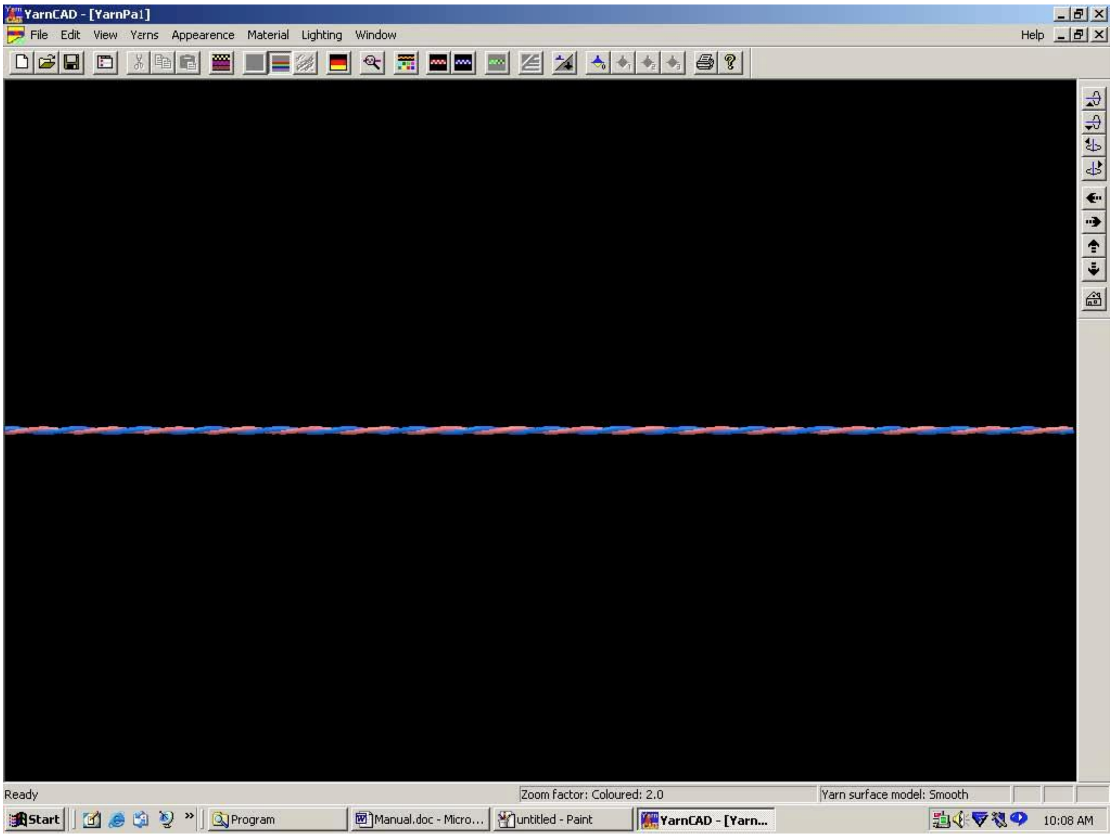

Figure 4. Example of the two-ply Yarn Image

All yarn parameters can be modified using *Yarns→Specification* in the Main Menu or by clicking *Specification* icon.

Colour of any individual strand can be changed using *View→Custom Palette* in the Main Menu or by clicking *Toggle Palette* icon.

Yarn image can be viewed from different angles by rotating and moving the image in 3D.

It is possible to design many yarns and fabrics with different combinations of properties. Each new yarn will be shown in an individual window consecutively labelled *YarnPa2*, *YarnPa3*, and so on. It is possible to see all the designed yarns by using *Window→Tile* (Figure 5.)

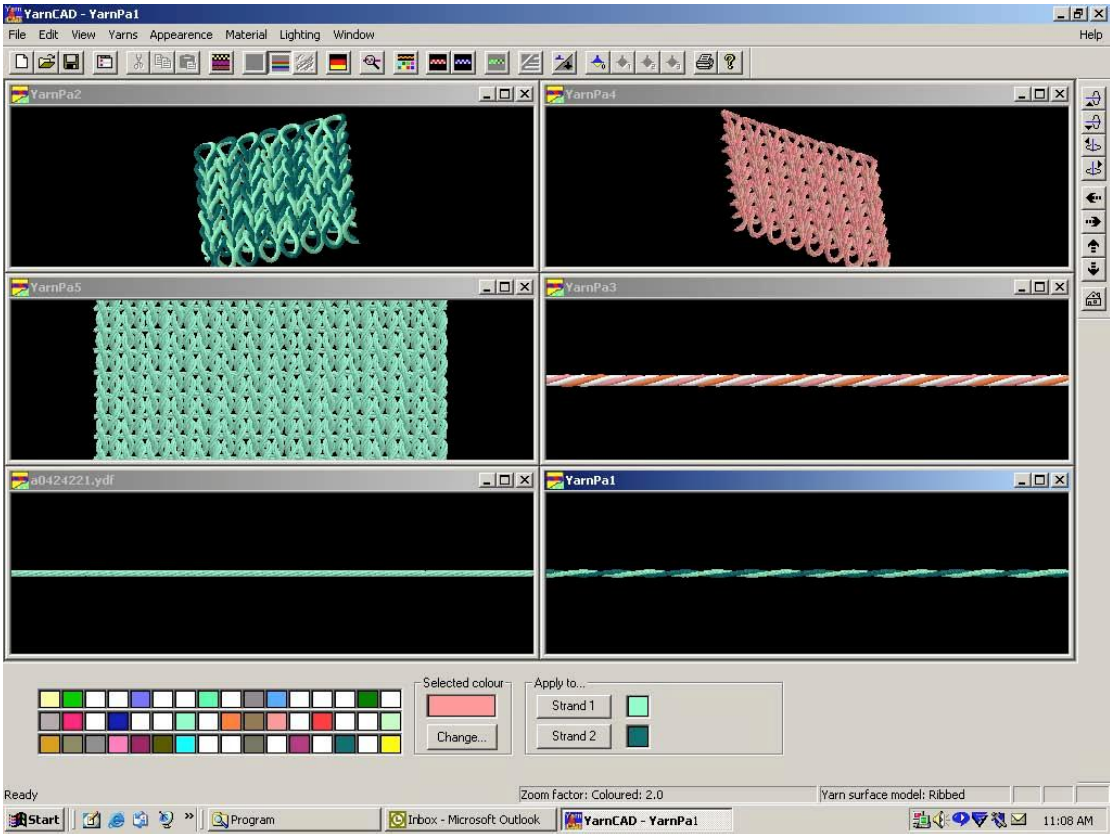

Figure 5 Example of Tiled Windows

Procedure for User Testing

The experiment was carried out in 12 individual sessions, which were all held in the same usability lab. During each session, video recordings were made of the computer screen and the participant's voice, while the experimenter was also present to observe and take notes.

The planning and design of the user testing was based on the framework laid out by Rubin (1994) in his book, "Handbook of Usability Testing: How to Plan, design, and Conduct Cost Effective Tests." The conducted user testing consisted of a main performance test designed to gather extensive usability data via verbal protocol analysis and a post-test questionnaire. The main performance test was composed of the following four steps:

(1) Participant greeting and a background questionnaire.

Upon arriving, each participant was greeted and asked to fill in the first questionnaire on demographic details, such as age, gender, work experience, specialism and education. It also enquired of the participants' experience in working with software systems. Participants were also advised that they would be anonymous throughout the session, and that they were given nondisclosure statements.

(2) Orientation

After completing first questionnaire, the participants received a short, verbal introduction and orientation to the test, explaining the purpose and objective of the test. These instructions, which were read out from paper to ensure consistency, told the participant to: 'think aloud while performing your tasks, and pretend as if the experimenter was not there. Do not turn to her/him for assistance. If you fall silent for a while, the experimenter will remind you to keep thinking aloud. Finally, remember that it is the software, and not you, who is being tested'. All parts of the test were explained and the participants were notified of their right to leave the session should they become uncomfortable.

(3) Performance test

The performance test consists of three major tasks including software exploration, user manual, and knowledge of textiles. For each task, user verbalizations and keystrokes were recorded, using video tapes which included the audio records and screen capture routines using Camtasia Studio™ recorder. At the end of the tasks, a full transcript of each session was made, matching verbalization with keystrokes and screens.

(4) Participant debriefing

After all the tasks were completed or the time expired, each participant was debriefed by the experimenter in one of the side rooms and the debriefing session audiotaped. The debrief included the following:

- Filling out a brief preference questionnaire pertaining to subjective perceptions of usability of YarnCAD
- Participant’s overall comments about his or her performance
- Participant’s responses to probes from the test monitor about specific errors or problems during the test

The debriefing session served several functions. It allowed the participants to say whatever they like, which is important if tasks are frustrating. It provided important information about each participant’s rationale for performing specific action, and it allowed the collection of subjective preference data about the software through the post-test questionnaire.

Number of Participants Required

Nielson (1994) suggests that sample sizes as small as five participants will yield sufficient information about problem solving behaviour. Nielson (2000) further points out that “as soon as you collect data from a single test user, your insights shoot up and you have already learned almost a third of all there is to know about the usability of the design. When you test the second user, you will discover that this person does some of the same things as the first user, so there is some overlap in what you learn. So the second user adds some amount of new insight, but not nearly as much as the first user did. As you add more and more users, you learn less and less because you will keep seeing the same things again and again.”

So Nielson states that “after the fifth user, you are wasting your time by observing the same findings repeatedly but not learning much new.”

Test Environment and Equipment Requirements

The lab for the user testing was a simple setup (Figure 5.), including one seat, a laptop with the YarnCAD system installed and the Camtasia Studio™ recorder, which could clearly record participant on-screen activity and verbal data at the same time. One video camera was used to take down the graphics on screen and audio data as well as to prevent any unexpected technical problems occurring during the testing by losing data. Both verbal data and the mouse movements and click actions on the screen can be used as the basis for coding and verbal protocol analysis.

The main role of the researcher was simply as an observer during the entire testing. The researcher operated the camera, worked silently and stood behind in order not to interfere with the test.

Figure 5. User Testing Lab with Video Recording

User Profile

The main concern of this research was how to narrow the gap between design and technology. To ensure valid information during our think aloud study, the authors decided to use 12 participants. This number far exceeds the overall sample size deemed necessary by Nielson (1994), sufficient information should be available even after discarding.

The research was conducted with a sample of 12 participants, all of whom were staffs or students from School of Design at the University of Leeds. At the time of the study, each of them had a textile education background and/or work experience in the textile industry, which generally meant that they had some basic textile knowledge. They included a variety of specialists from yarn, weaving, knitting and printing.

To collect participants' protocols and data, the author used the Camtasia Studio™ recorder (TechSmith Corporation) for all video captures of on-screen activity including a timed recording of all the mouse movements and click actions and to record a simultaneous think-aloud protocol without disturbing the testing process. Subsequently using a coding scheme, every word is transcripted as well as all interjections and exclamations, in order to reconstruct on paper what has been said during the session.

Teaching Participants How to Think Aloud

During the testing, although some participants can spontaneously respond aloud without any difficulty, it is most likely that they normally do their work silently. However, participants who felt that "thinking aloud" seemed unnatural were not prompted, following Green (1998).

As part of the instructions to participants during the pretest briefing, the experimenter let the participants know that he was interested in what they were thinking about when performing the task because he valued their reactions to the product. He asked them to think aloud as they worked, not just a description of the task itself because the experimenter prefers to any suggestions or explanations of the software, these will help experimenter to improve afterwards.

TASKS SET FOR PARTICIPANTS

In order to evaluate the YarnCAD system by means of think-aloud protocols, three major tasks were formulated that together cover the software exploration, user manual, and knowledge of textiles. All tasks were designed to be equally difficult, and could be carried out independently from one another, in order to prevent participants getting stuck after one or two tasks. The entire set of tasks was as follows:

Study 1: Simple searching task

Task 1 was designed to generally evaluate the function keys of the software including the main menu and tool bar, which allow participants to design a new yarn, try to explore for themselves without reading the YarnCAD user manual.

Study 2: Information (manual) provided task
Task 2 focuses on the user manual, the participants had to read and find the information provided on designing a new yarn of their choice while producing a think-aloud protocol.

Study 3: Simulation yarn task
Task 3 was designed to test the knowledge and process of yarn production. The participants had to simulate a yarn provided for them, focus on understanding the process of design from real yarn.

Coding Procedure and System

Once the 12 sessions were completed, the participants' explorations and other mouse click actions were studied in order to detect usability problems in the YarnCAD system. As a result, the best five original verbal protocol data were selected and segmented in clauses and coded by the author. The verbal protocols were coded with the program MAXQDA. Altogether, the corpus consisted of 1558 coded segments in total. To increase the reliability of analysis, the author applied a method similar to the Delphi Method, each protocol was encoded twice. There was at least a ten day break between the first coding exercise and the second coding exercise. Subsequently, the final protocols were encoded through arbitration of the first coding and the second coding.
Each utterance was coded using the following variables.

Type of Action

The author distinguished two generic types of actions: active and reactive actions. These related to different levels of verbal data in Ericsson and Simon's model.

1. Active actions are verbalization of tasks resulting from deliberate user goals and intentions (I am going to the homepage). These utterances of active actions also refer to level 1 and level 2 data according to Ericsson and Simon's theory.

2. Reactive utterances start from an observation in the task context (mainly on the computer screen) which asks for a reaction from the user (I cannot click on this item) or an evaluation (This is not what I am looking for). These reactive utterances represent level 3 verbalizations provide usability practitioners with data required to build up a friendly and ease-of-use product.

3. Interjections and exclamations are regarded as **non-code** utterances in the transcript of what had been said during the session.

(adapted from Hooijdonk, C V and Maes, A and Ummelen, N, 2005)

Table 1 shows a fragment of the coding history for one participants. Some of the participants' contributions had to be discarded as they had not been able to carry out the think aloud exercise effectively. Eventually seven usable records were identified and the best five of these were used in the analysis. From these it was possible to identify the main problems experienced, to different degrees, by designers and technologists with regard to parameter requirements and pre-knowledge. It was also possible to identify the main usability issues and consequent interface solutions.

Table 1. A Fragment of Coding History
(A: Active Action; R: Reactive Action; N: Non-code;
PL: Layout Problem; PT: Terminology Problem; PD: Data entry Problem; PC: Comprehension Problems; PS: Slow Response)

NO	1st code	2nd code	Arbitrated	Dialogue	time	Action
52	PD	PD	PD	I don't see anything different when you click on yarn dialogues…	8.04	Click smooth/medium/ribbed/auto
53	N	N	N	Oh…	8.15	
54	A	R	R	I'm going to do this again…	8.18	Click back/weaving/worsted/next
55	A	R	R	I'm going to do this again…	8.26	Click slub/next
56	N	N	N	oh…	8.31	
57	PD	PD	PD	but I can't go backwards…	8.36	
58	A	R	R	I wanted to add more strands.	8.40	Click cancel
59	A	A	A	I'm going to start this again.	8.46	Click file/new/weaving/worsted/next
60	A	A	A	And… choose straight…	8.56	Click straight/next
61	N	N	N	okay…	9.00	
62	R	R	R	so here you can add strands.	9.02	Click add strand
63	R	R	R	What is the number of yarns is 4? Okay	9.07	Add yarn to 4
64	N	N	N	So…	9.12	
65	A	A	A	I'm going to change the colours…	9.19	Click colour (strand 3)
66	N	N	N	mmmm…	9.25	
67	N	N	N	And…	9.29	Click colour (strand 4)

Conclusions

Technology Gaps

The authors employed the YarnCAD system as a measurement tool to investigate the gap between designers and technologists, and the result was quite surprising as it revealed a lack of basic textile knowledge in both designers and technologists. It is reasonable to assume that such a problem will have a major impact on the knitwear design process. It certainly supports the statement from Kavanagh (2004), which is

'When it comes to acquiring technical knowledge a designer's ability to exploit that knowledge will often be dependent on how well the designer is able to communicate with technologists.

These main issues will be discussed here as bullet points but we will stick to the yarn design matters and ignore the more general navigation matters which were also a part of the study.

(1) The first input parameter which caused problems to the participants was that of which type of yarn did they wish to create. They were given the choice of 'woollen/condenser spun; worsted/roller drafted; and cotton spun'. Of the twelve participants only one was confident in answering this. Rather disappointing when we consider the backgrounds of the subjects but it made us realise that some form of image would have to be provided to ensure that user would be able to make a correct choice.

(2) The next input parameter which caused problems was 'linear density'. It had been decide that the interface would use 'tex' as the most common count system. However not only did we find that more of the participants preferred 'Metric' or Worsted' we also found that the understanding of the count systems was generally poor and that knitters were much more comfortable when given a choice of a count range which would suit a particular gauge of knitting machine.

(3) If linear density had proven surprisingly difficult then twist was even more challenging for the subjects. Only one had any idea about the relationship between linear density and twist content at the single strand level and, more surprising, was that very few had any understanding of the use of different twist direction. It has therefore been decided that interface will offer the choice of 'hard twist, normal warp, normal weft, hosiery and soft hosiery'.

(4) Another surprisingly difficult decision amongst the subjects studied was that of the folding twist. It has been decided to simply offer the choice of a hosiery twist which is 0.5 X single twist or a balanced twist which is 0.67 X single twist. Of course the user will be able to alter the default values for customisation purposes and for yarns comprising more than two strands.

(5) The original interface system also offered packing factor as an input variable

however this is not a commonly used term in the industry and so descriptions such as lean, bulky and very bulky will be offered.

(6) The original interface also offered CV of irregularity as an input and this will still be offered although it has been found that few users really understood what this was. It should be the CV figure obtained from a standard evenness tester such as the Zellwegger Uster Tester. An average default figure could be used as a default value but this could be altered to allow the effect of unevenness to be observed.

(7) The input parameter used in the original interface to identify the fibre type was the specific volume of a fibre (g/cm3). However this was an unknown to all the subjects and so the future interface will offer a choice of common natural and synthetic fibres and default to the relevant specificl volume value.

Solutions

The author re-designed YarnCAD user interfaces to provide solutions for the technological gaps that had been found and for some of the main navigational problems. Interface modifications were as follows:

Interface 1: Provide a welcome screen and getting started tutorial

(a) add a dialogue for a new yarn/open existing file.
(b) show a getting started with YarnCAD and tutorial to beginner.
(c) make the Help menu active.

Interface 2: delete inactive function key

(a) yarn type and visual properties－delete hairiness (confused user).
(b) yarn production—type: delete item of crepe, braided knitting, braided weaving as these function keys are not active yet

Interface 3: modify existing function key

(a) add yarn material selection
(b) show example of yarn count / knitting machine gauge.
(c) show a picture of twist direction.
(d) yarn production—spin process: pop up the picture of woollen, worsted.
(e) The three main modification function keys should be bigger: show fabric; yarn specification; undo
(f) set default of background colour change into grey colour rather than black.
(g) use the simple term “bulk” instead of “average packing density”.
(h) under the parameter more button set default of Fibre type to the Fibre density link.
(i) set default when you click on selection of twist level, it will link to yarn material and yarn Tex system.

These interface changes were presented to the software design team and these were all incorporated into the new YarnCAD software currently being developed.

The Use of Think Aloud for Usability Testing

Think aloud protocols traditionally have been used by academic researchers as a qualitative data collection method. This method is currently gaining acceptance in industry usability testing. The authors have adopted the thinking-aloud protocol as a primary method for obtaining data from users.

Nielsen's "Usability Engineering" is the most comprehensive and practical discussing of usability engineering and testing, covering the usability engineering life cycle from product conceptualization to design and evaluation. Nielsen states that think-aloud protocol "may be the single most valuable usability engineering method. One gets a very direct understanding of what parts of the interface/user dialog cause the most problems, because the think aloud shows how user interpret each individual interface item".

Thinking aloud is recognised as a very popular and effective method in terms of usability testing. The advantages of protocol analysis versus other methods have been reported in the literature. For example, Yamagishi and Azuma (1987), Henderson *et al*. (1995) examined four usability evaluation methods: logged data of objective performance, questionnaires, interviews and verbal protocol analyses to evaluate different software packages (spreadsheet, word processor and database) and found that protocol analysis is the most efficient regarding its usefulness to highlight specific usability problems.

Yamagishi and Azuma (1987) concluded that: "Both the strengths and weaknesses of each technique were isolated. Protocol analysis and interviews are time consuming, but useful in identifying problem areas for a system. Questionnaire and logged data analysis, both of which can produce some sorts of quantitative results rather easily, are useful only for limited purposes, such as for comparative analysis among systems, versions or categories of users".

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