A MODEL APPROACH TO EFFECTIVE DOCUMENTATION

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Abstract

Many people believe that good documentation is important, yet few use it regularly and effectively. An attempt is made to find reasons for this contradictory behaviour, by examining the existing practices of providers and users of documentation. Reasons for not using documentation appear to fall into two classes; predictable interaction effects and unpredictable interaction effects. Providers usually try to predict the problems users are likely to have at the user-documentation interface, by following standard quality control procedures. When these fail to produce good documentation, users become dissatisfied and turn elswhere for their information needs. On the other hand, good quality documentation may not be used for reasons which cannot be predicted, and often cannot be explained. An approach which suggests methods for dealing with both of these situations is formulated, and ideas for raising the status of documentation are discussed.

Chapter 1

The problem with documentation

Most people believe that documentation in the broad sense; including tutorial guides, reference manuals, maintenance manuals, operations manuals, command summaries, on-line documentation, on-line help, error messages, and the like, can be critically important to the success or failure of a complex system. The problem is that despite this belief, documentation is often not used, even by those who are most in favour of it. Some people do not use documentation because they have tried it and found it to be unsatisfactory. Others avoid using documentation, not because they are dissatisfied with it, but because they prefer to use alternative sources of information. Finally, there are people who will not use documentation whether it is satisfactory or not; they simply have an aversion to it.

The aim of this thesis is therefore to analyse the causes of the documentation problem and, by using the writer's experience in the documentation field, to suggest possible solutions. Although the issues raised in this study apply to all forms of documentation, the experiences to which the writer refers (principally in Chapter 4) involve hard copy documentation, not on-line documentation.

1.1 Motivation for the research

The motivation for the research had its origins in the writer's experience with documentation over a number of years, both as user and supplier. For example, the writer first used documentation regularly whilst serving as an electrical technician in the Royal Air Force. This documentation, although it was always technically correct, was often difficult to follow because of its 'text-book' style, which was particularly unsuited to field conditions. Furthermore, it sometimes gave the impression that it was written by people lacking in 'hands-on' experience of servicing complex electrical/electronics equipment under difficult physical conditions and severe time constraints.

However, service personnel did not have the luxury of being able to reject poorly presented documentation. Indeed, there was a strong incentive to use the documentation, because if an aircraft crashed due to equipment failure, the subsequent enquiry would determine whether or not the faulty equipment was serviced 'by the book'. If it was not, the technician could be held responsible. Consequently, maintenance personnel made the best of the documentation and introduced their own improvements wherever possible.

Following service with the RAF, the writer worked for the Post Office Engineering Department as a research and development engineer. After designing (or helping to design) new postal mechanisation equipment, the writer was often required to produce documentation for the operation and maintenance of this equipment throughout the UK. At that time, no attempt was made to establish the characteristics of the users of the documentation, or their field conditions; it was simply assumed that if the documentation made sense to the writer based on his knowledge of the design, it would also make sense to the user. There was also no 'feedback' from the people in the field to indicate the usefulness of the documentation. This practice was widespread, and still in existence when later on the writer worked for the Post Office as a freelance technical author.

After a period as a full time lecturer at a College of Technology, the writer resumed work as a freelance technical author. After completing several small projects, the writer was commissioned by a large UK company to write the documentation for a new materials handling machine, that was being developed for use in offices mostly throughout the UK, but also in the USA and in Jersey. The project was interesting, not only because the machine was state-of-the-art in two fields of interest to the writer (electronics and computing), but also because the project manager wanted something different from the existing company style of documentation that had been in use for a number of years. The project resulted in an eleven volume manual set, comprising a mixture of A4 and A5 manuals.

It was while working on these manuals that the writer first became really interested in the documentation problem mentioned at the beginning of this chapter. This interest was primarily due to frustration, when it became clear that the end-users were mostly unimpressed with the manuals, and were in some instances reluctant to use them. The frustration arose because the writer knew most of the reasons for the users' dissatisfaction, but was unable to do very much to improve the situation.

In the first place, the documentation did have technical deficiencies, which the writer was aware of, but was unable to correct, because of the constraints described in Chapter 4. Due to these deficiencies, the classes of non-user described on Page 2 had a legitimate excuse for their behaviour. This experience made the writer acutely aware of the need to raise the status of documentation within an organisation, so that the necessary resources would be made available to ensure the competency of the documentation produced.

Secondly, the writer was aware that the documentation was not being introduced to the users in a way that would increase the probability of acceptance (see Chapter 4). The consequence of this was that the criteria used to reject the documentation were often not related to the actual faults in the documentation (which the writer was prepared to accept!), but instead were based on perceived faults due to a lack of understanding of how the documentation should be used.

For example, the idea was that a <u>set</u> of manuals would be permanently available as a reference source at a central point in each office, and that people ranging from machine operators to system designers would be issued for personal use only the manual or manuals that concerned them. Maintenance staff, for instance, required only two manuals to do their work, one of which was A5. As this arrangement was not properly explained to the maintenance staff, a common reason given for not using the manuals was that 'you would need a trolley to carry them around'. Despite patient rejoinders that this was not the case, and that one of the two manuals required could be carried in a toolbag, the attitude persisted.

Although the outcome of the documentation project was not totally disappointing (for example, the people in Jersey declared the manuals to be 'indispensable'), the writer felt the need to learn something from the experience. First, the literature on documentation was reviewed to see what other practitioners were doing to solve the documentation problem. Second, the circumstances in which the writer's documentation project took place were analysed to see what lessons could be learned. This thesis is therefore based on the outcome of these activities and the consequent implications.

1.2 Why effective documentation is important

It was suggested at the beginning of this chapter that documentation can contribute to the successful operation of a system. In fact there are a number of reasons why effective documentation (effective in the sense that it is both competent, and used properly) is important. Some of these reasons are listed below:

1) *It can help to create a positive attitude towards a new system.* In many cases documentation is the first point of contact a user has with the system, and first impressions are generally important and lasting [1] [2]. Well designed and well produced documentation can give the user confidence in the system [3], and lay the foundation for a good working relationship [4] [5] [6] [7]. Although competent documentation cannot hide the disadvantages of a poorly designed system, incompetent documentation can easily make a well designed system incomprehensible to the user [7] [8].

2) *It is a vital part of the interface.* The interface between user and system consists of all the features with which the user interacts while using the system, including documentation [9] [10]. The more complex the system, the more important are the utilitarian and educational roles played by documentation. For example, operating manuals help to ensure that equipment is used effectively [6] [11] [12]; maintenance manuals help to reduce out-of-service time [4] [11] [13]; and system manuals help the user to understand how the system works [7] [10] [14] [15] [16].

3) *It increases the probability that documentation will be used.* Although there is no guarantee that competent documentation will be used, documentation that is seen to be suitable and sufficient for its purpose will be able to

compete well with alternative sources of information. This is especially true either when intrinsic information sources (see Page 14) are not adequate [17], or when knowledgeable colleagues are not available [1] [9].

4) *It reduces the possibility of human error.* Ineffective documentation tends to increase the likelihood of dangerous trial-and-error operating and servicing methods [4]. Without proper documentation, users tend to rely on 'word-of-mouth' information to solve their problems; information which is often inadequate and/or incorrect [2]. In addition, maintenance technicians are likely to miss important maintenance details (or carry them out badly) if they do not have clear, concise information with which to work [9].

5) *It avoids a waste of time and system resources.* Competent documentation helps to make users productive, self-sufficient and satisfied [7] [18]. Documentation that is unclear, inaccurate, incomplete, poorly organised, and/or out of date reduces productivity, makes users more dependent on others, and causes dissatisfaction with the system [19]. Time is wasted talking and thinking about problems that good documentation would solve easily, and the system is not used to its full capacity. In extreme cases, the system may be abandoned as unworkable [2] [20].

6) *It avoids the need for additional training.* When documentation is poor, extra training is often needed to compensate [4] [10]. Often this training focusses on the system, and not on the documentation. Consequently, when users have difficulty with the system, they tend to use their training notes instead of the documentation, so that faults with the documentation are never corrected.

7) *It reduces the possibility of litigation.* Poor documentation can lead to demands for compensation. One problem occurs when faulty information causes system failure or product failure [2]. Another more serious problem occurs when someone is injured in an accident caused by incorrect or inadequate safety instructions [18].

1.3 What users expect from documentation

A number of surveys have identified three factors that people most want when using documentation as a source of information [21] [22] [23] [24]. These are shown below together with the associated design characteristics:

1) *Information should be easy to find* (consistency, signposting, and arrangement);

2) *Information should be easy to understand* (simplicity, concreteness and naturalness);

3) *Information should be task sufficient* (completeness, accuracy, and exclusivity).

Unfortunately, there is plenty of evidence that people are often dissatisfied with the documentation they get. This dissatisfaction is expressed in a number of ways. For example, dissatisfied users either cannot find the information they need [11] [19] [25], or it takes so long to find that the cognitive effort required outweighs the benefits [1] [2] [13] [26]. The most commonly cited cause of this complaint is the lack of adequate access structures such as indexes and contents pages [2] [8], or inadequate/incorrect cross-referencing [19] [27]. Poor structure is also cited by users as a hindrance in their search for information. Specific complaints include inconsistent and confusing text organisation [2] [14] [5] [6] [20] [27] [28] [29] [26] [30]; poor page numbering systems [18]; confusing page headings [6] [20 [31]; and disorganised and unintuitive arrangement of text [28] [32].

People's understanding of documentation is also affected by poor writing [17] [13] [2] [4], poor quality illustrations [7] [18] [20], and poor style and format.

Complaints about writing include 'abstract, vague, and misleading' [9] [11] [33] [27] [28] [24] [29] [30] [35]; 'formal, stiff and patronising' [25] [36] [26] [37]; 'too simple and patronising' [38]; 'too many unexplained acronyms and abbreviations' [6] [20]; and 'generally incomprehensible' [19] [31]. Complaints about illustrations range from 'not enough' [2]; to 'not integrated correctly with the text' [6] [20] [28]. Complaints under the heading of style and format include 'visually unattractive' [4] [39]; 'poor quality printing' [25]; 'inadequate or excessive use of typographical and spatial cues' [28]; and 'lack of white space' [28].

Documentation is also often criticized for not being task sufficient. Inaccuracy is a very common complaint [1] [5] [6] [20] [25] [29] [31] [35], followed by other comments such as 'too long and too complicated' [12] [40] [33] [25] [28]; 'incomplete and/or out of date' [1] [5] [13] [19] [27] [29] [26] [30] [32] [35]; 'not properly directed at the target audience' [41] [35] [36]; 'not task oriented' [2] [27] [28] [34] [36] [26]; and 'purpose unclear' [9] [42] [43] [26] [35].

Research has shown that dissatisfaction with documentation can adversely affect future reader behaviour, such as continued reliance on documentation [44].

Fortunately, there is a large body of knowledge available which not only provides techniques for improving the quality of documentation, but also addresses the issue of how to make documentation more usable. Therefore, providing a technical author follows the rules, and keeps the user in mind at all times, there should be little cause for concern. However, as the experiences described in Chapter 4 indicate, it is not always possible for an author to produce usable and acceptable documentation. For this and other reasons, many people lack confidence in documentation, and consequently turn to other sources of information when they need help.

1.4 Alternative sources of information

As it happens, there are some very understandable reasons why people choose not to use documentation, other than dissatisfaction with the quality. Indeed, in view of the options available to them, it is not surprising that using documentation as a source of information has a very low priority for many people. Consider, for example, the workplace factors shown in Figure 1 [13]. Although this diagram implies that a worker can choose either intrinsic or extrinsic information sources, the dotted line indicates that it is quite possible for someone to operate and maintain a system without using extrinsic information sources (and hence documentation) at all.

Intrinsic information sources are attractive to the system user because they encourage the user to interact with the equipment. For instance, these sources include information that the user 'reads' off the machine (stimulus properties), and feedback from the machine after the user has responded to a stimulus. Hence the user is engaged in continuous information processing all the time the system is in operation. However, the weakness with intrinsic sources of information is that the user may misinterpret the sensory data received in this way.

Despite the possibility of misunderstandings, research has shown that people almost always prefer intrinsic sources to extrinsic sources, even when the extrinsic sources are first rate. Indeed, there seems to be a natural tendency for people to want to use trial and error methods of finding out rather than asking other people or using documentation [13] [3] [2] [15] [40] [35]. This tendency may be due to experience (many experienced technicians are typically not dependent on documentation when carrying out maintenance [1] [10]), or impatience to get to grips with the system [13] [3] [2] [14] [15] [40] [45] [35].

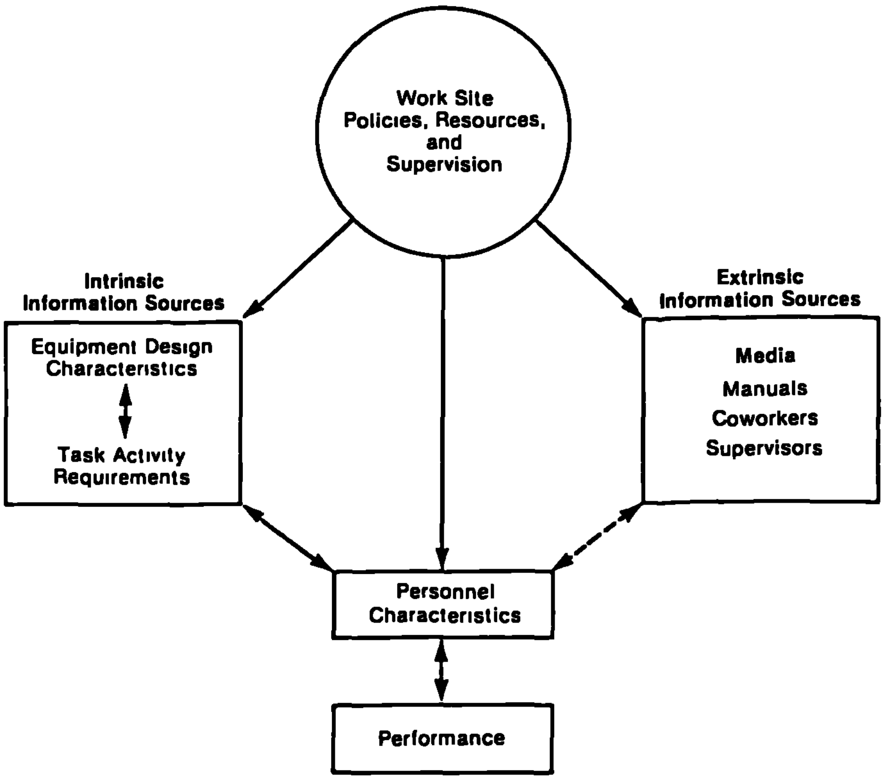


Figure 1 Intrinsic and extrinsic information sources

The use of intrinsic sources of information usually continues until something goes wrong, e.g. either the user cannot interpret the stimulus properties of the system in order to identify the actions to be performed, or the actions performed in response to a stimulus do not have the expected effect. In this case the user usually turns to the extrinsic sources of information which include supervisors, co-workers, and manuals. Even then, there is no certainty that documentation will be used (see Figure 2 [13]).

Some of the reasons for not using documentation as an extrinsic source of information (apart from its poor quality) are as follows:

1) *The user has preconceived ideas about documentation*. Users already have a great deal of knowledge about the world, and this generates expectations about written communications. Conflicts between the written material and the user's presumptions may result in users having difficulties in understanding, or even not reading, certain parts of the documentation at all [46].

2) *The documentation is not targetted correctly.* Experts tend to have better problem solving heuristics than novices. Not only are they able to formulate better questions, but they also have better strategies for using

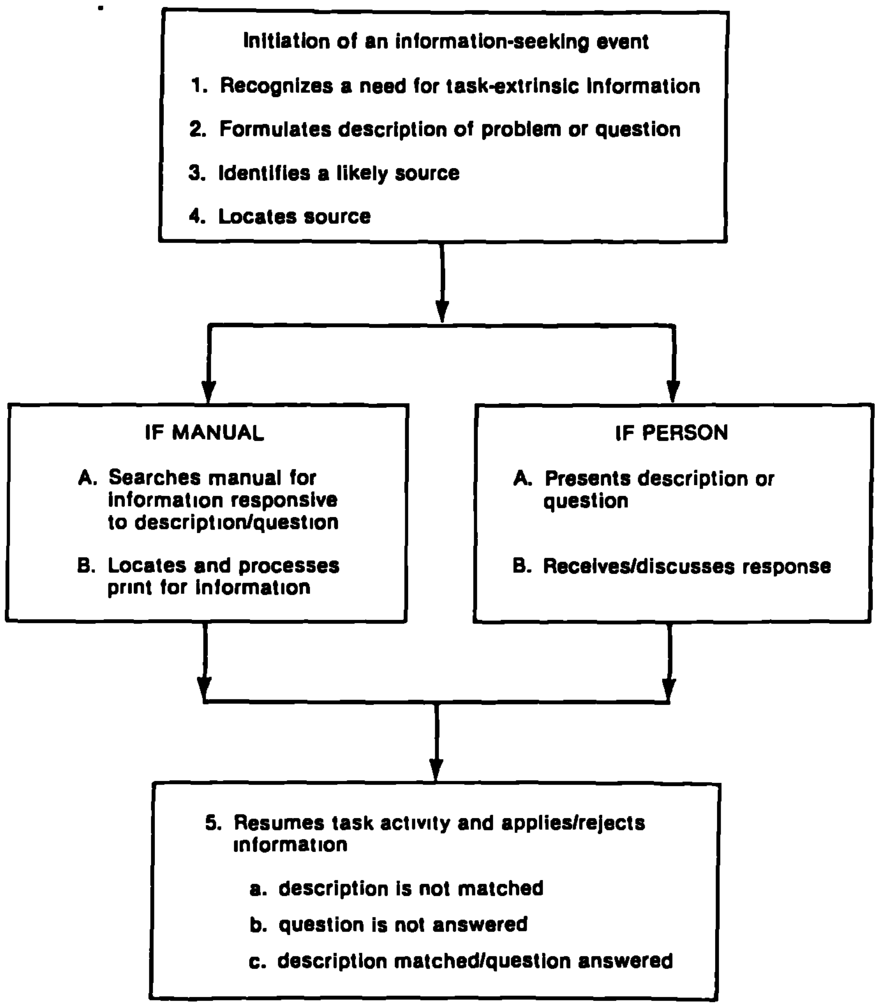


Figure 2 Information seeking behaviour

the system itself to find the answers. Thus when experts have a problem, they tend not to use documentation as a first resort. The same is true for novices, but this is probably due to the fact that novices often have difficulty in forming questions [47].

3) *Some people prefer to ask other people*. They do this either because it involves enjoyable social contact [2] [15], or because they just feel safer asking others [45]. Sometimes it is because they cannot formulate a question on their own [14];

4) *Some people will not read documentation*. People either actively dislike reading instructions [13] [2] [31] [45] (possibly because they have difficulty reading [17] [1] [14] [16]) [48] [31]), or they just cannot be bothered to read [14] [45];

5) *Some people find that the cognitive cost of looking for information in documentation outweighs the advantages* [14] [28].

1.5 How the research evolved

Initial research (outlined earlier in this chapter) confirmed that documentation was important, identified the faults that people complained about the most, and explained some of the other reasons why documentation is not used. At this point the research suggested that the documentation problem could be solved either by making documentation more competent, i.e. by making it suitable or sufficient for its purpose, or by directly addressing users' problems, e.g. looking at ways of improving the readability of documentation. Indeed, most of the literature on documentation was found to consist of guidelines for producing usable documentation to acceptable standards.

Thus although competence was a necessary condition for effective documentation, it was clearly not a sufficient one, since competent documentation could only be considered effective if it was used properly. However, as the use (or non-use) of documentation is not always predictable, the writer decided to explore the idea of a model of documentation that could be used to identify the less obvious causes of the documentation problem and, perhaps, suggest appropriate solutions. In particular, the writer was looking for a candidate model that would suggest ways of persuading people to use documentation.

Although an extensive literature search revealed a number of interesting models, the one that seemed the most promising was the Shannon-Weaver model described in Chapter 2. The writer chose this model because it described the relationship between technical author, documentation, and user in terms of communication theory, which seemed very appropriate, and made it possible to use the idea of 'noise' in the communication channels to explain why documentation was not always effective. For example, the model introduced the idea of psychological noise as 'any emotional reaction that reduces the ability of the user to reconstruct the message properly' [49]. Hence psychological noise could explain why even the most carefully prepared documentation might not be used.

Although the communication model seemed to be a satisfactory model for describing effective documentation, the writer accepted the possibility that the insights offered by this model were peculiar to the particular perspective of 'documentation as communication', and would not hold if a different perspective were taken. To allow for this possibility, the writer devised a new and independent model (Chapter 3), based on the idea of documentation as an element in a man-documentation system (MDS). When the models were compared they were found to be equivalent in that they both revealed the documentation problem as consisting of two components; one predictable and one unpredictable. When the writer focussed on these components, two important factors were identified.

First, from the writer's experience, it was clear that the predictable component could not be solved simply by following guidelines on good practice; the support and co-operation of people such as system designers and system managers was also required. Thus if a technical author could not get sufficient access to the system or its designers, the documentation was likely to be flawed.

Second, it was clear that the unpredictable component could only be addressed at the user-documentation interface, since no one knows in advance how the user is going to react. In the writer's view, the time to address the unpredictable component is when people are receiving training on the system associated with the documentation, and the effect will be greatest if training on how to use the documentation effectively is given at the same time.

The considerations mentioned above led the writer to devise the general man-documentation system model shown in Chapter 4, which embodies the principle of greater liaison and co-operation between technical author, design staff and training staff, and suggests that technical authors should form part of the system design team.

In the last analysis, people will only use documentation if they believe in it. However, this belief may not always arise from self-analysis; some kind of extrinsic motivation may be necessary. To explore this idea further, the writer devised the training philosophy described in Chapter 5. This assumes that extrinsic motivation has a better chance of changing attitudes towards documentation than reliance on the intrinsic properties of documentation alone. The implications of this approach, and other possible solutions to the documentation problem, are identified and discussed in the final chapter.

Chapter 2

A communications perspective

The most common theme running through the literature is that documentation is all about communication. Indeed, documentation can easily be seen as part of the general communication family (Figure 3). Therefore, it would appear that a communications perspective on documentation is justified, and can be supported in a number of ways:

1) Although the term 'communication' has a very broad meaning, and encompasses all forms of interaction or transmission of effect from one system to another, it clearly includes documentation as part of the communication hierarchy. Furthermore, there are narrow definitions which also clearly include documentation both as process and as product. Two such definitions of communication are:

" A process by which information is exchanged between two or more systems (individuals, social organizations, animals or machines) existing within a common environment." [50]

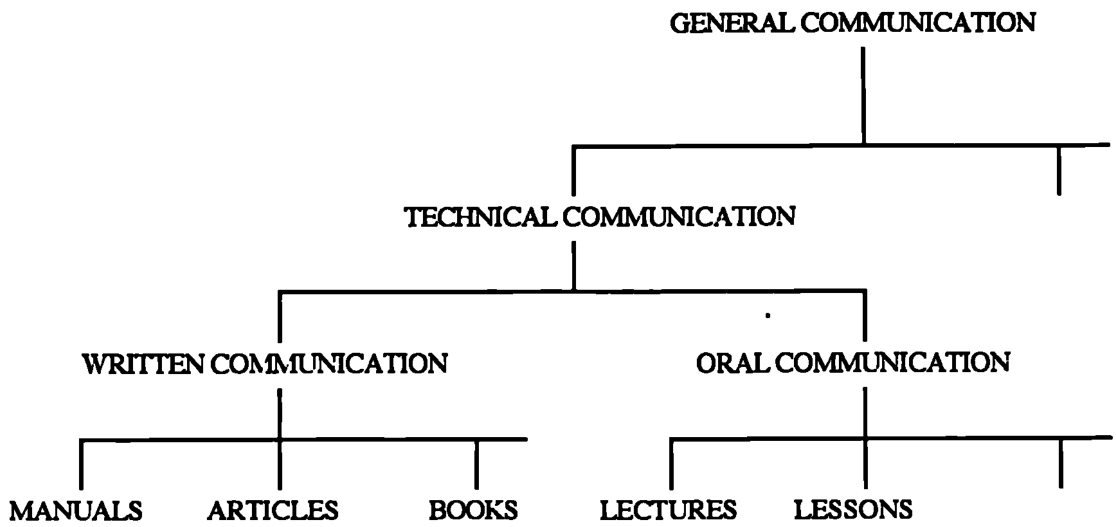


Figure 3 A communications hierarchy

" A process of transmitting and receiving via certain media and channels, information* encoded in symbols that elicit meaning in the minds of the parties to the communication" [51]

* {Information is generally defined as "patterned matter or energy" [52], which "reduces uncertainty in the future behaviour of the interacting systems" [53] [54] [55] [56]. When the system includes people, meaning may be attributed to the information. This, again, is a narrow definition of a word which can be interpreted in various ways, but it seems sufficient here.}

2) The field of communication theory is a scientific discipline which addresses problems inherent in the process of transmission and reception of information [51]. Communication theory is not only concerned with the description and analysis of all forms of communication, but may also be used to design more effective ways to communicate information to particular audiences. Since technical documentation is a form of communication, the communication discipline can help the technical author to predict the relative effectiveness of different forms of communication, and particular messages. A communications perspective therefore seems appropriate.

3) Communication theory is concerned with the description and analysis of communication primarily through the use of models which define the functional components of a communication [51]. Although these models have their limitations, they can make it easier to identify categories of variables and the relationships between them. Consequently, a model of communication may provide a useful way of exposing weaknesses in the conceptual structure of the documentation process as it is presently conceived.

4) By using modelling, documentation may be viewed in two entirely separate ways; from a communications perspective (i.e. using a model of communication) and from a cybernetics perspective (e.g. using a human-documentation system model). This approach may make it possible to develop a better understanding of the documentation process, and perhaps identify new routes to effective documentation.

2.1 General models of communication

The literature on documentation has several models of communication which could be used to describe the documentation process [50]. One of the earliest models is that suggested by Laswell (*who, says what, in which channel, to whom, and with what effect*). This model is simple and graphic, and at a high level of abstraction it could be used to define the principle of communication embodied in documentation. It does however lack a number of elements necessary for an understanding of the documentation process.

Other models of communication are shown in Figure 4 [50]. The first, the SMCR model (Figure 4a), could be used to define the principle of communication embodied in any type of documentation. It clearly establishes the factors that influence the fidelity of communication, and at which point in the communication process these factors operate, but it also suggests a one-way flow of information from source to receiver (i.e. no feedback). This does not necessarily disqualify the model from being a model of documentation, because in practice it is rare for an established feedback loop to exist between authors of documentation and potential users (although communication is sometimes established via telephone, or a reply card which is sometimes sent with the documentation.

The conceptual model (Figure 4b) describes the ways in which individuals and organisations can decide which messages are communicated, and how these messages are modified or deleted in the process. The model embodies the cybernetic principle of feedback, but makes no concessions to the importance of the context or the environment.

A useful way to interpret this model is as follows: person(s) A receive(s) stimuli X_i from the environment, but the reception is imperfect, because there are omissions and additions caused by selective perception and distortion resulting from bias in A. A then produces a message X^1 and communicates it to C (C is an editor or gatekeeper). C selects a message to communicate to the eventual audience B, and modifies it as necessary (X^{11}). The basis for this modification (which could be described as editing) is the stimuli C receives from the environment ($X_{3,}$ X_4), and the feedback loop with A (f_{CA}). Once B receives the message, feedback takes place between B and C (f_{BC}), and between B and A (f_{BA}). The feedback continues iteratively until B is satisfied with the communication.

In the special case of preparing documentation, A may be considered as the technical author, C as the editor (either a literary editor, or a technical editor, or both), and B as the user. X_i represents the information that the technical author collects from engineers, scientists, and other sources (usually, but not necesarily, those involved with the design of the system described by the documentation), and which forms the basis of the documentation. The technical editor is also free to obtain information from the field, and often needs to do so in order to verify important technical data.

The conceptual model is interesting because it embodies feedback loops. In practice, this feedback usually takes place before a manual is published and issued to its users. The feedback between editor and author takes place at various stages during the product development cycle, and there is also iterative testing of drafts and prototypes under laboratory conditions by people who try to emulate the ultimate user. However, since it is rare for drafts and prototypes of new manuals to be tested by the actual people who are going to use them, the feedback from B to A and C is not a significant factor in the real world.

The third model of communication shown in Figure 4c, is a more comprehensive model, relatively simple but with two distinct advantages over the previous models: one, it embodies the notion of feedback; and two, it recognises the importance of context to the communication process. Its value as a descriptor of the documentation process is apparent from the following explanation of the communication process [51]:

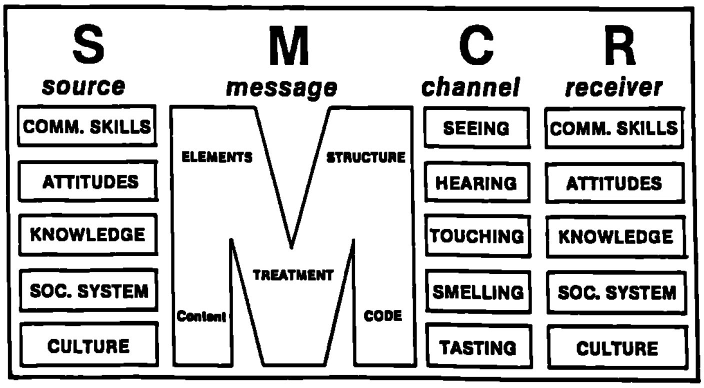


Figure 4a SMCR model of communication

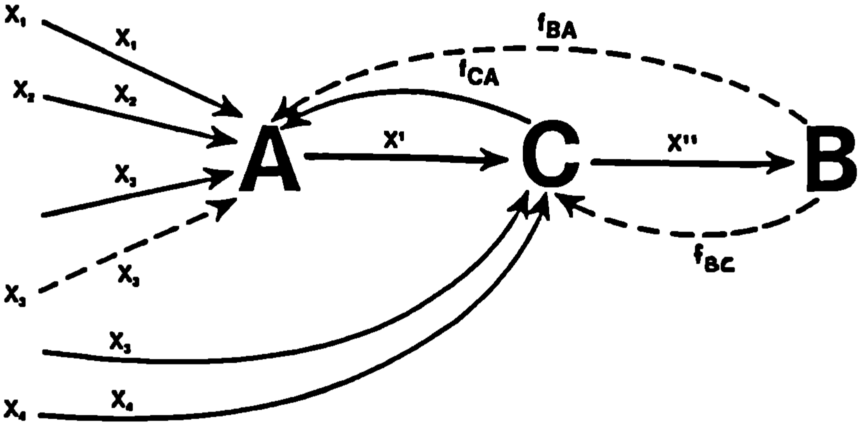


Figure 4b Conceptual model of communication

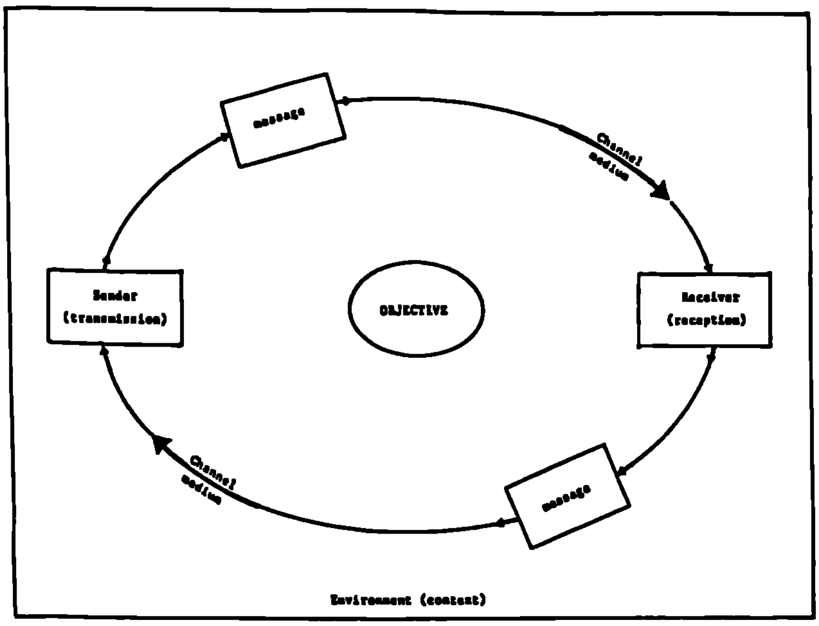


Figure 4c Comprehensive model of communication

"The sender has information which is to be transmitted, but before it can be sent it has to be encoded into symbols which can be understood by the receiver. At this point the information becomes a message and must be put into the proper format for the particular communication. The message travels by some medium or channel where decoding takes place so that the information has meaning for the receiver. Often there is a reciprocal communication from the receiver and the sender and their roles are reversed."

A number of important points of interest may be identified in this model. First, there is the circular pattern which illustrates that communication is a continuous, dynamic process. Second, the objective of the communication is shown as being central to it. Finally, the rectangle around the communication process indicates that the communication cannot be dealt with adequately unless the context (environment) is taken into account.

The types of model described above have been criticized [50] for one or more of the following reasons:

1) They represent communication as a linear, one-way act, rather than as a cyclical two-way process over time;

2) They contain a source bias: i.e. stress is placed on the dependency rather than on the relationship of those who communicate and their fundamental interdependency;

3) They tend to focus on the objects of communication as simple, isolated physical objects, at the expense of the context in which they exist.

4) They tend to focus on the messages *per se* at the expense of silence, and the timing of messages.

5) They suggest that the primary function of all communication is persuasion as opposed to mutual understanding, consensus, and collective action.

6) They tend to concentrate on the psychological effects of communication on separate individuals rather than on the social effects, and the relationships among individuals within networks.

7) They are based on a belief in one-way mechanistic causation, rather than on the mutual causation that characterizes human information systems.

Many of these criticisms apply to the theory and practice of technical documentation. Technical documentation is still mostly a one-way mechanistic process, concentrating on the production of isolated physical messages without considering the context in which they will be used or the social impact that results from them. Furthermore, documentation is often produced in isolation, away from the people who are going to use it. Authors often have no idea of the environment, or the organisational structure of the workplace, in which the documentation is going to be used.

2.2 The Shannon and Weaver Model of Communication

This mathematical model first appeared in 'The Mathematical Theory of Communication' (1949). The model was used to describe communication over a mediated device such as a telephone. The five distinct elements in the model may be defined as follows (see also Figure 5a):

a) *The Information Source* - this provides the inputs from which a message is formed;

b) *The Transmitter* - this transforms the message into signals and transfers the signals to a distribution medium;

c) *The Mechanical Channel* - this carries the signals to a receiver and is subject to 'noise' which affects the communication;

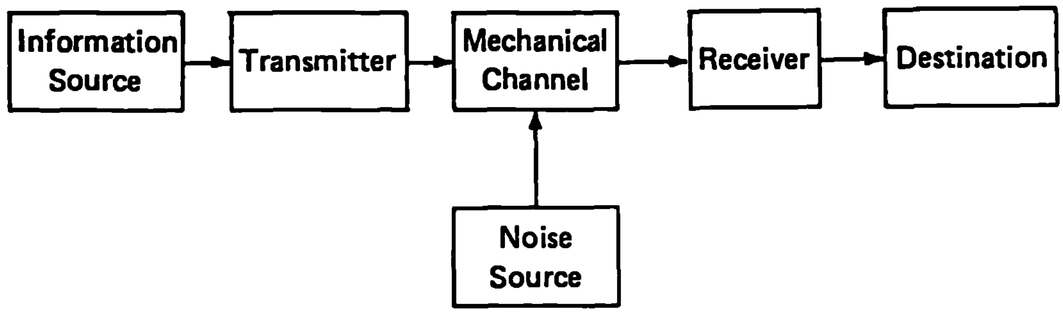


Figure 5a The Shannon-Weaver Model of Communication

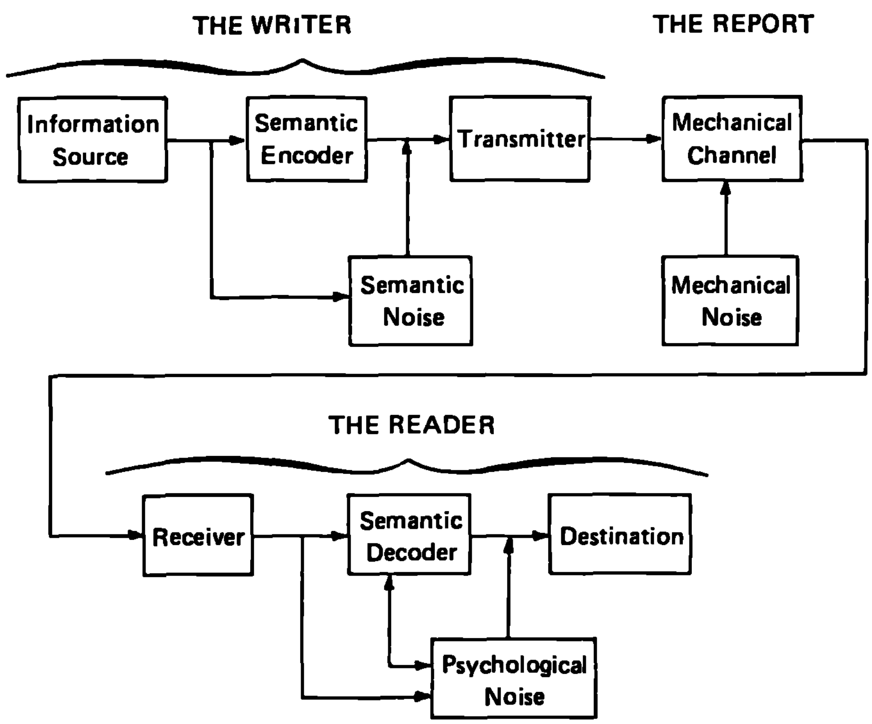


Figure 5b Modified Shannon-Weaver model of documentation

d) *The Receiver* - this reconstructs the signals into the original message;

e) *The Destination* - this translates the message into meaningful information.

The Shannon-Weaver model differentiates between the information source and the transmitter, receiver, and destination, but lacks the critical notion of feedback (the exchange of information rather than the one-way transfer of it), and ignores the context or environment in which the communication takes place. However, its advantage is that it introduces the notion of 'noise' to account for the factors that reduce the effectiveness of a communication. This makes it a more suitable model to describe the documentation process than the others described in 2.1, because it suggests a way of describing the unpredictable problems that occur at the user-documentation interface.

In fact, the notion of 'noise' can be expanded by a modified version of the Shannon-Weaver model (Figure 5b) which is closer to the current documentation process [3] [19] [57]. The model is particularly useful because it clearly specifies the major elements in the documentation process and identifies reasons why communication (and hence documentation) may not always be effective.

The main elements of this modified model are defined below in documentation terms, where a, b, and c represent the functions performed by the technical author; and e, f, and g represent the multiple functions of the user:

a) *Information Source* - this is defined as the mind of the author, aided by extraneous material such as notes, diagrams, recorded interviews etc forming the factual database. It selects the message to be transmitted, and decides the thesis and intent of the communication.

b) *Semantic Encoder* - this is the role of the author as he selects the particular channel to be used (in this case documentation) and 'codes' the message into appropriate mental symbols (words, numbers, etc.).

c) *Transmitter* - here the author's role is to perform the physical act of changing the symbols into the graphic signals that appear on the pages of the documentation.

d) *Mechanical Channel* - this is the finished documentation. Its design characteristics are composed of: the characteristics of the signals it carries; the structures (grammatical, logical, mechanical) into which the signals are placed; the organisational structure of the subject matter; and the physical format itself.

e) *Receiver* - this describes the user of the documentation as he reads the signals, before sending them to the brain as coded symbols.

f) *Semantic Decoder* - this describes the user as he translates the coded symbols into a message.

g) *Destination* - this is where the user interprets the message, and in so doing reconstructs the authors's intentions and decides what to do with the information received.

Another important feature of the modified Shannon-Weaver model is that it identifies three types of 'noise' that can affect the quality of the communication (and, hence, the effectiveness of documentation): 'semantic' noise, 'mechanical' noise and 'psychological' noise.

Semantic noise, includes faulty diction (causing ambiguity or wordiness), improper sentence or paragraph structure, poor organization, and failure to consider audience needs.

Mechanical noise, includes errors in spelling, inconsistencies in typography, poor visual layout and design, and any physically or visually distracting element that prevents the user from understanding and acting upon the message.

Psychological noise, is defined as any emotional reaction by users of documentation that reduces their ability to reconstruct the message properly, including doubt, disagreement, boredom, anger, or indifference. The source of this noise may be the message itself, the semantic or mechanical noise created by the author, or some internal or external stimulus.

2.3 Reducing psychological noise

From the communications perspective, the goal of technical authors is to achieve a satisfactory signal-to-noise ratio so that the documentation communicates successfully. In practice, authors are entirely responsible for the semantic and mechanical noise, and may be partially responsible for the psychological noise.

Authors must accept responsibility for the semantic noise, if they alone are responsible for generating the writing. Authors must also take responsibility for mechanical noise when it is their job to supervise the work of others involved in the documentation process, e.g. the printer, or illustrator. However, authors cannot control all the psychological noise because users sometimes react to documentation in unexpected ways. It is with regard to this unpredictable psychological noise that the communication model is most valuable, because it suggests an area of the user-documentation interface which needs to be investigated in more detail if the documentation problem is ever to be completely solved.

Although the term 'psychological noise' is not widely used in the literature, it will be used in this thesis as a convenient way of focusing on all those features of documentation which users find unsatisfactory, and which, in the last analysis, may cause them to look elsewhere for the information they need. Reader's complaints are well known (a list is given in Chapter 1), and so are the remedies adopted by technical authors to make documentation more acceptable. In this sense, psychological noise will be divided into two classes: that which can be anticipated and prevented, and that which cannot be anticipated, and is possibly never known to the author. It is the latter class which is perhaps the most interesting.

Most authors try to reduce the noise under their control by following a standard documentation design process [5] [15] [16] [19] [42] [43]. The model in Figure 6, attributed to Felker [58] [59], is typical, and makes the

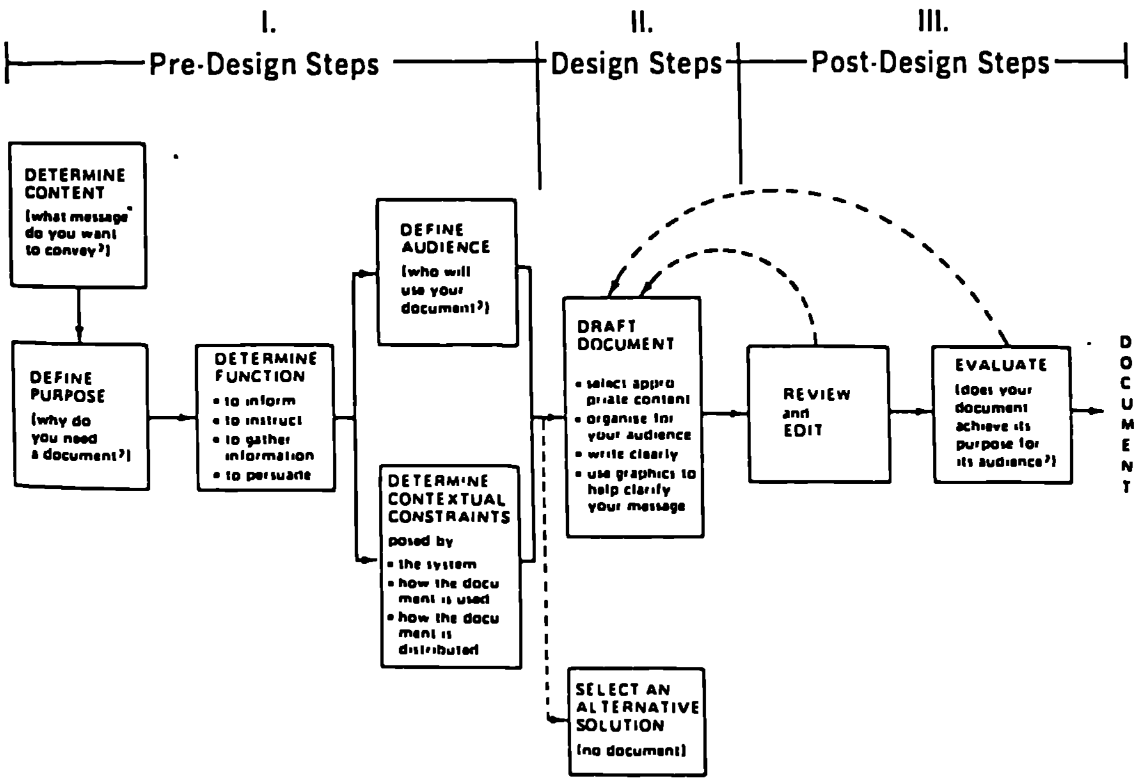


Figure 6 Felker's model of the documentation process

point that the process of producing documentation, as macro-structure or micro-structure, is very well formulated. Most models (including Felker's) divide the production process into three distinct stages: pre-design (planning), design (drafting), and post design (testing). Monitoring processes, not shown in Felker's model, usually operate across all stages to emphasize that producing documentation is not a set of serial steps but a highly dynamic process in which relatively low level events (e.g. such as not being able to place an illustration near to its related text) can modify higher level goals.

Process models usually begin with an analysis of the rhetorical context (the purpose, the audience, the tasks to be carried out by the audience, and the constraints on the designer). The middle stage identifies the components of drafting and the need to identify problems with the draft by expert analysis of the document and by audience-centred testing. The model then continues beyond the design stage to an evaluation phase, stressing that the author's task is not finished until the principles used in the design phase have been validated by testing the document with an audience and a task that replicate the rhetorical context.

The three stages of Felker's model are discussed below:

2.3.1 Pre-design steps

A successful technical author must also be a good information designer and a good manager. Apart from preparing the documentation itself, the sequence of planning, drafting, testing, reviewing and revising must be scheduled and monitored, usually to a tight deadline. With regard to the reduction of psychological noise, the author needs to make decisions about the following elements, and ask the right questions:

a) *Scope and content*: Is there enough information to produce the documentation? What information should be put in, or left out? What examples and explanations will best serve the purpose?

b) *Purpose*: Is the aim of the documentation to inform, persuade, instruct, or train? What is the best way to accomplish the purpose?

c) *Audience*: Who will be reading the document? What are their characteristics and their needs? How will the reader use the documents? What tasks do they have to perform?

The main prerequisite for reducing psychological noise at the planning stage is to know as much as possible about the potential users of the documentation. As Houp and Pearsall, authors of one of the most influential texts in the field, put it [60]:

" To be a good writer, then, you must you must know your audience - its purpose and knowledge. Perhaps in no other kind of writing is this business of matching a particular piece of writing to a particular audience as important as it is in technical writing."

Technical authors are constantly being advised to develop a clear idea of the audience for whom they are writing [15] [19] [25] [32] [48] [58] [61] [62] [63] [64] [65]. Users of documentation may be classified according to the roles they play in the workplace [10] [66] [67], and/or their level of expertise [19]. Hence authors may write specifically for operators as opposed to technicians [6] [68] [69]; or for novices as opposed to experts [7] [68] [70] [71]. This kind of distinction helps the author to make correct decisions about the level of technical complexity, organisation, diction, grammar, and design suitable for the group in question.

Smillie [17] goes further and suggests that a user description should be developed for each category of people required to operate or maintain a new system or product. A user profile of this nature should, he suggests, address job-relevant skills, knowledge and expertise, and reading ability, and make it easy for the author to select the content of documentation.

This approach is clearly applicable in some specific instances. For example, a troubleshooting manual for maintenance staff can be written in a different way from a systems description manual for supervisory staff, because it is unlikely that either group would want to read the other's documentation. When groups are roughly homogeneous, there is very little difficulty in classifying users in terms of their roles in the hierarchy, and therefore producing the appropriate documentation.

If, however, the users are a diverse group, as is often the case with people who use computers, the author's task is not so clearly defined. The intended user may turn out to be several different groups of users performing different types of job activities and sharing only a general type of relationship to the same piece of equipment or content area. In this case it cannot be assumed that the documentation produced will satisfy everyone. Also, apart from the differences mentioned above, people may not only have different linguistic, educational and intellectual backgrounds, but they may also differ in attitude and motivation [1] [20] [38]. One way of dealing with this problem is either to provide a set of manuals for a particular piece of equipment (each manual addressing a particular level or role), or to have sections within a manual that cater for different types of user, and a user guide to help the reader select an appropriate path through the documentation [72].

2.3.2 Design

Having established who the readers are, an author must study their characteristics and try to satisfy their information needs, because by selecting the right information content and formatting, an author can powerfully influence the reader's willingness and ability to use documentation [6] [17] [18] [58] [59] [67] [73] [74] [75] [76] [77] [78]. The relevant questions for the author to ask now concern organisation and design. For example, what is the most effective way to organise the information (e.g. use of text versus use of graphics)? How can the design reinforce the purpose of the document? Which design features will appeal to the audience and persuade them to use the documentation?

The answers to these questions will depend on the type of documentation the author intends to produce: at the macro-level it can mean sequencing blocks of text to achieve the desired effect (learning for expository material, ordered action sequences for procedural material); at the micro-level it can come down to deciding on the order of sentences and paragraphs. In all cases the emphasis should be on maximising communication.

However, before deciding on the organisation and design of a particular type of documentation, authors are advised to find out a number of relevant facts: what previous experience the user has had with similar text [61]; what the user's expectation of the current text is likely to be [20]; and how much the user knows about the topic of the text [18] [20] [79] [80]. When an author has this information he can decide what to include and what to omit, and how to structure the information so that it does not make excessive processing demands upon the reader.

It is worth repeating that an author ought to know as much as possible about the human factors that may affect acceptance of the documentation. Attitude and motivation, personality, daily concerns in the workplace, are all likely to contribute to the documentation problem. Unfortunately, it is not easy for an author to know these things, particularly when it is not practicable for the author to meet a sufficient number of users in their workplace. Attitude surveys prior to the start of the documentation process might help, but these are often unreliable indicators of the way people are actually going to behave.

Apart from not having any contact with documentation users, authors frequently have no first hand experience of the work users do, or the conditions under which they do it. Authors really ought to know the psychological and physical contexts within which the documentation will be used [3] [18] [48] [58]. Acoustic noise (making it difficult to concentrate), bad lighting, the need to troubleshoot quickly to minimise downtime (pressure to perform), can all contribute to the documentation problem and these conditions should therefore be known to the author.

For instance, the way text will be used and in what setting ought to be taken into account when the author is designing the documentation [1] [38]. Size and style of type, clarity of graphics, size of text are all variables that might be affected by different user contexts. A good example of this is the design of a troubleshooting manual which the user may have to hold in one hand while working on equipment, perhaps in cramped and poorly lit conditions; large print and clear graphics could be essential here.

Another factor affecting the author's choice of organisation and design is the way people use documentation (leaving aside the question of environment for the moment) [19] [31] [81] [82]. If a manual is chosen as an information source, it is mostly used in the way suggested by Wright [81], who has identified three key activities; searching, understanding, and applying. The design of the documentation, the information it gives and the way it presents it, may support or hamper any of these activities.

Furthermore, design options which support some activities may be detrimental to others. For example, a manual which includes full details of all modifications to a piece of equipment may help the reader once he has found the information he wants, but the search task may be considerably more onerous. So it is important to evaluate design options against the full spectrum of readers' needs.

An author who knows of the user activities identified by Wright and others can take anticipatory action to assist the user. For example, when users intend to search documentation for information their activities may be summed up as formulating a question and looking for a potential answer. If the user finds either of these activities difficult, psychological noise will be present. To avoid this an author can try to anticipate not only the kind of question a user is likely to ask, but also the user's search strategies. Thus an obvious thing the author can do is to ensure that there are adequate access mechanisms (contents pages, indexes, consistent page numbering etc). In practice, the best way for an author to allow for user behaviour is to carry out a user edit [83], which involves watching readers directly while they work and interact with a system, using only the documentation as a guide. The author would then gain an understanding of how readers use text at work.

The second of Wright's user activities is identified as understanding, where the user must first comprehend the documentation and then create an action plan. As before, a user edit would show an author how the text helps or hinders understanding. If a user edit is not possible, there are a number of common sense actions an author can take. The most obvious of these is to write well constructed sentences, using the appropriate words for the intended reader and the task. If an appropriate text structure is used, skilfully blended with appropriate illustrations, the documentation should help to create good mental representations of the system described. The content, of course, must be accurate otherwise the action plan created by the user will fail.

The final act of the user (and in some ways the most critical) is to execute the action plan and evaluate the outcome. At this stage, if the action plan fails the user may become permanently biased against documentation (it is unlikely that the user will accept the blame for the failure). By anticipating this stage, an author can help to reduce the risk of user failure. Perhaps the most obvious thing to do is to ensure that there is reference between the equipment and the documentation (e.g. it can be quite upsetting to a maintenance technician if a photograph in the documentation is that of an earlier model of the equipment showing different adjustment points).

Another intelligent move is to anticipate procedural problems and signpost them. Also, bearing in mind that the environment in which the documentation is used may not be conducive to concentration (e.g. a busy workshop) it is vital to reduce the cognitive load on the user by reducing the number of inferences he has to make.

2.3.3 Post-design steps

Once the manual has been written it is usually validated by asking someone (not the targetted user) to perform the task on the equipment using only the manual. If the performance is successful, the manual is deemed to be technically accurate and intelligible. If not, the manual is corrected and revalidated.

After the validation stage, the documentation may be verified by asking a sample of the actual users to use the manual at work for a trial period (although this is not often practicable). Again, an iterative process is desirable in which the manual is corrected and re-verified until everyone is satisfied that it is a complete, accurate, understandable, and usable document.

Evaluation is also a vital factor in the design of documentation. Many technical authors have difficulty appreciating the needs of the user, and adequate testing is required both to ensure that the current text corresponds to the original plan, and that the choice of expression is consistent with the knowledge and communication needs of the people who are going to use the documentation. Fortunately, since documentation is a designed product, it is always amenable to ergonomic evaluation and improvement.

Document evaluation usually takes one of three forms, distinguished by the way information is collected, and the nature of the feedback. The three forms are text-focused testing, expert-judgement testing, and reader-focused testing.

a) *Text-focused testing* methods include readability formulas (e.g. Fog and Flesch), [29] [32] [36] [84]; and computer-based stylistic analysis programs (e.g. UNIX's Writer's Workbench) [84] [85] [86]. Traditionally, this type of testing concentrates on the words and sentences in the text and then draws conclusions about the reading level, use of language, and so on. There are however three serious criticisms of text-focused methods. First, they concentrate too much on word and sentence level features of text. Second, they provide little, if any, information about how the document is working at the paragraph and whole text level. Finally, the methods provide no information about the needs of the reader.

b) *Expert judgement-focused* testing is important because it helps to improve the consistency, accuracy, coherence, completeness and appeal of verbal and visual information. Testing is done by people who have a great deal of knowledge about the text, its audience, or writing itself. The techniques used are called reviews (peer review, technical review, and editorial review). These methods of testing have only one real drawback; they tend to be carried out by 'insiders', i.e. people who are too close to the text or the product it describes. This means that the documentation may work well for people who developed or influenced the creation of the text, but fail miserably for the average user. For this reason external reviews should be carried out by professional 'outsiders'.

c) Reader-focused testing gets information directly from the intended audience (or, more often, a representative sample). Information may be collected from readers as they read and use a document (concurrent testing) or after they have finished reading it (retrospective testing).

i) *Concurrent testing* - This type of testing evaluates the real-time problem-solving behaviours of readers as they are actively engaged in comprehending and using the text for its intended purpose. Concurrent reader feedback methods include Cloze testing, performance testing, thinking aloud verbal protocols, and behaviour protocols (e.g. the user edit).

The primary feature of behaviour protocols is that participants do not talk aloud while they perform a task. They simply carry on as normal while the evaluator and/or a computer program records what they do. Often the evaluator is in a separate room and the behaviour is monitored via closed-circuit television or two-way mirror. This is particularly true of user edits [83], which involves watching readers directly while they work and interact with a machine, using only the documentation as a guide. The observer pays close attention to how readers use text, when they use text, and how the text helps or hinders understanding.

ii)*Retrospective testing* - This method includes questionnaires, interviews, focus groups, and reader feedback cards, and is the most frequently used of the reader-focused methods. Basically, it asks readers to paraphrase, recall, summarize, recognize, or draw inferences about particular text items or text features. However, the feedback from users should be used cautiously, since reader's memories are not necessarily accurate and the information they provide is often vague. In addition, people often say what they think the interviewer wants to hear, rather than tell the truth, which may be embarrassing.

To sum up this Chapter; the communication model provides a way of explaining the documentation problem, and the Felker model provides a way of partially solving it. Felker's model is, therefore, primarily a job aid for producing effective documentation. It clarifies the roles of the author, the user, and the task; it has feedback loops, which allow a limited amount of two-way communication; and it recognises the effect of the environment or context in which the documentation is used. Felker's model is compatible with the communication model in that it offers a good practical approach to the task of reducing semantic and mechanical noise, and also highlights the activities that are necessary to reduce the predictable psychological noise.

Any author working to Felker's model tries to reduce predictable psychological noise in three ways: by finding out as much as possible about the audience during the pre-design stage; by organising and designing the material for maximum communication during the design stage; and by testing/evaluating the documentation on people before it is issued, at the post design stage. If carried out properly, these measures can produce excellent documentation, *but, as has been stated before, excellence is no guarantee that documentation will be used!* This suggests that there are factors outside the scope of the Felker model (e.g. unpredictable psychological noise) which need to be addressed in a different way.

By taking this approach, it is possible to assert that the weakness of current documentation practice is that most of the effort to make the documentation acceptable takes place before the documentation is issued, on the grounds that nothing much can be done afterwards (apart from the reader-focused methods mentioned earlier, which are often either not implemented, not general enough, or not effective). In this sense, authors often treat documentation as a 'fire and forget' missile, overlooking the fact that documentation has no means of altering its course to suit the psychological variations of its users.

Of course, it is possible that the idea of unpredictable psychological noise exists only in terms of the communication model which defines it. Perhaps the Shannon-Weaver model of communication is not the most appropriate model to describe documentation, and that some other model would reveal a totally different explanation for the documentation problem. To verify the implications of the communication model, the writer has devised an entirely different model which is described in the next chapter.

Chapter 3

A cybernetic perspective

Chapter 1 described the need for effective documentation, but made the point that in practice, documentation was not always effective. Chapter 2 used models to describe the body of knowledge available on documentation, including current research interests, and showed that a modified version of the Shannon-Weaver model of communication was the most general model available for describing the documentation process. In fact, the research showed that all models of documentation in the literature could be fitted into this general model.

Since the documentation process is clearly not satisfactory, despite the best efforts of the practitioners in the field, there is a *prima facie* case for suggesting that there is something <u>fundamentally</u> wrong with the process, a fatal flaw if you like, which cannot be corrected by endlessly trying to improve on certain aspects of the detail (e.g. experimenting with different page layouts, or typefaces), no matter how worthy this activity may be in itself. For example, excellent presentation counts for nothing unless documentation is read.

One way to identify this fatal flaw (if indeed it exists) is to use an approach based on the idea that things are best understood when viewed from various perspectives. Hence an alternative model of the documentation process could be used to comment on the Shannon-Weaver model, and assess its merits as a necessary and sufficient basis for effective documentation. This alternative model would have to be very general, based on a different set of axioms from the Shannon-Weaver model, and suggesting a set of possible applications of which the documentation process is clearly a viable example. In the writer's view, the model that is most likely to achieve this is a cybernetic model of a human-documentation system, devised by the writer, and described in this Chapter.

3.1 Why use cybernetics?

At one level, documentation is about the communication of information from one person to another, and many writers on cybernetics have mentioned information as being a key cybernetic concept. For instance, Wiener, in the preface to his famous book 'Cybernetics', expressed the view that cybernetics was primarily concerned with information and feedback. More recently, Fellget [87] described cybernetics as the science and technology of information and its useful application. Fellget went on to explain:

" ....the definition of cybernetics as concerned with information and its application, at once suggests a systematic enumeration of topics within the subject; namely the acquisition of information, its transmission and storage, its transformation, and its outcome in control action"

The remarks made by Fellget could easily describe the documentation process whereby the writer gathers information from appropriate sources, transmits this information via hard copy documentation (which also acts as a storage medium) to a reader, who transforms the information for his own use and acts upon some object in accordance with his understanding of the information he has received. This link between documentation and cybernetics is also supported by Kuhn's [88] model of a cybernetic system (Figure 7), which could be used to describe the activity that takes place when a technician interacts with, say, a troubleshooting manual.

However, there are more links between documentation and cybernetics than information alone. One way to bring out

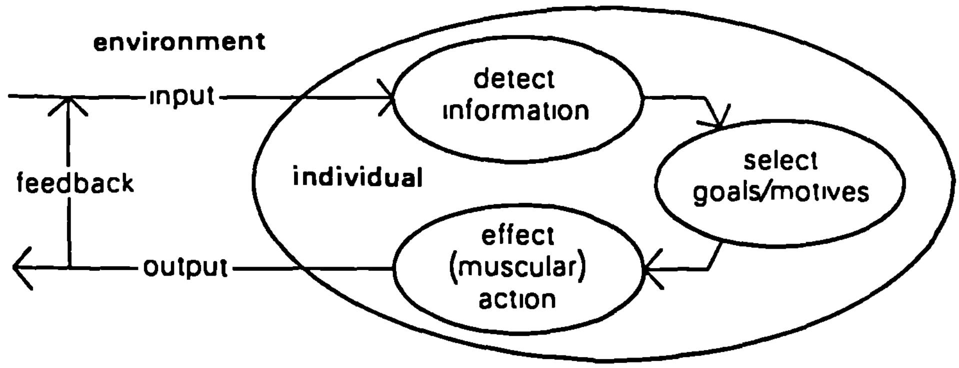


Figure 7   Kuhn's model of a cybernetic system

the totally cybernetic nature of the documentation process is by establishing a simple model from first principles (see Figure 8a). This model takes into account not only what *actually* happens in practice, but also what *ought* to happen.

The writer's proposed model is based on the assumption that A controls D through B and C, i.e.:

'A communicates with C through B so that C may act on D in the way that A requires'

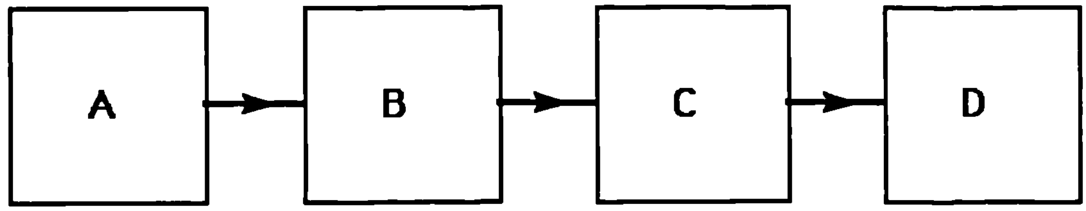
Hence Wiener's original definition of cybernetics as 'control and communication in the animal and the machine' is appropriate, since A, B, C, and D may be entities in either of these. Similarly, Beer's view of cybernetics as being applicable to business systems [131] is valid, since A may be a works manager communicating a directive (B) to a line manager (C) about the control of a group of assembly line workers (D). Since the model is of general applicability, it can equally well describe the special case of interest here, where A is an author, B a troubleshooting manual, C a technician and D a machine that is faulty from time to time.

Referring back to the model, it would not be unreasonable for A to want to know how well B and C are carrying out their instructions. Of course, in an ideal system, there would be no need for this, since A's instructions would not only be perfect, but they would also be executed correctly. In the real world, the situation is a little different. The A's do not always get it right, and the rest of the components of the system often behave erratically. Thus the system in Figure 8a, described as being subject to error, fits nicely with Bauer's [89] view of cybernetics:

"...the concept of cybernetics is based on the notion that error is an inherent aspect of natural, physical, and social systems. One can set goals and make plans, but the cybernetic model demands an active information system with sensors to determine the consequences of actions. In addition it demands provision for feeding this information back to decision centres and readiness to change one's behaviour in response to signals of errors being committed."

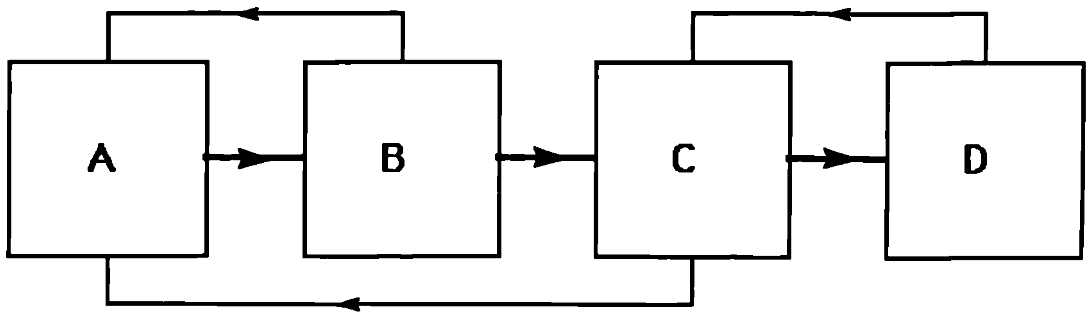
Using the notion of feedback, the simple model may be amended to include the feedback loops shown in Figure 8b. Again considering the particular example of documentation, the following feedback loops would be sensible:

1) The author (A) produces a first draft of the manual (B), tests this against some pre-arranged criteria,



Control and/or communication

Figure 8a Basic Cybernetic Model without Feedback



Control and/or communication

Feedback

Figure 8b Cybernetic Model with Feedback Loops amends the draft if necessary, retests, and continues in this iterative way, until the documentation is ready for use. Thus there is a feedback loop between documentation and author. It can also be argued that the author-documentation system starts off in a state of severe disequilibrium (many amendments, some of which are important) and gradually moves via intermediate states of less severe disequilibrium (few changes of minor importance) to a state of equilibrium where the documentation is judged to be satisfactory. In this sense the author-documentation system is a homeostat in Ashby's terms [132].

2) When the technician (C) uses the manual (B) to attend to a fault on the machine (D), he requires knowledge about the effect of his actions. Thus a feedback loop is established between technician and machine. As in 1) above, the technician-machine system can be considered to be in equilibrium until a fault occurs (a 'disturbance' in Ashby's terms [132]). If the troubleshooting manual is effective, the system is soon in equilibrium again. If not, a state of disequilibrium will exist until the fault is put right. Thus the technician-machine system may also be thought of as a homeostat in Ashby's terms [132].

3) If the troubleshooting manual does not contain the information the technician needs to fix the fault, or if the

information is wrong, he needs to report this to the author, along with any solution he may have found from other sources. Therefore, a feedback loop is required between technician and author. If the fault in the manual is significant, a temporary state of disequilibrium between author and manual will exist until the manual is amended. In this sense it can be claimed that the whole system is a homeostat, subject to occasional disturbances but eventually moving to the equilibrium state where author, manual, technician and machine are in some sort of accord. Of course, if the author had been able to predict all possible faults with the machine (Ashby's Law of Requisite Variety [132]), the manual would be able to compensate for disturbances (albeit with a time lag) and the feedback loop from technician to author would not be needed.

Control and communication, information, feedback, homeostasis, requisite variety, are all important concepts both in cybernetics and in the documentation process. Consequently, the remainder of this chapter will attempt to describe a cybernetic model of a human-documentation system coincident with the philosophy of Pask [90]:

" The cybernetician has a well specified, though gigantic, field of interest. His object of study is a system, either constructed or so abstracted from a physical assembly, that it exhibits interaction between the parts, whereby one controls the other, unclouded by the physical character of the parts themselves."

3.2 A cybernetic basis for a human-documentation system

The idea of a human-documentation system (HDS) starts with the premise that when someone uses documentation to answer a question about a particular human-machine system (HMS), an HDS, with clearly defined goals, comes into being. For example, if there is a fault on an HMS, the user goes to the troubleshooting manual to find a way of dealing with it. Similarly, someone may use an operating manual to learn how to use an HMS. In each case, meaningful interaction between user and documentation is necessary if the HMS system goals are to be achieved (they may not be, but that is another matter which will be addressed later!). Furthermore, the HDS may be based on the same principles as the HMS that it describes, to help create the right mental model of the HMS.

To establish the identity of a human-documentation system as a member of a more general family of systems, the writer has devised a basic building block for all interactive systems, called the entity-entity (or E^2) system. This system is deemed to come into existence when, and only when, two entities interact for a purpose, i.e. the system has specific goals. The model of this system (which the writer calls a *triel*) is shown in Figure 9. A triel has three elements: a control element and two entities:

a) *Control* - this element (which may be real or virtual) consists of system goals, and a controller.

i) System goals are either imposed from outside the system, or derived from interaction between the elements of the system. These goals are not immutable; they may be changed or modified by internal or external constraints.

ii)The controller monitors the system and ensures (as far as is possible) that the system remains in equilibrium (in this context equilibrium is defined as the state of the system when it is meeting its system goals). A controller may be simple or complex. If it is complex, it may have a set of attributes, some or all of which may be used to control the system. Indeed, a sophisticated controller may be able to select the entities that are most likely to achieve the desired outcome (that of attaining system goals), and replace or modify them if they do not behave as expected.

b) *Entities* - each entity in an E^2 system may itself be an E^2 system, where the goal set of this (sub) system

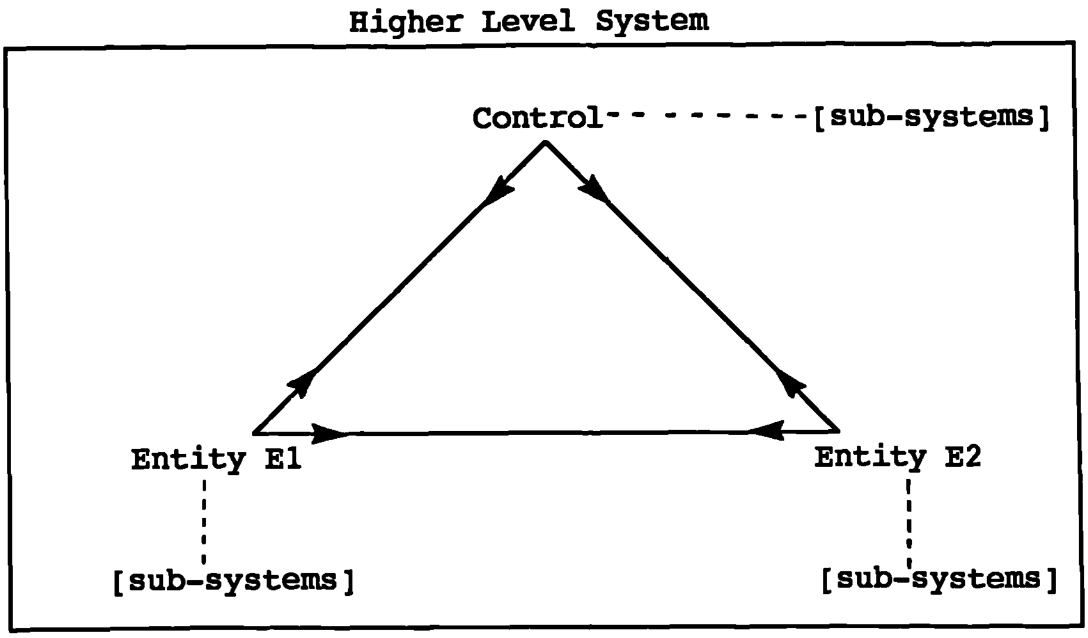


Figure 9 E^2 system model

determines the behaviour of the entity. Entities may also be simple or complex. If they are complex, they may have a set of attributes (E^2 sub-systems) all, or only some, of which may have a bearing on the behaviour of the entity. Attributes not used initially may be called upon later by the regulating mechanism to ensure equilibrium in the higher level system. Also, unused attributes may be used simultaneously or additionally as part of yet another E^2 system. The more complex the entity, the more 'roles' it may play in other E^2 systems, without losing its fundamental identity, or compromising its alternative roles. Indeed, whichever E^2 system an entity is in, is to all intents and purposes the only system that matters.

c) *Communication* - the communication that takes place between the three elements (as shown by the arrows) is in the form of interactions. Thus E1 and E2 interact to attain system goals. Control interacts with E1 and E2 to ensure that their behaviour is compatible with achieving the system goals. All interactions give rise to corresponding interaction effects.

The E^2 model is too general to describe the documentation process in a meaningful way, but it can be used as the basis of an intermediate stage in the evolution of the human-documentation system (HDS). This subordinate level of abstraction focuses on the entities E1 and E2, and the nature of the interactions that take place between them. It also fixes the nature of E1, but allows E2 to remain general thus paving the way for a truly general HDS model. This intermediate stage is called the human-*artefact* system.

3.3 The human-artefact system

There are many meanings attached to the term 'artefact', and some of the more relevant meanings are shown below:

'A thing made by art, an artificial product' [OED]

'Something made or given shape by man, such as a tool or a work of art' [Collins]

'A thing made by human workmanship' [Chambers 20th Century]

'Anything made by man, especially something useful'[Longman Dictionary of Contemporary English]

'A usually simple object (as a tool or ornament) showing human workmanship or modification as distinguished from a natural object' [Webster's Third New International Dictionary]

'A product of artificial character due to human agency' [Webster's]

'Any object made by man, especially with a view to subsequent use' [Random House Dictionary of the English Language]

'An artificial product' [Shorter OED]

'Anything made by human art and workmanship; an artificial product' [OED Supplement]

'A product of human art and workmanship' [Concise OED]

There are many artefacts in the world, and like other things they may be divided into classes. One class of interest that can be identified comprises all artefacts that are part of human-artefact systems designed to achieve specific aims and objectives. This class of artefact is large and diverse and includes items such as hand tools, computers, robots, lecture notes and maintenance manuals.

In discussing a human-artefact system (HAS), a reasonable proposition is that the success of the system (i.e. whether or not it meets its system goals) depends to some extent on the effectiveness of the working relationship between human and artefact. This presupposes two things: first, that the artefact is fit for the task it has to perform; and second, that it is being used correctly.

If, for example, the merits of a chisel were being discussed, there could be general agreement on whether it was 'up to the job', meaning perhaps that the blade was sharp, well tempered, honed at the right angle, firmly embedded in the handle, etc. Futhermore, there could also be general agreement that the handle was of the right size and shape, robust enough to take blows from a mallet, and designed not to slip out of the hand. Thus for any artefact there exists either actually or potentially a set of design criteria, based on system goals and the user, that could be used to assess its suitability.

However, artefact competence alone is not enough; to be effective, the artefact must also be used properly. Even if an artefact is inanimate, its contribution to the system goals will depend on the skill and application of the user, e.g. the concert violinist will get more out of the instrument than a novice; and a racing driver will drive better around a track than the average motorist. The world is full of examples where human and artefact are in tune and together achieve success. But if an artefact is used badly, system goals are not likely to be met.

Knowing how to use an artefact is a function of training and experience. The user must be trained not only on the means to achieve the system goals, but also on the characteristics of the artefact. However, experience in using the artefact for the pursuit of system goals has to be of positive value if the human-artefact relationship is to be successful.

Naturally, someone will want to use the artefact if they have confidence that it will help them to achieve their goals; but this confidence can be easily dissipated if the artefact does not live up to expectations. For example, if the artefact behaves consistently and predictably all will be well; if not, users will lose confidence not only in the artefact, but also in their own ability to use the artefact successfully. This may cause negative attitudes to be formed towards the artefact.

Now, although skill and experience are obviously key factors in the success of an human-artefact system, the effect of negative attitudes cannot be underestimated. If the user has a negative attitude towards the artefact (or the system goals), no amount of skill training will ensure an optimum working relationship. Thus a person's attitudes may be the significant factor in achieving a good working relationship with the artefact.

If negative attitudes are caused by a badly designed artefact, or unreasonable system goals, they are usually predictable and preventable. Unfortunately, there is often no way of knowing exactly how a user will react to an artefact, in which case there is nothing the system designer can do but wait until the system becomes operative and then make the necesary adjustments.

But what of the artefact? Can an artefact be said to have an 'attitude' towards the user? Perhaps not in the psychological sense, but certainly in the sense that if badly used, the artefact will perform badly (which at the right level of abstraction is the same for human beings!). Of course, as artefacts become more intelligent they will (and do!) possess the means to 'answer back' if used incorrectly, and they will thus be able to 'educate' the user into more reasonable behaviour, leading to a more successful outcome.

3.3.1 A general model for a human-artefact system

Figure 10 is a triel describing the relationships in a human-artefact system. The apex of the triangle represents system control, comprising system goals and system designer (controller in the basic triel). Entities E1 and E2 are now the user and the artefact. As before, two way arrows

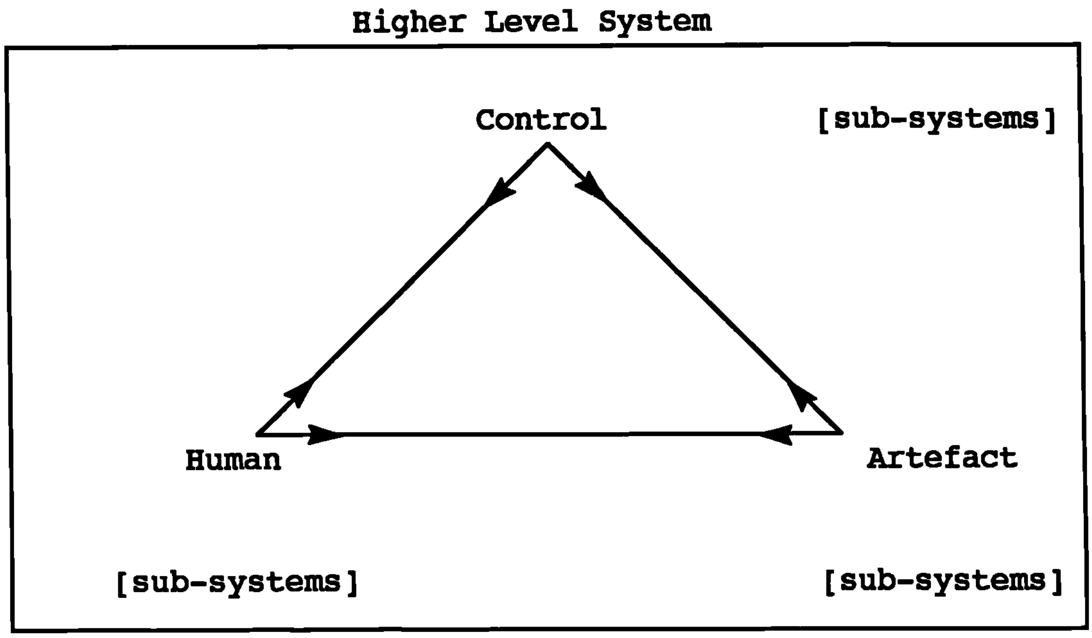


Figure 10 Human-artefact system model

represent the communication and control relationships in the system. The system goals determine, and to some extent are determined by, the attributes of the human and the artefact. The human determines the attributes of the artefact; and the artefact determines the attributes of the human. These concepts suggest rules for the design of an effective human-artefact system, where the rules apply to the components of the system as well as to the system itself:

a) *The Artefact Element* - An artefact should be designed in accordance with the following considerations:

i) system goals;

ii)the role of the artefact in the system;

iii)the role of the user in the system

iv)the attributes of the user

v) the attributes of the artefact.

b) *The User Element* - Selection and training should reflect the following considerations:

i) system goals;

ii)the role of the user in the system;

iii)the role of the artefact in the system;

iv)the attributes of the artefact;

v) user attributes.

c) *System Goals* - Since the system only really exists when user and artefact come together, it can only be defined in terms of the elements of the system (what the system consists of), and the goals of the system (what the system should do). Furthermore, since a system is judged by whether or not it attains its goals, it is important that the goals are capable of attainment, given all that is known about the elements of the system and their likely interaction. Consequently, the system goals must be based on:

i) the attributes of the user;

ii)the attributes of the artefact, and

iii)the designer's knowledge, based on (i) and (ii), of what the system is capable of when user and artefact interact.

3.3.2 Limitations of the HAS model

Any human-artefact system, designed for a specific purpose according to the model, ought to work as well as expected, and often does. However, there are many occasions when an apparently well designed system does not work in the way that the designer intended. This phenomenon has been attributed by the writer to two causes; the *predictable interaction effect* (PIE) and the *unpredictable interaction effect* (UIE).

Both kinds of interaction effect only become apparent when the system comes into being, i.e. when user and artefact interact. The difference between them is that the PIE is deemed to be foreseeable, and the UIE is not. This difference is not trivial, and may have considerable impact not only on the way artefacts are designed, but also on the way human-artefact systems are brought into use.

The notion of a predictable interaction effect relates to knowledge that <u>is</u> available in the world, but may not be possessed by the designer of the system (or a designer may have such knowledge but deem it to be unimportant). For example, the use of colour to emphasise an important feature of an artefact would be wasted on a person who is colour blind. Such knowledge is available in the world, and ought to influence the design of an artefact, but in practice it may be overlooked.

Unpredictable interaction effects are deemed to be unknowable by the designer or anyone else. On the other hand, it could be argued that UIE's exist only because of our incomplete knowledge of the way the world works, and that UIE's are really PIE's in disguise. There is, no doubt, some truth in this, but it is not a helpful argument on which to base a solution to the problem presented by UIEs.

In an attempt to simplify the position, the writer has defined the PIE as a demonstrably predictable phenomenon (i.e. it is understandable from knowledge that was available before the event, and in that sense it could have been predicted), and the UIE as a demonstrably unpredictable phenomenon (i.e. there is no evidence that necessary and sufficient knowledge was available before the event). Once a UIE has been identified, it becomes a PIE, and from then on is part of the body of knowledge about the particular class of system under discussion.

The inability to predict interaction effects is not necessarily a reflection on the competence of the designer. Designers can only operate within the limits of their knowledge, experience and perceptions. For instance, it would be unreasonable to expect a designer to possess all the knowledge available about a complex human-artefact system, since this is like being expected to count all the grains of sand in the world - possible, but impracticable!

However, the more research that is done prior to the launching of a new system, the more information the designer will have about interaction effects. Hence, it may be possible to reduce both kinds of interaction effect considerably. This is particularly true if all, or most, of the intended users of the system are given the opportunity to try out the system before it is launched. Unfortunately, it is not often possible to do this.

Of course, interaction effects are not all bad. In fact, each effect (PIE and UIE) may be considered to have a positive and negative component, where positive components work in favour of the system, and negative components work against the system. Thus when a user interacts with an artefact there are four possible outcomes:

1) PIE_p - this is the positive component of the predictable interaction effect, which represents a successful (and unexpected) outcome, and adds a new dimension to the system. It is important that this information is fed back to the designer who may wish to upgrade system goals, and inform other users of the enhancement to the system.

2) PIE_n - this is the negative component of the predictable interaction effect, which represents an unsuccessful and unexpected outcome (system failure). This system failure may or may not be correctable by the system as it stands (i.e. in Ashby's terms the system may lack requisite variety). If the existing system is unable to respond it may be necessary to replace or modify one or more

of the three elements of the triel. It is therefore vital that information on the PIE_n is fed back to the designer so that the appropriate action may be taken.

3) UIE_p - this is the positive component of the unpredictable interaction effect, which represents a successful outcome, and adds a new dimension to the system. It is important that this information is fed back to the designer who may wish to upgrade system goals (if the event is repeatable), and inform other users of the enhancement to the system. Also, if the user/artefact attributes that led to this effect can be identified, they may be used as criteria for the selection of users and artefacts.

4) UIE_n - this is the negative component of the unpredictable interaction effect, which represents an unsuccessful outcome (system failure). This system failure may or may not be correctable by the system as it stands (i.e. in Ashby's terms it may lack requisite variety). If the existing system is unable to respond, it may be necessary to replace or modify one or more of the three elements of the triel. It is therefore vital that information on the UIE_n is fed back to the designer so that the appropriate action may be taken.

The consequences of negative interaction effects may be severe. Since it is often the case that no-one knows quite what to do, the response tends to fall into two categories. Either people persist with the system in the hope that things will improve, or they abandon it. The former strategy often causes stress for the people that have to work within the system; and the latter strategy may lead to a wastage of people and equipment. Either way, not only is the system itself held to be badly designed, but there is also a loss of confidence in the ideas on which the system is based.

3.3.3 Criteria for assessing a human-artefact system

Suppose the measure of a system's *effectiveness* is represented by a scale of Ø to 10. On this scale, 5 could be used to represent a system that works <u>exactly</u> according to the designer's expectations (i.e. no surprises!). A system that is better than expected would be above the median and a system that is worse than expected would be below the median. As has already been suggested, a system that performs in an unexpected way may be subject to a predictable interaction effect (PIE), or an unpredictable interaction effect (UIE). Thus a low score on the scale may be caused by a PIE_n or a UIE_n. Similarly, a high score on the scale may be due to a PIE_p or a UIE_p.

Clearly, a system that is not working as well as expected will attract more attention than one that conforms to (or betters) the designer's expectations. But the scale should not be interpreted as 'below 5 = unsatisfactory; above 5 = satisfactory'. The scale should be seen as a continuum, with all states capable of movement to the right, e.g. a 5 is a potential 6, and so on. Even if a system scores 10 on the scale, there is no need for complacency since a 10 on one scale may be a Ø on a higher and better scale of expectations.

Based on the ideas above, an iterative procedure for applying a cybernetic assessment procedure is described below. This procedure should be used during the system design process and, ideally, continue during the working life of the system:

1) For any given system, assess the scale position.

2) Look for PIE_n's, which may be thought of as weaknesses in the system.

3) Apply known techniques for dealing with these PIE_n's.

4) Reassess the scale position.

5) Look for PIE_p's, which may be considered as underdeveloped strengths. The effect of developing these strengths may be to cancel or modify the effect of the PIE_n's.

6) **Reassess the scale position.**

7) Look at other systems (not necessarily human-artefact systems) to see if they have PIE_p's that are transferable to the system under analysis.

8) **Reassess the scale position.**

9) Look for UIE_n's and nullify or modify them.

10) **Reassess the scale position.**

11) Look for UIE_p's and try to enhance them. Again, an enhanced UIE_p may nullify or modify the effect of a UIE_n.

12) Look at other systems (not necessarily human-artefact systems) to see if they have UIE_p's that are transferable to the system under analysis.

13) **Reassess the scale position**

14) Continue with the procedure (if necessary).

3.4 The human-documentation system

Section 3.2 introduced the idea of the E^2 system, consisting of three elements: control and two interacting entities. Following this, Section 3.3 identified a particular example of the set of all possible E^2 systems, i.e. the human-artefact system. It is now possible to identify the basic human-documentation system (HDS) as an example of interest from the set of all human-artefact systems.

The basic HDS is shown in Figure 11. It comes into being when someone uses documentation to comprehend another human-artefact system. Because of its antecedents, the HDS obeys all the rules developed in the earlier sections on E^2 and HAS systems e.g. there is a *user element*, a *documentation element*, and *system goals*. The technical author needs to be aware of the predictable and unpredictable interaction effects that may occur in an HDS, and therefore take whatever measures are possible to reduce the negative components of these effects.

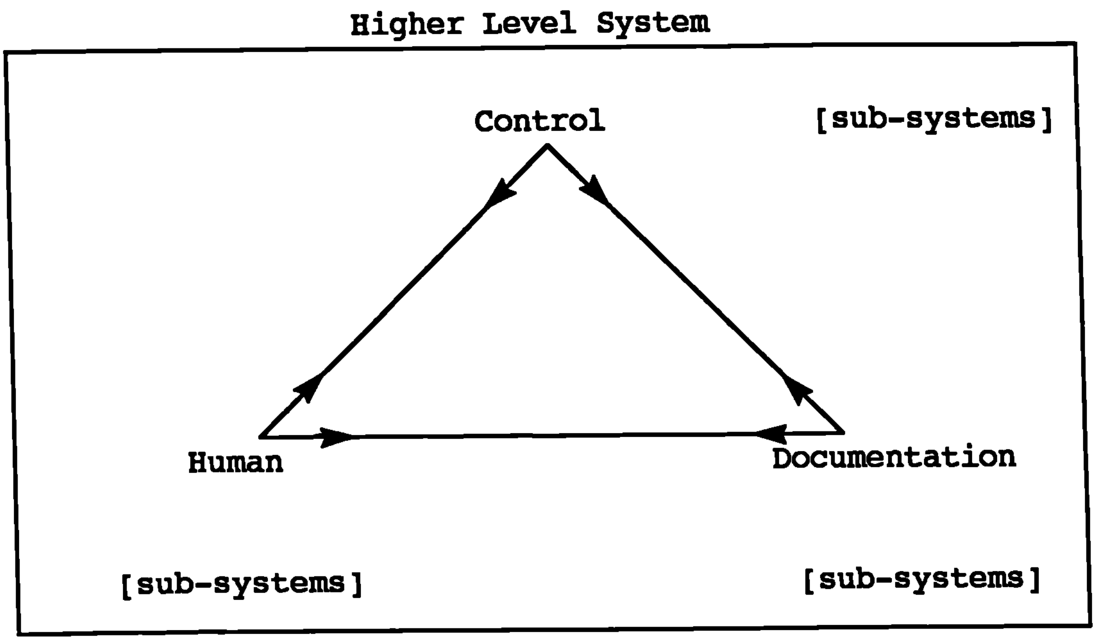


Figure 11   Basic human-documentation system model

3.5 Relationship between HDS model and communication model

At one level, the communication model and the HDS model share the same concept; namely that users' reactions to documentation are to some extent unknowable and therefore there is no way to guarantee that documentation will be acceptable to the user. The psychological noise identified by the communications model therefore has its counterpart in the predictable and unpredictable interaction effects of the MDS model. Looking only at the reasons why people do not use documentation, the predictable psychological noise may be seen as corresponding to the negative component of the predictable interaction effect; and the unpredictable psychological noise corresponding to the negative component of the unpredictable interaction effect.

Under ideal circumstances, predictable problems with documentation can be solved during the production process, leaving only the unpredictable problems to be dealt with once the documentation is issued. In practice, neither type of problem can be solved unless documentation is given a sufficiently high priority. The consequences of underrating the importance of documentation are described in the next chapter, along with suggestions for improving its status.

Chapter 4

The case for an integrated systems approach

In parallel with the early work on this thesis, the writer worked as a free-lance technical author for a major organisation with offices throughout the UK. One project carried out by the writer was to produce extensive documentation for a large, complex, human-machine system, which embodied state-of-the art techniques in mechanical, electronic and computer engineering. For contractual reasons, it is not possible to give explicit details of the organisation or the system, but general information about the system and its documentation is given in Appendix 1.

The writer's experiences with this project are described in some detail in the early part of the chapter, because they exemplify many of the things that can go wrong in a documentation project. Later in this chapter, the lessons learned from the project are used to suggest ways of anticipating and preventing such difficulties.

4.1 The documentation project

Given the nature of the system, it was obvious from the outset that a comprehensive and usable set of documentation would be required to enable staff to operate and maintain the machine effectively. The company wanted the documentation to be in the form of a set of eleven manuals which could provide source material for a wide range of employees, from operators to office managers. Each member of staff was to be issued with the manuals appropriate to the task they performed (for instance, maintenance engineers required only two manuals; routine maintenance instructions, and troubleshooting), and the full set of manuals was to be available at a central point in each office for reference. Information supplied by the manuals was to fall into three general categories; operation, description and maintenance.

An important factor to the company was time. At the start of the documentation project there were two prototype machines on trial in separate offices, and a contract had been signed for 12 production machines based on these prototypes. It was therefore important that the documentation should be ready in time to train staff prior to the installation of these new machines, particularly as it had been agreed in principle that the training course would be based on the documentation provided, and not on conventional training notes.

As a further complication, the documentation had to reflect differences in the production machines due to varying operational conditions. For example, the type of material processed at one particular office was significantly different from that handled in the rest of the UK, and this involved important changes. Also, one production machine had to be modified for use in the USA, where operational conditions were significantly different.

On the basis of the company's requirements, the writer proposed that the documentation should be designed as an information system, with the usual systemic properties (see Figure 12). Thus in information system terms, the documentation would consist of an information archive, and a set of rules (known as information processes) for storing, retrieving and using the information contained in the archive (see Figure 13). The practical implementation of this information system proposed by the writer was as follows:

a) The documentation would consist of an ordered set of manuals, with each manual addressing a separate theme (see Figure 14). This would allow manuals to be used singly or in specific combinations, and new manuals could (if necessary) be added to the set without affecting other manuals.

b) Each manual in the set would consist of an ordered set of pages, with each page addressing a separate topic

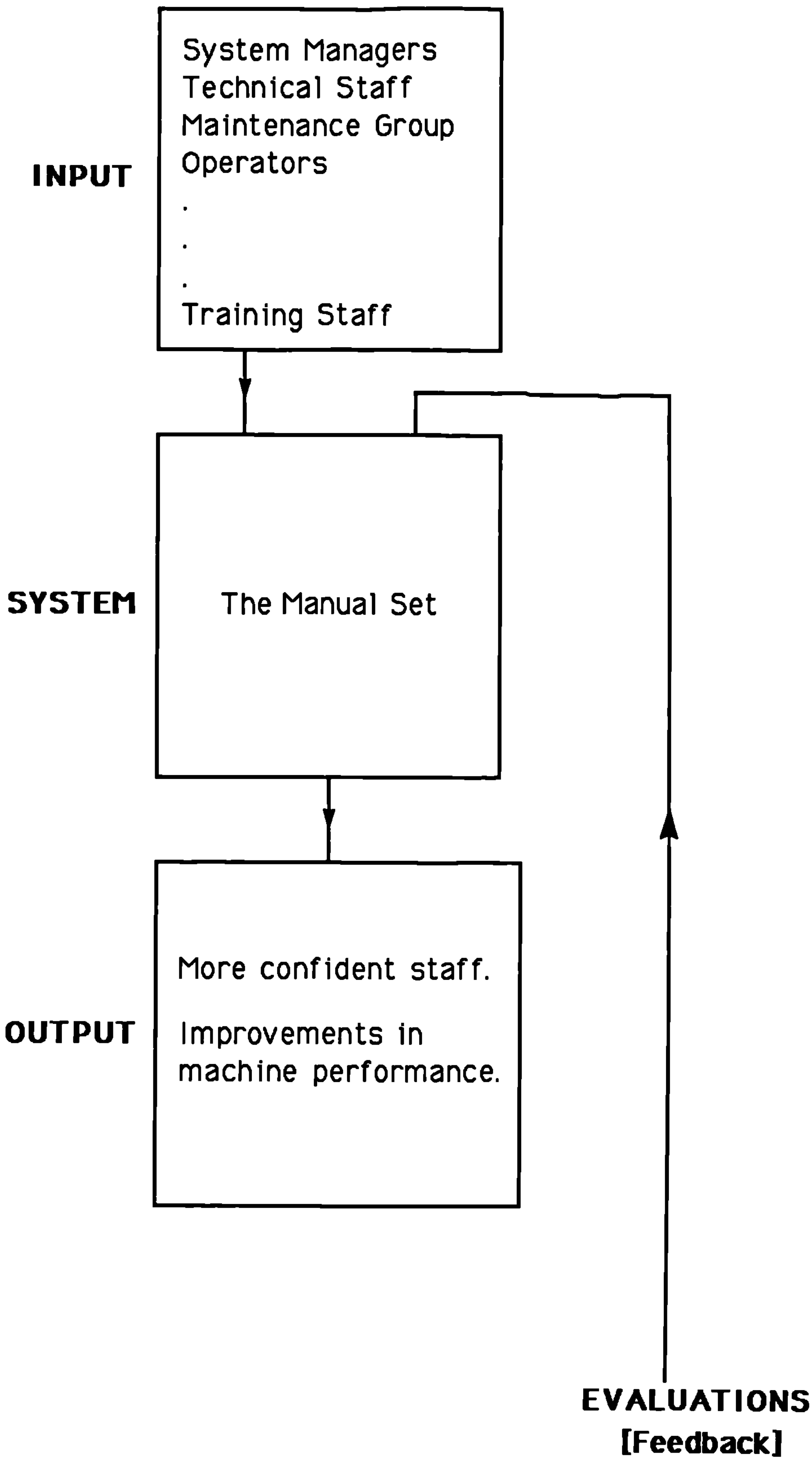


Figure 12 System environment

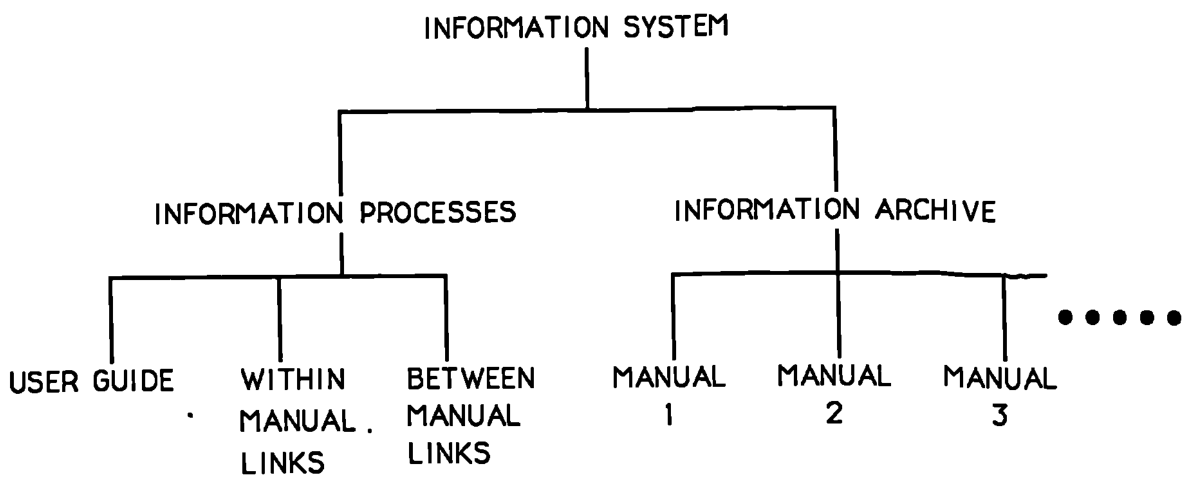


Figure 13 Information system structure

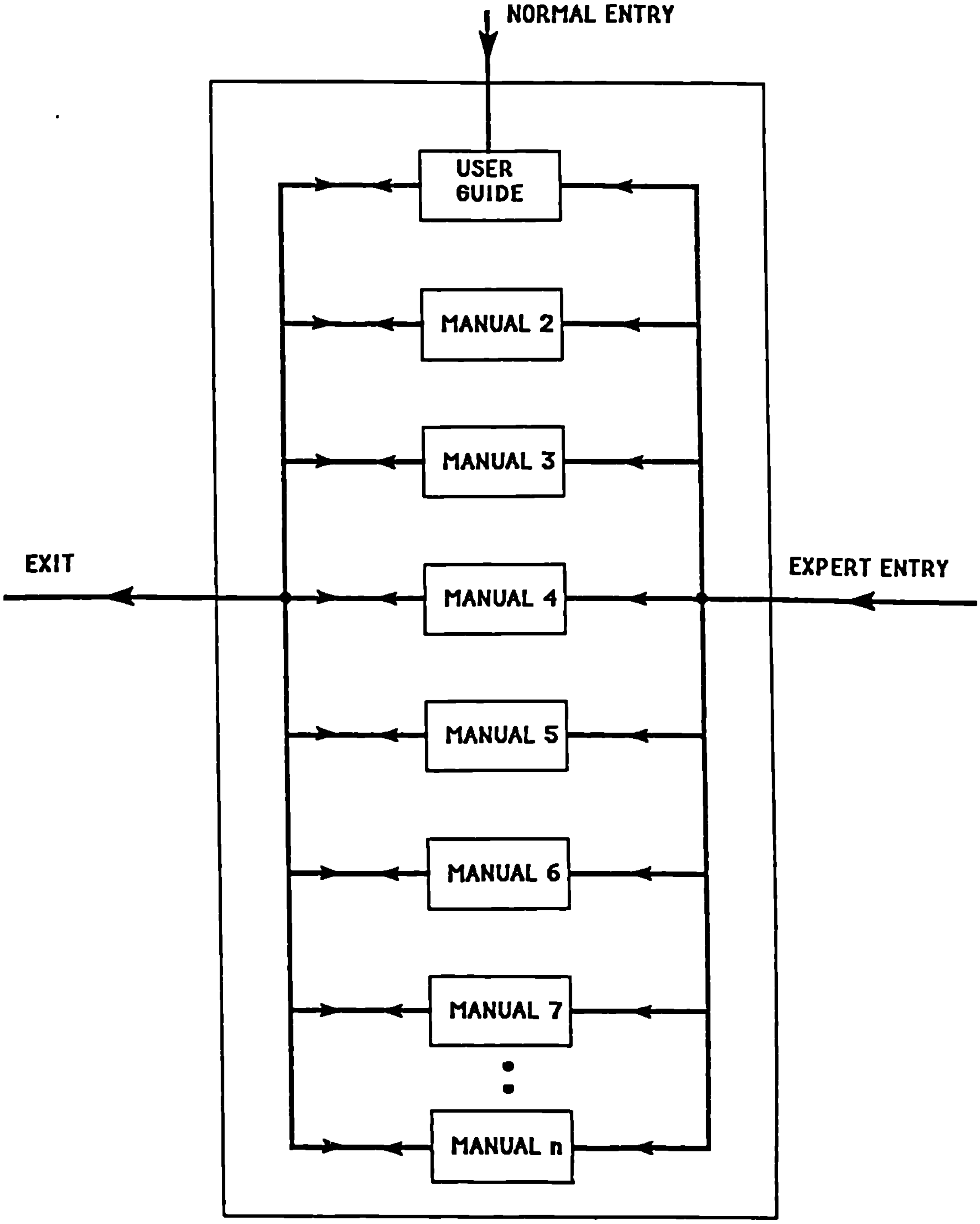


Figure 14 Addressing the manual set

(Figure 15). Each manual would have its own numbering system, and if the pages were held in a ring binder (the preferred method), a manual could be updated easily without affecting other manuals.

c) Each page would contain information directly relating to the topic, and (where appropriate) directions to other parts of the documentation containing references to the topic.

The writer further proposed that the documentation project should take place in the stages shown in Table 1:

TABLE 1 PROPOSED PROGRAMME FOR PRODUCING THE DOCUMENTATION

STAGE	ACTIVITY	SUB-GOAL
1	**Design**	Collect the data: Study the machine Study drawings and specifications Talk to people Analyse the data: Prepare proposals for form, style and content of manuals Discuss proposals with the company
2	**Development**	Prepare draft manuals Liaise with illustrations staff Attend regular progress meetings Edit drafts
3	**Evaluation**	Discuss final drafts with company Carry out field testing Carry out final editing Prepare documentation for printing

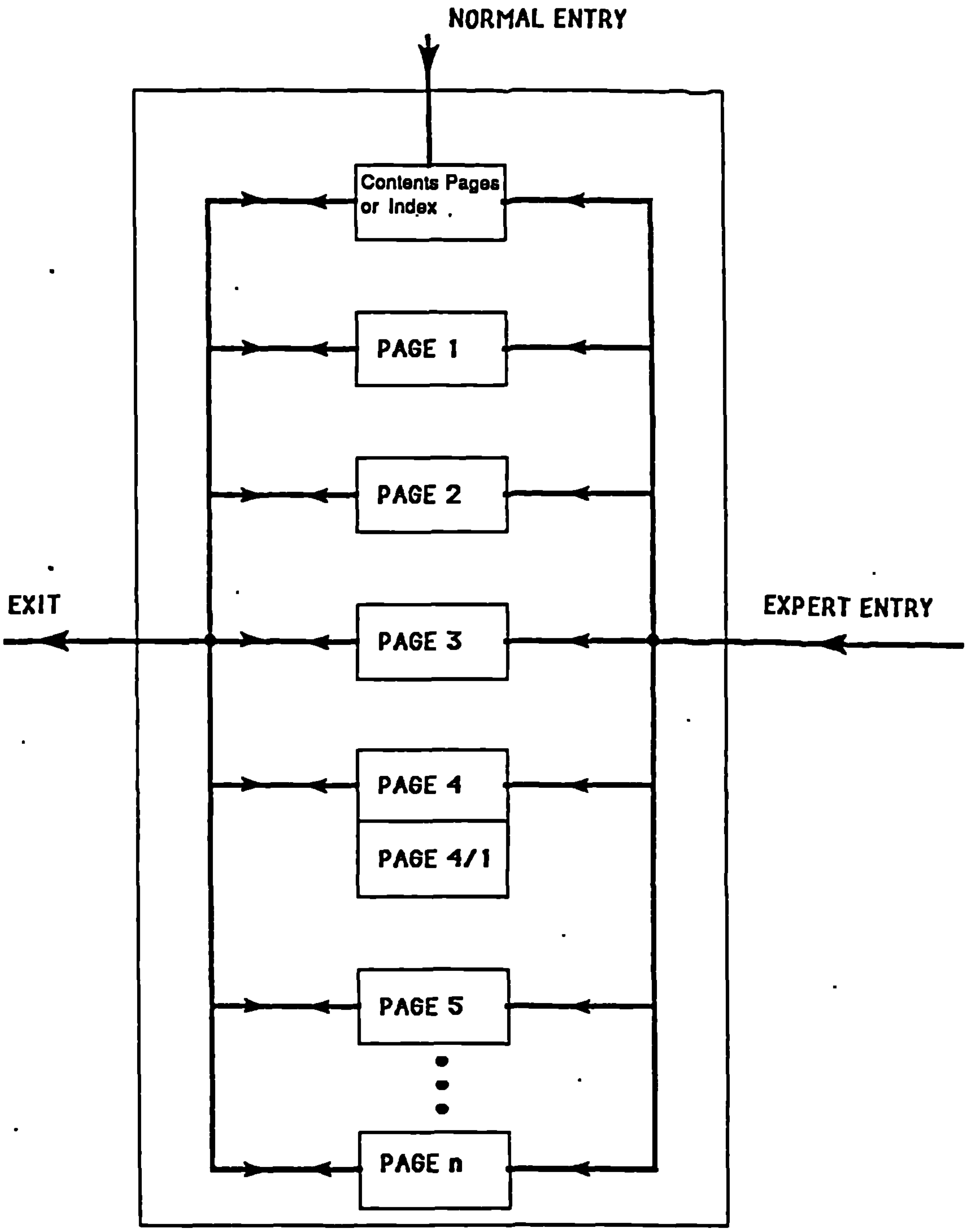


Figure 15 Addressing a manual

The company approved the programme and agreed to co-operate fully in its implementation. On this basis, the writer had high expectations of producing good quality documentation on time. Unfortunately, things started to go wrong almost immediately, with the result that the documentation was late and not as good as it might have been. Because of these factors, the documentation is now not generally liked, and seldom used.

4.2 What went wrong?

The immediate practical difficulties faced by the writer were lack of access to the machine, the experts on the machine (the design team), and the intended users of the documentation. This meant that in the early stages of the project the writer had to work almost entirely from drawings, prototype specifications, observation, and brief encounters with design staff, usually as they went about their business. Although this enabled some progress to be made, it was not enough to keep the project on schedule, and the writer was therefore unable to meet the deadlines that had been set by the company. This failure to keep to the agreed timescale had unfortunate consequences, which are described later.

4.2.1 Lack of access to the machine

In the writer's opinion, 'hands-on' access to a machine is vital to the task of producing authentic, credible, and usable documentation. This is particularly true of operational and maintenance documentation, where an author often has to write a set of instructions leading to a desired outcome. If these instructions are not correctly validated/verified by the author actually working on the system, they are likely to lead to unintentional, and possibly undesirable, outcomes. At one level this can be dangerous, and at another level it can cause loss of confidence in the documentation.

At the start of the project, the only machine available to the writer was a prototype in daily use at a busy office. This machine was maintained by design engineers because local engineering staff lacked the necessary knowledge (this was, of course, why documentation was needed urgently). It was vital to keep the machine in regular use, not only because it was needed for operational reasons, but also because it was being used to prove the drawings required to build the production machines. Consequently, the company could not afford to take the machine out of service for any length of time to enable the writer to gain first hand experience; and furthermore, they did not want the writer to work on the machine between operational shifts in case anything went wrong and the machine was out of service during a busy period.

Even when the production machines were being built, the writer was again unable to gain significant access. In this case, the reason given was that the company building the machines had penalty clauses in their contract, and they could therefore not afford to fall behind in their production schedule. It must be admitted that the company had difficulties of their own, because many of the production drawings had to be altered as the result of experience with the prototype. This, incidentally, made it difficult to talk to design staff (see 4.2.2) because apart from nursing the prototypes they had to spend time with the firm making the production machines.

4.2.2 Lack of access to people

A vital part of the work of a technical author is knowledge elicitation, i.e. acquiring information from domain experts. The relationship between expert and author is a sensitive one at the best of times, usually because the expert just wants to get on with the job and resents being asked to explain and justify actions which seem self explanatory. In the project described here it was impossible to establish any meaningful relationship with the design team, and the writer's attempts to force the issue only made matters worse. In fact, design staff complained to the project manager that the writer was 'asking too many questions'. In the end, only secondary communication was possible (see a) and b) below).

The difficulty over access to people arose from the problems experienced by the design team (the only people who had significant knowledge about the machine) with the prototype and production machines. Design staff were working at full stretch either to keep the prototype in operation, or to ensure that the production drawings were accurate. Sometimes errors discovered on the production drawings led to modifications which had to be tested on the prototype. In addition, software faults were found which took many man-hours to correct.

Whilst appreciating the difficulties experienced by the design staff, the writer was also acutely aware of the need to have access to their knowledge. This led to a certain amount of conflict between the writer and members of the design team. Typically, the project manager would be asked by his staff 'What do you want us to do, fix the machine or talk to the technical author?' Invariably the machine took priority! The documentation project was therefore downgraded, although the company still expected the work to be completed on time!.

Since it was impossible to spend any significant time with design staff, the writer tried other strategies for acquiring information, such as 'think aloud protocols' and 'information by default':

a) *Think aloud protocols* - the writer persuaded the project manager to buy a Sony M-88V micro-cassette (a small, easy to carry, voice operated device) for each member of the design team. The idea was that staff would use think aloud protocols, an idea borrowed directly from cognitive psychology, where it is often used to investigate reasoning strategies when solving problems.

Unfortunately, the scheme failed for three reasons. First, effective use of these protocols involves a period of training prior to use, and the company could not afford to release staff for this purpose. Also, think aloud protocols are most effective when monitored by the investigator, and the staff did not like their work to be monitored. Finally, think aloud protocols are usually used as a basis for structured interviews, which should take place fairly rapidly after a recording is made. This, of course, was impossible because of the pressure on staff to meet their workload. In the end, only one person out of six used the recorder while working on the machine (the resulting transcript was very useful!), and the project had to be abandoned.

b) *Information by default* - another scheme used by the writer was to assemble draft manuals using whatever information that was available and give it to the design team for comment in their own time, and at their own pace. The idea was that each person would read the document, make amendments (which had to be initialled) and pass the document on to the next person on the list. After the documentation was seen by all members of the design team, the amended draft was returned to the writer (the last name on the list).

This scheme worked well in a negative way, i.e. mistakes and misunderstandings introduced by the writer were usually identified and corrected, but very little new information was introduced. Consequently, the process did not enrich the documentation in the way that face-to-face knowledge elicitation sessions might have done, although two people did use their microcassette recorders to comment on the drafts, which was quite useful. There was also a suspicion that the scrutiny was not always as rigorous as it might have been, e.g. when one drawing that had been passed by everyone was sent back with a minor query, it was completely redrawn.

The only other people who could have supplied useful information to the writer were the staff who were building the new machines. Unfortunately, because of the factors mentioned in 4.2.1, this proved to be difficult as well. Indeed, on several occasions at the factory, technicians building the machine were forbidden to speak to the writer on the grounds that it was interfering with their duties.

4.2.3 Other factors affecting user acceptance

Another source of contention was that the company made a number of decisions on training, without consulting the writer. In the writer's opinion, these decisions (described below) helped to undermine the success of the documentation project because they caused users to form negative attitudes towards the documentation. If the writer had been allowed to influence these decisions, it is possible that the documentation project might have ended more successfully. Of course, it is also true that if the documentation project had been completed on time, the problems outlined would not have existed.

a) *Use of interim training manuals* - at one point the company asked for incomplete documentation (known as interim training manuals) to be published so that design staff could give preliminary training to maintenance technicians from the offices scheduled to receive the first production machines. These people came to the office where the prototype was in use, and one of the design staff gave them their first introduction to the machine (and, of course, to the documentation!). Ironically, the company allowed the machine to be taken out of service for this course, so that the technicians could have 'hands-on' experience. The writer was not invited to attend the course, but the course proceedings were recorded, and the resulting transcripts provided some useful information.

It is accepted by the writer that the company had to arrange these courses because of pressure from local staff, but in the writer's opinion three errors were made. First, because the manuals were sub-standard, they prejudiced staff against the documentation. Second, because gaps in the documentation were filled either by speculation, or by the results of trial and error methods, staff were inoculated against the more comprehensive information that came later. Finally (and with due respect to the design staff), the interim training manuals were not introduced, or used, in the way the writer intended, i.e. as an information system.

Thus a process was started which eventually led to the users' looking upon the documentation as irrelevant to their needs. Given that training had to be arranged before the documentation was ready, it would have been better either if simple introductory course notes had been written, or if only the part of the documentation that was sound had been used. Otherwise, had the training been conceived as a joint effort between the writer and the design staff, the damage might have been limited.

b) *Use of distance learning material* - the second questionable decision made by the company was to use distance learning to prepare technicians for a course that was to be held at the company's training centre using the completed documentation. There is, of course, nothing wrong with distance learning per se, but in the circumstances it proved counter productive to the aims and objectives of the documentation that was being prepared for use on the course.

The main problem was that the distance learning material was different from the documentation in style and purpose, and because it also had a limited scope, it was more acceptable. It was also the first well prepared material on the machine the technicians had seen (see description of interim manuals). Therefore the distance learning material effectively upstaged the documentation, to the point where people on the course were asking for more distance learning material instead of using the manuals. This might have been avoided if there had been more co-operation between the training staff and the writer when the distance learning material was being prepared. For example, the material could have been structured as a microcosm of the documentation.

c) *Organisation of the training course* - a course was organised at the company's training centre to introduce field maintenance staff to the production machine. A machine was installed at the training school, and it was agreed that the documentation prepared by the writer would be used as a basis for training, in place of the customary training notes. Indeed, training staff were supposed to guide trainees into the correct use of the documentation as an information system.

This was a good idea in principle, because it assumed that trainees would customise the manuals issued to them in the light of their experiences on the course, and then take these personalised manuals back to their offices. In practice the scheme was flawed in a number of ways:

i) The writer was not allowed to have any influence over the way the documentation was used on the course, presumably because training staff felt that it was their prerogative to devise course material. However, since this was the first time that documentation had been used in this way (it was customary to provide a separate set of training notes based on lecturers' perceptions of the equipment), it might have been better for the author of the documentation to be involved in the design of the course.

For example, training staff did not show trainees how to use the documentation properly (i.e. as an information system), and consequently they found it difficult to relate the documentation to their problems with the machine. Also, as the documentation was competing not only with the distance learning material, but also with previous manuals, it was necessary to positively promote the documentation, something the training staff had no incentive to do.

ii) The writer was not given the opportunity to use the training sessions (and their immediate aftermath) to validate the documentation. For example, the writer formally proposed the scheme shown in Table 2, as a way of compensating for the difficulties experienced in the writing of the documentation, and to make up for lost time. As this scheme was not adopted by the company, the documentation was never properly validated.

TABLE 2 PROPOSED PROGRAMME FOR VALIDATING THE DOCUMENTATION

STAGE	PROPOSAL
1(a)	The documentation to be validated at the training centre, prior to the start of the first course, using the production machine. Validation to be carried out by one member of the training staff and one member of the design team. The writer (as technical author) to be present throughout to observe and record the proceedings.
1(b)	Concurrently with 1(a), other design staff at company HQ to check the documentation for accuracy and content.
1(c)	Writer to incorporate amendments arising from 1(a) and 1(b), and prepare updated documentation in time for the first course.
2(a)	Writer to attend each course to observe the reaction of the trainees to the documentation, and to record any changes that appear to be necessary.
2(b)	Design staff to assess the validity of the proposed amendments arising from 2(a), and to advise the writer of the amendments to be made.
2(c)	Writer to incorporate amendments arising from 2(b), and ensure that each trainee receives amended documentation.
3(a)	Data to be gathered for a trial period on the usefulness of the documentation in the field. During this period writer to visit selected offices to talk to staff and to obtain feedback on documentation.
3(b)	Design staff to assess the validity of the proposed amendments arising from 3(a), and to advise writer of the changes to be made.
3(c)	Writer to incorporate amendments arising from 3(b), and prepare updated material for issue to maintenance staff in offices.
4	Writer to attend editorial meetings with design staff to discuss final form of documentation, prior to printing and publication.

The final set of manuals was eventually produced to a very high standard (quality of paper, typeface, etc.), and the individual manuals were as good in style and content as could be expected under the circumstances. Unfortunately, by the time the documentation appeared in the field, users were already familiar with the machine, and saw no need to use the documentation.

However, one machine was sold to a company in Jersey, whose staff did not undergo the same training experiences (e.g. interim training manuals, distance learning, training course) as the staff in the UK. Being forced to rely solely on the manuals for support, they found them to be useful and indispensable (their words!). So perhaps some good came of the project after all!

4.3 How difficulties might have been avoided

In the writer's view, the difficulties that were experienced in producing good quality documentation on time could have been avoided if the writer had been introduced at an earlier stage in the design process, as an integral part of the design team. In this case the documentation would have developed at the same pace as the machine, and it would have been easier to amend well founded documentation during the machine's trial period, than it was to produce the documentation entirely. Furthermore, as an 'insider', it would have been much easier for the writer to influence decisions affecting the documentation project. As it was, decisions fundamentally affecting the writer's work were irreversible by the time the writer became aware of them.

The fact that the writer was not treated as a member of the design team is not, of course, surprising since documentation has a very low priority in many companies. However, a well qualified technical author (often a qualified engineer as well as a skilled communicator) can be a surprisingly useful asset. For example, there is a widely held view that if something cannot be described easily, it is unnecessarily complex and needs to be simplified. Thus a technical author in the design team, looking at things from a different perspective and asking questions like 'how does this work' and 'why does it do that', can contribute to the success of the machine in a number of ways, other than by writing good documentation.

There is also a strong argument for involving the technical author in the training programme, especially when training is going to be based on documentation rather than on an independent set of training notes. A technical author is, after all, a professional technical communicator and therefore in a good position to understand the techniques used by training staff, and their problems.

The relationship of training staff to technical author may be viewed in a similar way to the relationship of the author to design staff. Design staff have the responsibility for producing a working machine, but an author can provide a new and valuable perspective on the communicative properties of the design. Similarly, an author is responsible for producing working documentation, but training staff can provide a new and valuable perspective on the documentation when it is viewed as a training tool!

From a theoretical standpoint it is therefore important to recognise that the human-documentation system (HDS) first referred to in Chapter 3 does not exist in isolation; it must interact in some way with other associated systems. In this sense, a human-documentation system may be considered as a representation of a human-machine system (HMS), where the goals of the HDS are to assist the HMS (via the user) to attain its goals.

Similarly, a human-*course* system (HCS) may be said to exist, wherein the course acts as a representation of the human-documentation system (and therefore indirectly as a representation of the human-machine system). Thus the three systems are interdependent, and although the HMS could exist without the other two, their existence helps to guarantee its viability.

4.3.1 The human-machine system

The basic human-machine system (HMS) is shown in Figure 16. This system comes into being when someone uses a machine for a purpose. Because of its antecedents, the HMS obeys all the rules developed in Chapter 3 on E^2 and HAS systems, e.g.it has a *user element*, a *machine element* and *system goals*. As usual, the technical author needs to be aware of the predictable and unpredictable interaction effects that may occur, and must take whatever measures are necessary to reduce the negative components of these effects.

4.3.2 Training the user to use documentation

The human-machine system (and its goals) are of interest to the technical author only to the extent that they help to select goals for the human-documentation system. Of more importance to the technical author is the need to ensure that the human-documentation system is effective. Since the functioning of the system is not transparent to the user of that system (otherwise documentation would not be needed!), it would be unreasonable to expect that the functioning of the

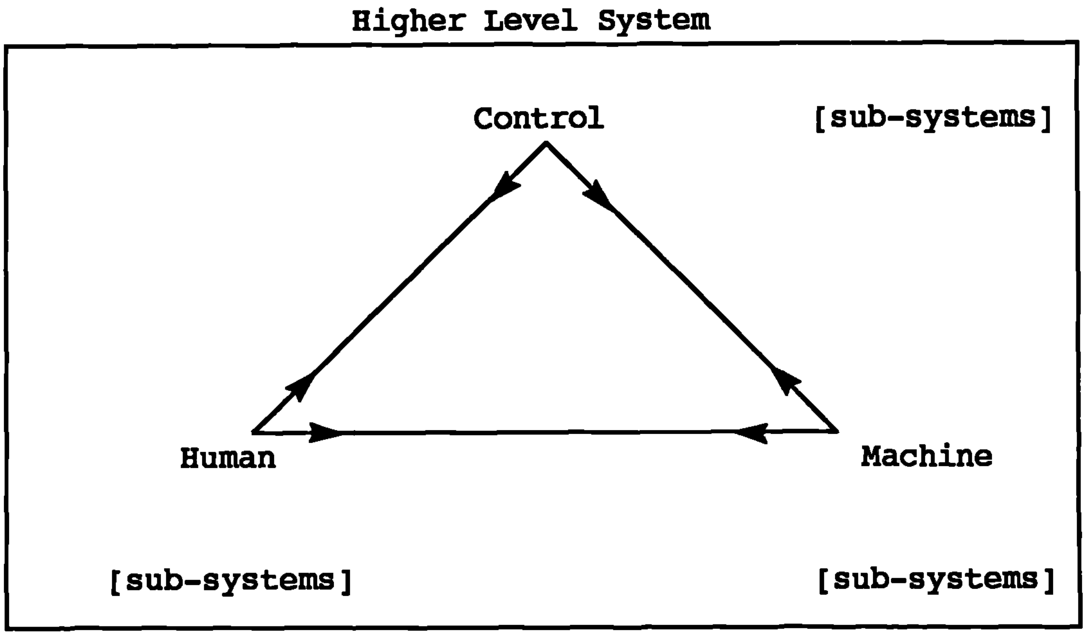


Figure 16 Basic human-machine system model

documentation would also be transparent to the user of the documentation.

Hence the technical author may consider it necessary for the user of the machine to be taught *how to use* the associated documentation. One way of doing this is to arrange for the documentation to be introduced at the same time as the training course on the equipment (perhaps even integrated with it). Hence if the training material and activities are subsumed under the title *course*, a human-course system (HCS) can be perceived in which the coursework is used as a representation of the documentation, and the goals of the HCS are to assist the human-documentation system (via the user) to attain its goals.

The basic human-course system (HCS) is shown in Figure 17. It comes into being when someone attends a course on how to use a system <u>and its associated documentation</u>. Because of its antecedents, the HCS obeys all the rules developed in the earlier sections on E^2 and HAS systems, e.g.it has a *user element*, a *course element*, and *system goals*. As usual, the course designer needs to be aware of the predictable and unpredictable interaction effects that may occur, and must therefore take whatever measures are possible to reduce the negative components of these effects.

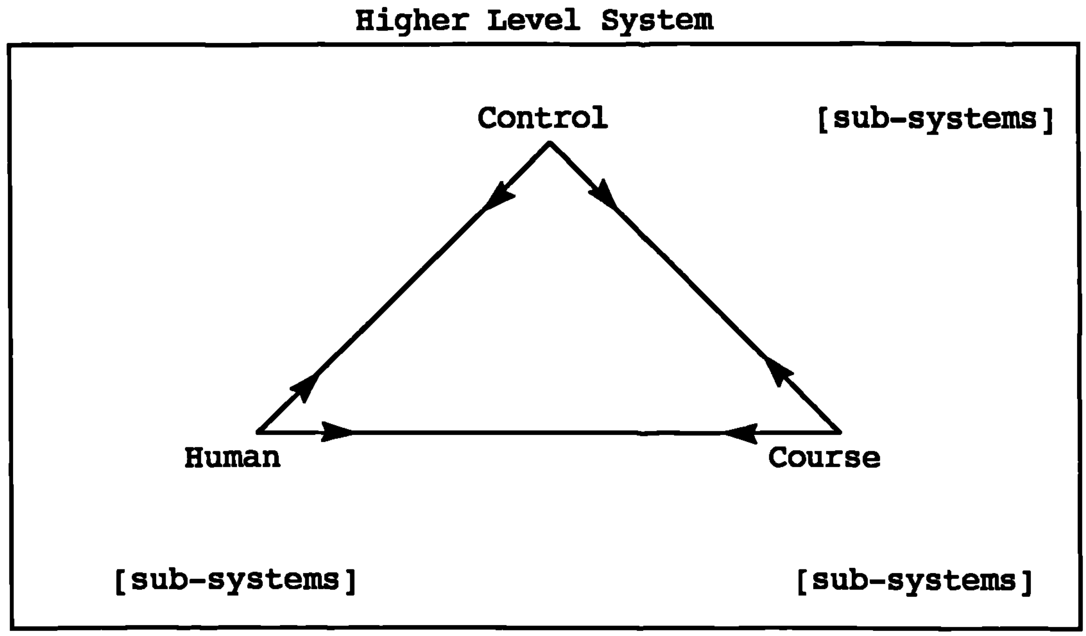


Figure 17 Basic human-course system

Since it may not be entirely clear how the user would benefit by being trained to use documentation, a digression at this point to clarify the position seems appropriate. While the writer sees many advantages in such training (e.g. it can help to overcome negative unpredictable interaction effects), a brief mention of one such advantage may make the point.

It has been stated before that many people are not inclined to use documentation, for a variety of reasons (see Chapter 1), some of which are not easy to detect. When this reluctance is due to a hidden negative attitude towards documentation, the negative component of an unpredictable interaction effect comes into play. This effect may be very difficult to overcome, but is potentially reversible on a training course where instruction is oriented towards instilling positive attitudes towards documentation. A fuller explanation of how this could be achieved is given in the next chapter.

4.4 A full model of the human-documentation system

The full model of a human-documentation system consists of the basic model together with the higher (HMS) and lower (HCS) system models deemed necessary for the emergence of effective documentation (see Figure 18).

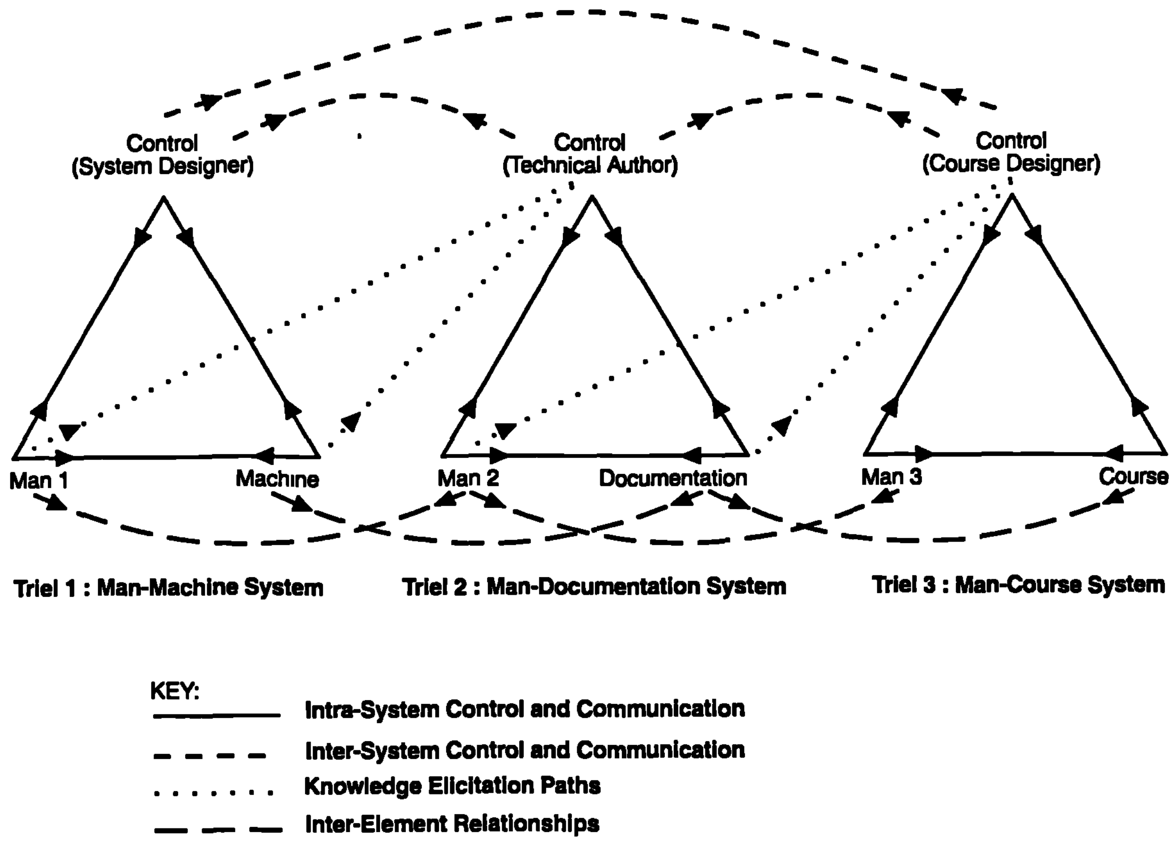


Figure 18 A full model of the human-documentation system

Since the individual system models have been explained earlier, it is only the interactions and relationships that are explained here.

4.4.1 Interaction between HMS (Triel 1) and HDS (Triel 2)

a) *Control (HMS) to/from Control (HDS)* - there is a need for two-way communication between the system designer (SD) and the technical author (TA) for a number of reasons:

i) A system designer needs to communicate HMS goals to the author, so that the appropriate HDS goals can be formulated;

ii) A technical author needs feedback from the system designer about the accuracy of the author's formal representation of the HMS;

iii) A technical author needs to be able to communicate information to the system designer arising from the author's interaction with Man 1 and the Machine (as individual entities, and as an interacting system);

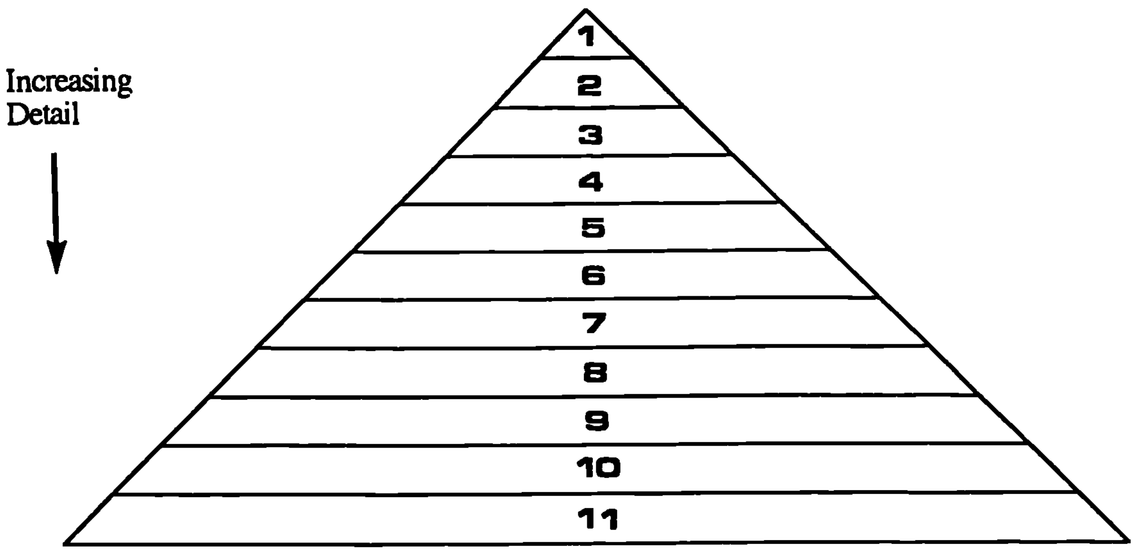
iv) A system designer needs to be able to communicate information to the technical author about changes in the HMS which could affect the documentation.

b) *Control (HDS)to/from Man 1*- the technical author needs to obtain first-hand information from (and about) the user of the machine, to determine the content and style of the documentation.

c) *Control (HDS)to/from Machine* - the technical author needs to obtain first-hand information about the machine, to determine the content of the documentation.

When a technical author has obtained all the information he needs from the human-machine system, he turns his attention to the human-documentation system. The user of the machine (Man 1) is now seen as a *user of documentation* (Man 2), where different attributes are involved.

The documentation is a representation of the machine because it describes the machine from various viewpoints, and its structure often parallels that of the machine. The meta goal of the HDS is therefore that the documentation should enable the user to control the machine (in the full sense of the word, e.g. to keep the machine in operation). In the case of the manual set described earlier in this chapter, this was achieved by the information/documentation relationship shown in Figure 19.



<u>Key: To Manuals</u>

1 = User Guide
2 = Operator
3 = Operations Manager
4 = Engineering Manager
5 = Troubleshooting
6 = Engineering Maintenance
7 = System Description (Materials Handling)
8 = System Description (Slave Processors)
9 = System Description (Master Control System)
10 = Electrical/Mechanical Infrastructure
11 = Machine Components

<u>Key: To Normal Use</u>

All personnel	1
Operational Staff	2, 3
Engineering Staff	4, 5, 6, 10, 11
Design Staff	7, 8, 9

Figure 19 Information/documentation relationship

4.4.2 Interaction between HDS (Triel 2) and HCS (Triel 3)

a) *Control (HDS) to/from Control (HCS)* - there is a need for two-way communication between the technical author (TA) and the course designer (CD) for the following reasons:

i) The technical author needs to communicate HDS goals to the course designer, so that appropriate HCS goals can be formulated;

ii) The course designer needs feedback from the technical author about the accuracy of the course designer's representation of the HDS;

iii) The course designer needs to be able to communicate information to the technical author arising from the course designer's interaction with Man 2 and Documentation;

iv) The technical author needs to be able to communicate information to the course designer about changes in the documentation which affects the course.

b) *Control (HCS)to/from Man 2* - the course designer needs to obtain first-hand information from (and about) the user of the documentation, to determine the course content.

c) *Control (CDS)to/from Documentation* - the course designer needs to obtain first-hand information about the documentation, to determine the appropriate course content.

4.4.3 Interaction between HMS (Triel 1) and HCS (Triel 3)

a) *Control (HMS) to/from Control (HCS)* - there is a need for two-way communication between the system designer (SD) and the course designer (CD) for a number of reasons:

i) A system designer needs to check that trainees are receiving the training they need to operate the system effectively;

ii) A course designer needs feedback from the system designer about the effectiveness of the course;

iii) A course designer needs to be able to communicate information to the system designer arising from the course designer's interaction with Man 3 and the Course (as individual entities, and as an interacting system);

iv) A system designer needs to be able to communicate information to the course designer about changes in the HMS which could affect the course.

4.4.4 Other interactions

a) Man 1, Man 2, and Man 3, are all appropriate subsets of the set of attributes possessed by the person who uses the machine, uses the documentation, and attends the course. The system designer, the technical author, and the course designer must all be aware of the three roles played.

b) The documentation is a representation of the system, and the course is a representation of the documentation <u>and</u> the system. Systems designer, technical author, and course designer must all be aware of the roles played by these entities in the overall system.

Since we are discussing a general model of the human-documentation system, no specific details have been given. Along with Ashby [91] we do not ask "What is this thing?", but instead "What does it do?". Consequently, the questions that can legitimately be asked of the model are:

i) What does it do to meet its system goals?

ii) What does it do to reduce the set of predictable, and unpredictable, interaction effects?

An attempt will be made to address these questions in the next two chapters.

Chapter 5

Changing attitudes towards documentation

Some of the merits of teaching people to use documentation were mentioned briefly in Chapter 4. If we accept that users' attitudes towards documentation are largely unknown to the technical author, it is probable that these attitudes (particularly negative ones) will emerge only when users come into contact with the documentation, i.e. when they attempt to use it. If these attitudes emerge under the controlled conditions of a training course, *where people have to use the documentation as part of the course*, it is possible that these attitudes may be changed permanently for the better. It is at least worth trying!

A course designer, planning a course which is designed to change attitudes, would need to know some attitude theory: the origins of attitudes, reasons for their persistence, and how they may be changed. Clearly, an overt approach to changing attitudes is unlikely to work, but a skilful blending of attitude theory into the course structure and methods could have the desired effect. To elaborate on this, the rest of this chapter is devoted to attitude theory, and its potential for changing users' attitudes towards documentation.

5.1 Definitions of the term 'attitude'

To understand the effect of attitudes on the use of documentation, it may be helpful to define the term 'attitude'. Unfortunately, there is no single definition of attitude on which all psychologists can agree, but the sample of definitions shown below might help to clarify the term:

"An attitude is a mental and neural state of readinesss, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related" [92]

"An attitude is a learned orientation, or disposition, toward an object or situation, which provides a tendency to respond favourably or unfavourably to the object or situation" [93] {The learning may not be based on personal experience but may be acquired through observational learning and identification.}

"....attitudes have social references in their origins and development and in their objects, while at the same time they have psychological reference in that they inhere in the individual and are intimately enmeshed in his behaviour and his psychological make-up" [94]

"An attitude is a predisposition to act in a certain way towards some aspect of one's environment, including other people." [95]

"An attitude can be thought of as a blend or integration of beliefs and values" (96)

" Attitudes are likes and dislikes" [97]

5.2 Components of attitude

To understand what it means for someone to have an attitude towards documentation, it may help to think of an attitude as having three components (see Figure 20 [97]):

1) A *cognitive* component - what the user *believes* about documentation. This component corresponds to the idea of documentation as a category, an idea that comes into use when people think about documentation. Thus the category 'documentation' can be inferred from the consistencies in

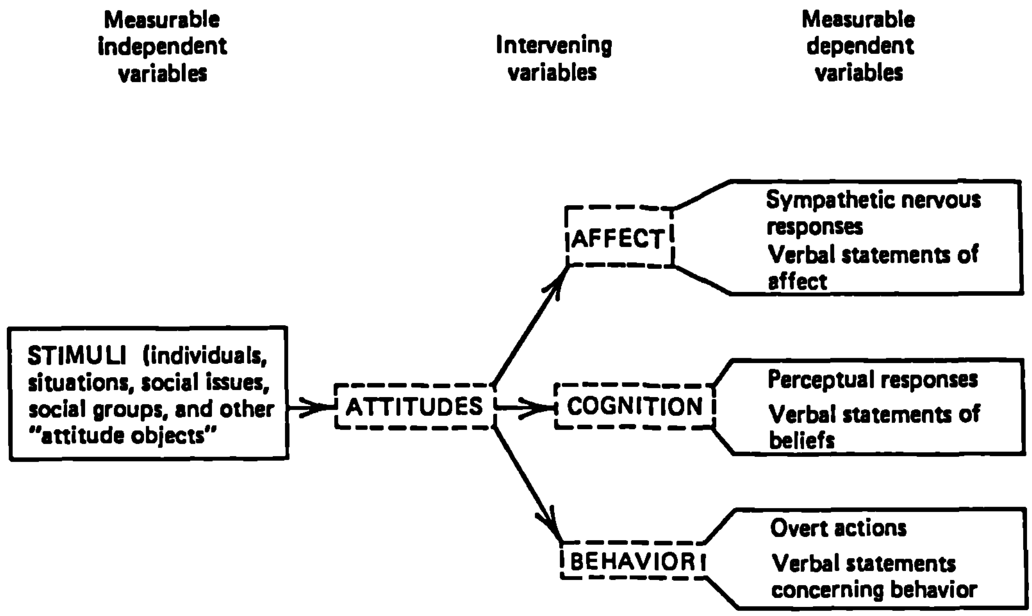


Figure 20 Schematic components of attitude

the responses people make to discriminably different stimuli such as manuals, handbooks, help screens, instruction leaflets, etc. Factual statements of the form 'documentation is........' are also part of this component.

2) An *affective* component - what the user *feels* about documentation. This component is the emotion that charges the idea (98). Someone who feels badly about documentation may be said to have a 'negative affect' towards it.

3) A *behavioural* component - how the user actually *responds* to documentation. This component is a predisposition to action, such as using or not using a manual.

The cognitive representation of a category such as documentation is the minimum condition for having an attitude towards it. However, this is not a sufficient condition, and an attitude towards documentation cannot be said to truly exist until the category 'documentation' becomes associated either with pleasant/unpleasant events or with desirable/undesirable goals. When this happens, the 'idea' of documentation becomes charged with *affect*.

The more pleasant the events, and the more frequently they occur in the presence of documentation, the greater the amount of positive affect that becomes attached to the documentation. Similarly, the more desirable the goals that can be reached through using documentation (and the more certain a person is that by using documentation he will attain desirable goals), the greater the positive affect.

Thus a maintenance technician who gets on well with documentation, and is able to use it successfully in his work, is very likely to have a positive affect towards documentation, and will tend to use it in preference to other sources of information. Unfortunately, the reverse is also true.

The supporters of the three component view claim that there is consistency between the components, which implies that people's behaviour towards documentation ought to be consistent with their verbal statements concerning it.

Unfortunately, people do not always behave towards an attitude object in the way suggested by their verbal statements. Thus they may dislike documentation, yet use it to impress their superiors (look how conscientious I am!). Or they may like documentation yet <u>not</u> use it, to impress their peers (look how clever I am!). There may also be instances where someone who approves of documentation will not use it because the culture in his working environment is against documentation (see adjustment function, page 131).

Since the evidence for consistency is inconclusive, many researchers have adopted the expectancy-value approach, which suggests that a person's attitude towards documentation might be a function i) of his salient beliefs that documentation has certain attributes, and ii) his evaluation of those attributes. Unlike the three-component view of attitudes, the expectancy-value approach makes no assumption that an individual's *behaviour* towards documentation will be consistent with his *attitude* towards it.

The expectancy-value approach is demonstrated in Table 3, which shows belief strengths and evaluation scores relating to documentation for a hypothetical case invented by the writer (the result shows that the subject's overall attitude towards documentation is moderately negative!).

Table 3 : Hypothetical Example of the Expectancy-Value Approach to Documentation

DOCUMENTATION ATTRIBUTE	BELIEF STRENGTH*	EVALUATION**	PRODUCT#
Helps the user to learn the system	+1	+2	+2
Helps management keep control over the workforce	+2	-3	-6
Helps to prevent costly errors in equipment maintenance and operation	+1	-3	-3
Helps in troubleshooting	+1	+3	+3
Is relevant to the user's needs	+1	+3	+3
			Sum = -1

* = Scales run from -3 (unlikely) to +3 (likely)
** = Scales run from -3 (bad) to +3 (good)
\# = Attitude defined as the sum of the products of the belief strength and evaluation scores

5.3 Attitude formation and development

Following the arguments of Triandis [98] and Katz [99], there are four reasons why people might form and develop attitudes towards documentation:

1) As part of their tendency to organise and simplify the complex information they receive from the world around them (Katz calls this the *knowledge function*). Thus a negative attitude towards documentation could enable someone to dismiss all examples of documentation as worthless,

thereby avoiding the cognitive effort needed to assess each individual example on its merits.

2) To protect their self-esteem by avoiding an unpleasant truth about themselves (the *ego-defensive function*). Thus having a negative attitude towards documentation might enable them to hide the fact that they find it difficult to process written information.

3) To help them maximise the rewards (and minimise the penalties) they might incur when operating in a given environment (the *adjustment function*). Thus if they have to operate in a workplace where the culture is against documentation, they can win the approval of their peers by adopting a negative attitude towards documentation.

4) To allow them to express their fundamental values (the *value-expressive function*). People like to express attitudes which reflect the values they hold dear. It is therefore possible that someone who feels strongly about teamwork in a group, might develop a negative attitude towards documentation. Thus it might give satisfaction to express this attitude in the form 'I never use documentation because I believe that problems should be solved by group dynamics'.

Attitude theorists generally agree that attitudes are learned, and there are two main theories as to how this learning takes place. One view is that attitudes are learned not so much from direct experience with an attitude object, but from close contact with a group that exhibits a strong affect towards that object. Thus an individual may develop an attitude toward documentation by being exposed to peer group pressure.

Other researchers have found that classical conditioning is a common cause of attitude formation [100] [101]. Although doubt has been cast on this evidence (mainly because of uncertainties about the experimental procedure), it is now generally agreed that positive or negative feelings can be directly linked with a stimulus through classical conditioning, and that the resulting affect will thereafter determine the evaluation of that stimulus.

Thus there are at least two ways in which classical conditioning might influence a negative approach towards documentation:

1) The appearance of a manual (CS) may evoke memories of unhappy experiences with other instructive reading material, i.e. school text books (UCR), creating an antipathy towards documentation (CR);

2) The sight or mention of documentation, initially a neutral stimulus, may become paired with a feeling of inadequacy when the user fails to use the documentation successfully (UCS). This UCS may lead to a feeling of antipathy (UCR) towards documentation in general. Eventually, the sight or mention of documentation (CS), may be enough to elicit antipathy (CR) towards documentation, without further interaction ever taking place.

Of the two theories of learning described, classical conditioning is likely to be more important when the attitude object is unfamiliar or neutral. As Petty and Caciappo [102] noted:

"As people learn more about a stimulus....their thoughts about it become increasingly more important determinants of their attitude towards it."

Hence it is likely that attitude formation may be linked to information processing. Thus if people can be educated to use documentation properly, there is a strong chance that they will form positive attitudes towards it.

5.4 Attitude change (I)

The most influential theories of attitude change are based on the principle of cognitive consistency, which treats people as internally active information processors capable of sorting and modifying a large number of cognitive elements to make cognitive sense of their environment. This is the principle which course designers should take into account when planning courses on how to use documentation. Three of the best known consistency theories are:

a) Heider's *balance theory* [103] - which claims that people seek harmony among their various values and beliefs, and tend to evaluate in similar ways things that are related to each other. This is similar to the knowledge function on page 131.

b) Osgood and Tannenbaum's *congruity theory* [104] - which maintains that when two attitudes or beliefs are inconsistent with each other, it is the less firmly held one that will change. Thus if new documentation is self-evidently good, weak negative attitudes may be changed.

c) Festinger's *cognitive dissonance theory* [105] - which claims that whenever someone simultaneously holds two psychologically inconsistent cognitions, that person will experience a negative drive state known as dissonance (a state of psychological discomfort or tension) which motivates them to reduce the dissonance by undergoing attitude change {cognitions are 'the things a person knows about himself, about his behaviour and about his surroundings [105]}.

Cognitions may be consonant, dissonant, or irrelevant to each other, and the amount of dissonance associated with a cognition k is given by the ratio:

$$\frac{\text{Sum of cognitions dissonant with k, weighted by importance}}{\text{Sum of cognitions consonant with k, weighted by importance}}$$

It is useful to remember that dissonance theory regards the human being not as a rational creature, but as a *rationalizing* creature, who needs to appear rational both to others and to himself. This can be seen from the three most common ways dissonance may be created, and then subsequently dissipated by attitude change:

1) *Dissonance following a decision* - If a person has to choose between two equally attractive objects or activities, then one way of reducing the resulting dissonance is to emphasize i) the desirable features of the one selected, and ii) the undesirable features of the one

rejected. In this way the number of consonant cognitions is increased and the number of dissonant cognitions decreased. In addition, people tend to actively avoid information which emphasizes the most desirable qualities of the one rejected (because this will add to the dissonance) and to actively seek information which supports their choice (because this increases consonance).

Thus in a particular working environment someone may have to choose between asking a colleague for information (there is usually a resident 'expert'), or using documentation. If asking a colleague is the first resort (e.g. for social or political reasons), the perceived advantages ('promotes a team spirit', 'it's easier') will block out awareness of the actual disadvantages (the expert may be taken ill or may be transferred elsewhere!). Similarly, reasons will be found to justify the decision not to use documentation ('it is difficult to use', 'it doesn't tell me what I want to know') even though these reasons may have no foundation.

2) *Dissonance resulting from effort* - When a voluntarily chosen experience turns out badly, the fact that the individual chose it may lead to the belief that it actually turned out rather well. The greater the hardship or sacrifice associated with the choice, the greater the

dissonance and, the greater the pressure towards attitude change. Thus if someone chooses to ask a colleague for information rather than use a manual, and if the advice given is faulty and leads to equipment breakdown, the decision may be justified by saying 'I've learned more from this than I ever could with a manual', even though the information contained in the manual was relevant and correct, and would not have caused a problem.

3) *Dissonance resulting from counter-attitudinal behaviour* - The attitudinal consequences of engaging in counter-attitudinal (sometimes called forced compliance) behaviour have been studied extensively within the framework of cognitive dissonance. Thus, a technician might be persuaded to use a manual to find and fix a fault on a particular machine as part of a field trial of new documentation (it is important that despite the name *forced compliance,* there must be no actual or perceived element of compulsion, or there will be no cognitive dissonance and consequently no attitude change). If the technician had a negative attitude towards documentation prior to this experience, the act of using a manual as a job aid is likely to cause cognitive dissonance, which may be resolved in one of two ways:

i) Either the attitude towards documentation will change (particularly if the manual proves to be helpful), or

ii) It may be argued that since the manual is not typical of manuals in general, there is no reason to alter the existing attitude towards documentation.

Another form of counter-attitudinal behaviour may occur when someone with a negative attitude towards documentation is persuaded to promote the virtues of documentation to another person who is unaware of this attitude (in the style of the Festinger and Carlsmith experiment [106]). Provided the subject feels that the counter-attitudinal behaviour engaged in is truly voluntary, and that the behaviour will have important (typically aversive) consequences for the other person, cognitive dissonance is likely to result. One way of reducing this dissonance is for the subject to adopt a more positive attitude towards documentation (in keeping with the maxim: 'if you can't change your circumstances, change your mind'). Then persuading another person to use documentation no longer produces discomfort.

Although Festinger's theory is useful, there are many researchers who are not convinced of its validity [107] [108] However, it is Bem's Self Perception Theory [108] that poses the major challenge to Festinger.

Bem argues that people have no need for internal consistency and that attitudes are mostly the result of people observing their own behaviour. Thus people with a neutral attitude towards documentation who are unable (for whatever reason) to use it effectively at the first attempt, are likely to infer that they do not like or 'get on' with documentation. In other words, initial behaviour may determine subsequent attitude.

This suggests that modification of behaviour may produce comcomitant changes in attitude. Bem's position is supported by other researchers in this field [109] who concluded that Self Perception Theory was a viable alternative to cognitive dissonance theory. Fazio [110] however argues that Bem and Festinger are both right depending on the circumstances; Bem is right when attitude is consistent with behaviour, and Festinger is right when behaviour is inconsistent with attitude.

5.5 Attitude change (II)

An altogether different approach to the cognitive consistency theory, is the notion that people may change their attitudes if exposed to persuasive communications. The pioneering work in this field was done by Hovland and his colleagues in the Yale Communication and Attitude Change Program in the 1950's [111].

Rather than develop a formal theory of attitude change, the Yale researchers took a more pragmatic view which can be characterized as a message-learning approach [102]. The basic idea is that for a persuasive communication to be effective (i.e. to cause a change in attitude) the message contained in the communication must at least be learned, such that it is remembered (the retention of the message is thought to depend on attention and comprehension).

However, learning a message is not a sufficient condition for a change in attitude to occur; in addition, the recipient must accept the learned message. As Hovland and Janis [112] put it:

" attention and comprehension determine how much of the content of the message the recipient will learn; other processes, involving changes in motivation, will determine whether or not he will accept or adopt what he learns".

Thus for a change in attitude to take place, the recipient must attend to the message; understand it; accept it; retain it; and act on it [113].

According to Hovland and Janis, attitude change due to persuasive communications is a function of the four inter-related factors shown in Figure 21 [129]. These factors (specifically related to documentation) are discussed below.

5.5.1 Source

The source of the communication in this instance would be one or more of the instructors at the training centre, who would need to be able to satisfy the criteria shown below:

a) *Status or credibility* - the more expert the source, the greater the possibility of attitude change. Instructors usually have the status and credibility to communicate a message effectively, but this factor will have less importance if the trainees have strong negative feelings about documentation. However, the credibility of the instructor will be stronger if the trainees can identify with him (e.g. if he has done similar work to them in the past).

b) *Attractiveness* - A source who is charming, humorous and possesses a pleasant manner is likely to be more persuasive than someone who does not have these qualities. As professional communicators, instructors are more likely than most to have the required qualities. An instructor without these qualities is likely to cause

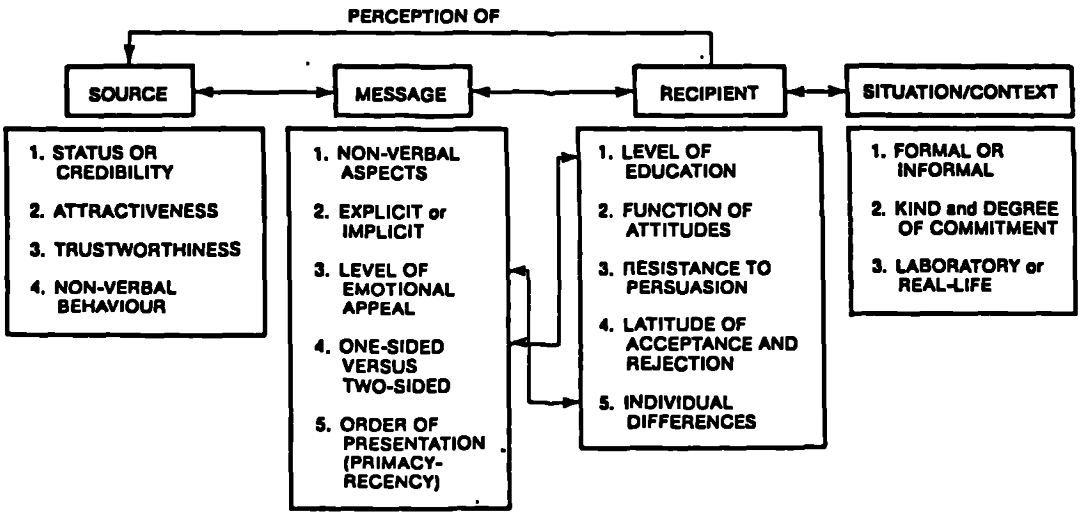


Figure 21 Major factors in persuasive communication

trainees to take the opposite view to the one being promoted by the instructor.

c) *Trustworthiness* - This relates to the perceived intentions and motives of the source. A source suspected of having ulterior motives will not easily bring about attitude change. Fortunately, an instructor is someone who is usually perceived to be acting in the best interest of trainees. Therefore, anything said about the merits of documentation is likely to be believed and acted upon.

d) *Non-verbal behaviour* - This is important because it can affect the perceived attractiveness and trustworthiness of the source. One especially pertinent dimenson of non-verbal behaviour is proximity. In an experimental study by Albert and Dabbs [114], it was found that most attitude change took place when the source was 14 to 15 feet away, and the least when the source was 1 to 2 feet away (people like to maintain their intimate zone!). Instructors are able to meet this criterion because they usually operate from the front of a classroom or lecture theatre, hence they automatically maintain a respectable proximity, either the social-consultative distance (4 to 12 feet) or the public distance (over 12 feet) recommended by Hall [115].

5.5.2 Message

The message in this instance could be to the effect that documentation is an essential tool in the field, and that familiarity with the documentation presented on the course will improve the ability of the trainees to cope with the complexities of the associated equipment. In order to deliver this message effectively the instructors will have to satisfy the following criteria:

a) *Non-verbal aspects* - Face to face communication is effective in changing attitudes because the source is able to receive feedback in the form of facial expressions, eye contact, body posture, and so on. This enables the source to anticipate arguments and hence modify the message or present counter-arguments. Maslow et al [116] found that over and above the content of a message, how confidently it is presented is a crucial variable. An instructor is experienced in face to face communication, and is usually able to interpret the body language of trainees and, if necessary, modify the communication to achieve the desired objectives (in this case to change attitudes). Instructors also tend to be confident communicators, which makes them more persuasive.

b) *Explicit or implicit* - The question here is whether the message should be clearly defined (so that no one is in any doubt as to the conclusions to be drawn) or whether an implicit message is more effective, leaving the recipients to work out the conclusion on their own. Fortunately, an instructor can use both types of message. Arguments for documentation can be stated explicitly at the beginning of (and throughout) the course, and the documentation can be used skilfully to convey the implicit message that documentation is a powerful tool for dealing with complex equipment.

c) *Level of emotional appeal* - Anxiety can be used to change attitudes, but it may not be effective under all circumstances and with all types of people (see Figure 22 [129]). The effect of inducing anxiety will ultimately depend upon the individual. People with a low level of initial concern (normal level of anxiety) will be more likely to change an attitude than someone with a high level of initial concern who may be pushed into Sector 3, where the person's defences will deal with the high level of anxiety, i.e. the message may be denied or repressed.

An instructor could create moderate anxiety by warning trainees that the equipment is too complex for them to manage without the aid of good documentation.

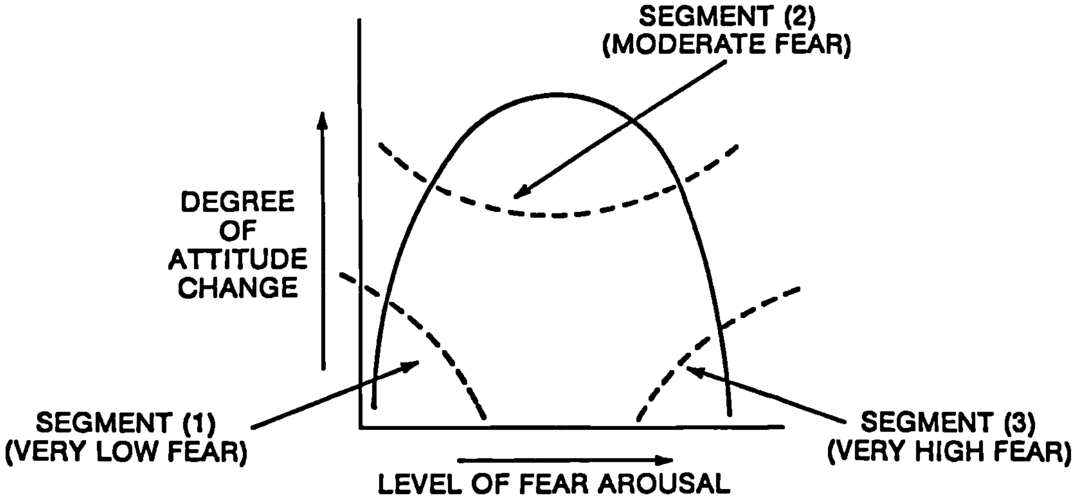


Figure 22 Attitude change and fear arousal

Otherwise, if the documentation is used as a teaching aid, fear of failing the course might be enough to encourage trainees to change their attitude (but possibly not permanently!).

A better approach might be for the instructor to first emphasize the complexity of the equipment (thereby creating moderate anxiety) and then give trainees <u>specific</u> and <u>precise</u> instructions on how to use documentation to deal with the complexity. If the trainees believe that these instructions (and hence the documentation) will work, significant attitude change may take place [117] [118]. Whichever approach is used, the instructor must know the trainees well: too little anxiety and attitudes may not change at all; too much, and the anxiety (and hence the message) may be denied or repressed.

d) *One-sided versus two-sided arguments* - Generally speaking, when an audience know about the counter arguments to a message, they are most persuaded by a two-sided approach which explicitly refutes these counter arguments [119]. Since instructors are able to choose their teaching methods, they can decide whether or not to give both sides of the documentation argument. For example, they can speak only of the advantages of using documentation, or they can give equal emphasis to the perceived disadvantages.

Before they make this decision they need to know something about their trainees (possibly by conducting a pre-test of attitudes). Trainees who already know about the counter arguments to documentation might be persuaded by an approach which explicitly refutes these arguments. Therefore, to bring about an attitude change, the instructor might emphasize the disadvantages of seeking information from sources other than documentation. However, when trainees are not strongly opposed to documentation, the single-sided approach, giving only the advantages, should work just as well.

e) *Order of presentation (Primacy-Recency)* - If a two-sided presentation is used, the question facing the source is whether to introduce the message first (thus taking advantage of the primacy effect) or to introduce it last (thereby relying on the recency effect). If both sides of the argument are presented by the same person, and if the audience is not initially aware that conflicting arguments are going to be presented, the primacy effect is likely to be the most powerful [120].

The primacy effect is also likely to dominate if the audience is very involved with the topic (i.e. if it is very controversial), but the recency effect will prove stronger if the audience is either not familiar with the argument or is not very interested in it [121].

Another important factor is the time interval between the message and its counter arguments. If this interval is small, the primacy effect is most significant; if it is large, the recency effect predominates [122].

Finally, if there is to be no delay between the message and its counter arguments, the arguments against should be given first and then strongly refuted. This ensures that attention is given to the main message for most of the presentation [123].

Fortunately, instructors have the advantage of being able to control the order and the timing of their communication. Thus if trainees are not initially aware that conflicting arguments about documentation are going to be presented, and/or if the issue of documentation is likely to be very controversial, the instructor can take advantage of the primacy effect by presenting the arguments for documentation first.

This strategy is particularly effective if the arguments against documentation follow shortly afterwards. However, if the trainees are either not familiar with the arguments against documentation, or if they are not very interested in the issue, the arguments for documentation should be given last to take advantage of the recency effect. If there is going to be a significant delay between each side of the argument, the case against documentation should be given first and then strongly refuted.

5.5.3 Recipients

The recipients of a message are the trainees whose attitudes the instructor is trying to change. To succeed, the instructor must take into account the following attributes:

a) *Level of education* - The more educated someone is, the more likely they are to be influenced by a two-sided argument [124]. Either they are better equipped to deal with this type of approach, or they feel more in control if they have all the information at their disposal before making a decision. Instructors may therefore have to vary the way they deliver their message, according to the status of the trainees. In a group of mixed ability, it might be appropriate to start with a one-sided argument, and reserve the two-sided argument for dealing with those trainees who need further persuasion. Fortunately, instructors are usually skilled at mixed-ability teaching.

b) *Function of attitudes* - Many psychologists believe that not all attitudes have the same significance for the individual, and that they in fact may serve different functions (see page 131). It follows from this that some attitudes may be harder to change than others. An instructor has therefore to take this into account and accept that a single approach may not work well for the whole group. To allow for this, the instructor may try to take advantage of all the functions by dividing trainees into teams for fault-finding exercises (designed around the manuals), in which competition between teams is encouraged.

In this situation, the *knowledge function* can come into play when trainees realise that intelligent use of documentation can ensure predictability, consistency, and stability in carrying out the tasks they have been set.

The emphasis on teamwork should exploit the *adjustive function*, since each team member will pay attention to the manuals to avoid incurring the disapproval of the others.

An instructor can make use of the *value-expressive function* by appointing carefully selected trainees (i.e. those with high self-concept and a sense of personal integrity) to the position of team leader. If such people are made to feel that the job is worthwhile, they will respond not only by using the manuals themselves, but also by encouraging others to do the same.

Finally, the ego-defensive, function could come into effect if members of a group hide their feelings by expressing their belief in the value of documentation, and emulating significant others in the group (but the attitude change may not be permanent unless this strategy proves to be successful).

c) *Resistance to persuasion* - Resistance is strongest when counter-arguments are available, and weakest when they are not. Not surprisingly, the more committed the audience is to an issue the more resistant they are to change [125]. Also, initial exposure to counter-arguments can 'inoculate' people against attempts to change their attitudes [126].

d) *Latitude of acceptance and rejection* - These terms refer to the arguments a person is (*latitude of acceptance*) and is not (*latitude of rejection*) prepared to accept. When the difference between the attitude a person holds and the one he is required to adopt is large, and when ego-involvement is high, the latitude of acceptance is small, and the persuasive message tends to fall into the latitude of rejection. Under these circumstances attitude change is extremely unlikely. However, the situation can be improved if the source is careful about the way he communicates the persuasive message [127]. For example, extreme statements unfavourable to the entrenched attitude tend to be perceived as even more hostile or unfavourable than they really are (*contrast*); while less extreme statements may be gradually incorporated into the person's latitude of acceptance (*assimilation*).

e) *Individual differences* - The likelihood that a persuasive communication will be able to change the attitudes of a group of people will depend to a large extent on the self-esteem, persuasibility, and intelligence of the members. Although the Yale researchers recognised the significance of these attributes, early research produced apparently conflicting results. For example, intelligence was sometimes linked with greater persuasibility and sometimes with less persuasibility.

McGuire [113] suggested that it was not uncommon for intelligence or self-esteem to have contrasting effects on message reception (including attention, comprehension, retention and yielding). He argued that intelligent people are likely to be better at comprehending and remembering a message (which should enhance message reception and hence attitude change), but are also more likely to be critical of the content of the message and (perhaps) more confident of their existing attitudes, which should diminish yielding, and hence attitude change. Following McGuire's reasoning, the relationship between intelligence and persuasibility is as shown in Figure 23 [113], where the probability of accepting the message (i.e. the probability of attitude change) is assumed to be a joint function of reception and yielding.

Evidence consistent with McGuire's model comes from Nisbett and Gordon's study of self-esteem and persuasibility [128]. They measured their subject's self-esteem and a week later gave them a number of statements about health which were either simple, unsubstantiated statements or statements with supporting documentation.

The unsubstantiated statements should have been easy to comprehend but not especially likely to produce yielding; the substantiated statements were more difficult to comprehend but contained more reasons for yielding. It was also found that subjects with medium self-esteem changed attitudes most when the statements were unsubstantiated, whereas subjects with high self esteem displayed most attitude change when the statements were more complex.

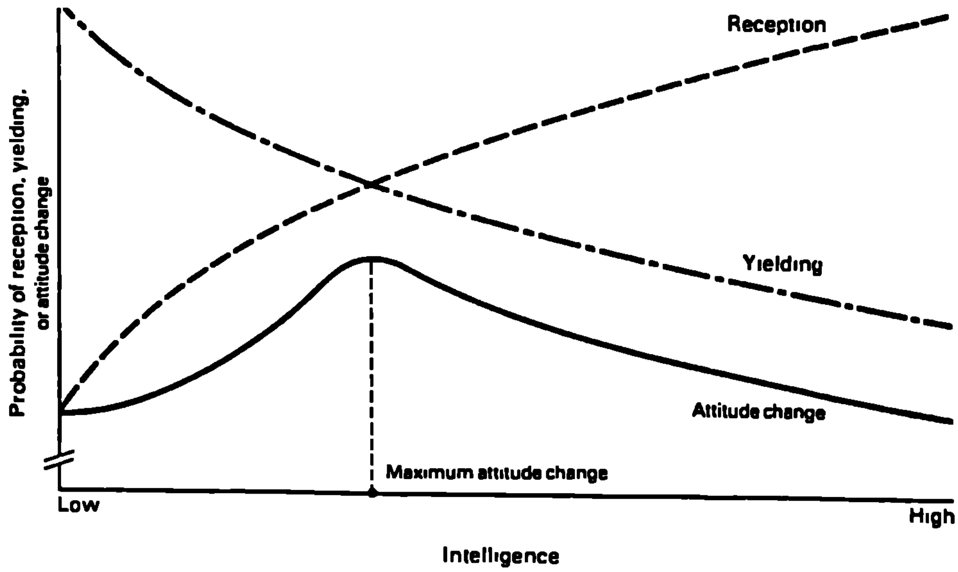


Figure 23 Intelligence and attitude change

These results have important implications for instructors who want to incorporate attitude theory in their lectures, because they would have to be very careful when instructing mixed ability groups. For example, a group of trainees may well contain representatives of the three groups of non-user described on page 1 of this thesis. If so, a different teaching style might be needed for individuals within the group.

It would be helpful when dealing with mixed ability groups if the instructor had a profile of each trainee, based on personnel records, and a pre-course attitude profile. This would also enable an instructor to form sub-groups with the necessary internal dynamics to change attitudes.

5.5.4 Situation or Context

The situation or context in which communication takes place is also important:

a) *Formal or Informal* - Informal situations such as group discussions or role play often prove more effective than formal situations, partly because people cannot identify who is trying to influence them and for what reason (see the last paragraph of 5.5.3).

b) *Kind and Degree of Committment* - In a group context, people may be obliged (by pressure to conform) to make a public committment to a particular attitude (see last paragraph of 5.5.3). Later, they may undergo a genuine attitude change through the need to reduce cognitive dissonance.

c) *Laboratory or Real Life* - Laboratory studies are more likely to produce attitude change than real-life situations for a variety of reasons [129]. Thus it is possible that instruction at the training centre could be more effective than instruction in the workplace.

5.6 Attitude and behaviour

From earlier discussions it was seen that there are basically two opposing views on attitudes, 1) that attitude causes behaviour (Festinger), and 2) that behaviour causes attitude (Brem). When considering the response of people to documentation, both views could be true, for example:

a) People may be influenced against documentation simply by hearsay or peer pressure. Thus a negative attitude towards documentation, developed without direct experience of using it, could lead to rejection (behaviour). Fortunately, the converse is also true.

b) People may be influenced against documentation when they have difficulties with equipment, due either to poor quality documentation, or the inability to cope with good quality documentation. Thus direct experience with documentation (behaviour) could cause either a negative or a positive attitude towards documentation. It is the task of the instructor to try to ensure that the trainee adopts a positive attitude.

Even if an attitude towards documentation exists, an instructor needs to be aware that it is neither a necessary nor a sufficient cause of behaviour. The attitude someone has toward documentation may be inferred from what he *says* about it, from the way he *feels* about it and the way he *says he will behave* towards it, but these are not reliable clues to the way he will *actually behave* towards it (particularly when back at work). Indeed, the relationship between attitudes and behaviour is sometimes quite weak and at other times quite complex (see Figure 24 [97]).

Generally speaking, attitudes involve what people *think* about, *feel* about, and how they would *like to behave* towards an attitude object. Behaviour, on the other hand, is not only determined by what people would *like* to do, but also by what they *think* they should do (social norms), by what they *have habitually done*, and by the *expected*

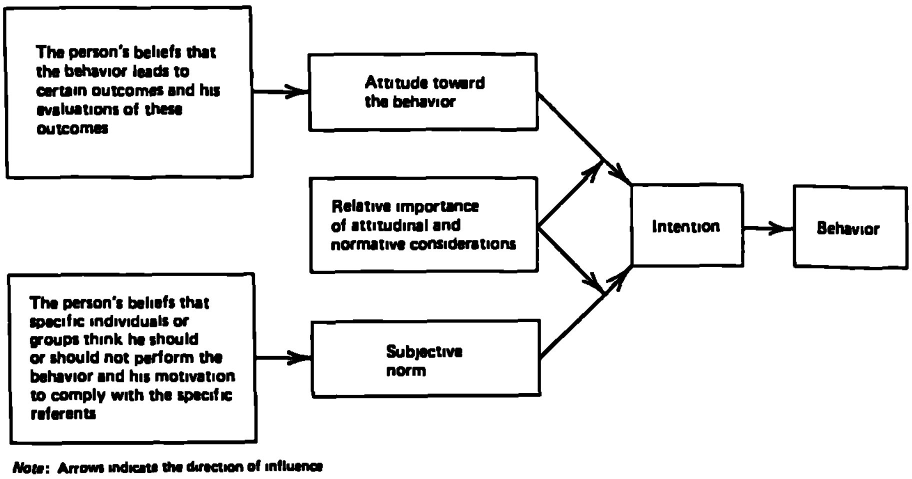


Figure 24 Factors determining behaviour

consequences of their behaviour. When these four aspects of behaviour are consistent, the correlation between attitudes and behaviour can be quite strong.

Thus a technician may want to use new documentation, but be inhibited from doing so by peer pressure (the prevailing norm) and the fact that he has simply lost the habit of using documentation. On the other hand, if the management insists that the documentation is used by everyone, the technician may consider it imprudent to refuse. Once he perceives it to be in his interest to use documentation, the inhibitions may disappear and a positive attitude develop (at least temporarily!).

5.7 A basis for an appropriate course

Triandis [97] suggests that the major dimensions underlying behaviour toward any kind of attitude object are positive versus negative affect; and seeking versus avoiding contact. This concept is shown in Figure 25 (modified by the writer to refer specifically to documentation), and implies that negative responses to documentation are identifiable, and potentially reversible. The argument in this chapter has been that the training environment is the best place for this reversion to take place, and this argument appears to be justified by the literature on attitude theory.

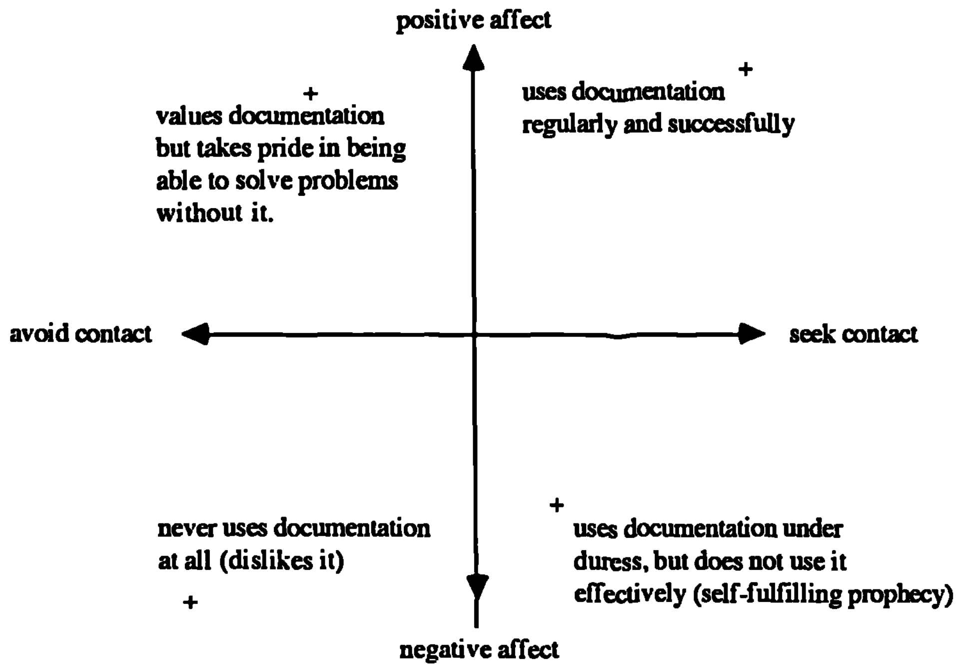


Figure 25 Dimensions of behaviour towards documentation

A course that was specifically designed to promote positive attitudes towards documentation might have the following features:

1) Trainees would be issued with documentation (i.e. the appropriate manuals for their function) instead of training notes, and one role of the instructor in the classroom would be to act as a guide to the documentation; teaching them how to use it, explaining diagrams, drawings, etc., helping them to find out for themselves the things they need to know, and encouraging them to make notes in their manuals for reference at work.

2) In the workshop, trainees would be encouraged to gain an understanding of the system with the aid of the documentation (i.e. mentally mapping the system to the appropriate sections of the documentation), by carrying out 'hands-on' exercises including simple tests and adjustments. Again, the need to personalize manuals would be stressed, because of the confidence that would give in the workplace.

3) Also in the workshop, trainees would be given real faults to deal with; faults which are moderately easy to diagnose and repair with the aid of the documentation, but difficult without it! Trainees would be encouraged to keep log books detailing the fault, and the action they took

to clear it, including the useful sections of the documentation, so that a mapping exists between certain kinds of fault and the appropriate areas of the documentation.

4) End of course examinations would test the trainees ability to use documentation effectively.

A course that was designed to reverse negative attitudes, remove psychological noise, or deal with the negative component of the unpredictable interaction effect (whichever viewpoint is taken) would need the close co-operation of system designer, technical author, and course designer as suggested by the full model of the human-documentation system shown in Figure 18, Chapter 4. By helping to ensure the effectiveness of the documentation, the model increases the probability that the human-machine system will work effectively (the prime objective!).

Chapter 6

The future for documentation

The ideas explored in the last chapter suggest that users' attitudes towards documentation may be changed for the better by an appropriately designed course based on attitude theory. This approach is intended to identify, and eliminate or reduce, the unpredictable psychological noise described in Chapter 2 (or the negative component of the unpredictable interaction effect defined in Chapter 3) and is in accordance with the full human-documentation system model defined in Chapter 4. Of course, more research is needed to establish the viability of the type of course described, but if it is proved to be successful, it may be a significant step towards totally effective documentation.

However, the case study described in Chapter 4 suggests that although it is important to change the attitudes of users, it is even more important to change the attitudes of managers and other senior staff who have the power to influence the success of a documentation project.

For as long as documentation is considered as an optional (and sometimes not very important) extra, the documentation problem described in Chapter 1 will remain. On the other hand, if influential people in an organisation can be persuaded to take documentation seriously, resources will be found to ensure the success of the documentation project, and reluctant users will take their cue from the management.

One way for documentation to be taken seriously is for it to become more academically respectable. At the moment, most of the information available on documentation is based on empirical findings, with the rest coming from academic research in other disciplines.

Empirical findings are certainly not trivial; in fact, they offer useful and practical advice on how to produce competent documentation, and could eventually lead to more abstract and general theories as the evidence accumulates and theoretical inferences are confirmed. Thus, one important role for documentation specialists is to provide a sound theoretical basis for the body of knowledge that currently guides their activities (see Chapter 2).

Academic research on the other hand is at the moment coming mainly from disciplines like Ergonomics, Cognitive

Psychology and Information Technology, where practitioners in these fields are becoming increasingly aware of the important and interesting questions that documentation poses. Therefore, another task for documentation specialists who want to raise the status of their domain, is not only to strengthen existing links with these disciplines, but also to find new links with other important domains.

For instance, consider the potential input from Cognitive Psychology. Understanding written information is a cognitive process, and documentation specialists can benefit from the many literature reviews available in cognitive psychology which summarize the available research on language comprehension and its implications for the design of written material.

Similarly, studies of the cognitive processes of writing can expose some of the cognitive limitations of documentation specialists *as writers*, and therefore affect not only the way technical authors work, but also the tools they use, and the training they receive.

However, the benefits are not all one way; research on the design of written information can have an equally beneficial effect on cognitive psychology. Information on how readers' interact with written materials raises a number of interesting questions for cognitive psychologists, and challenges their theories of reading. For example, most theories of reading are based on a simple three stage model: i) reading starts, ii) comprehension takes place, iii) reading stops.

This model, however, does not apply to most of the reading which takes place at work, where stopping is a much more frequent activity, and where continuation of reading often takes place somewhere other than at the last stopping point.

So research on documentation can challenge cognitive psychology to provide answers to the questions of interest to documentation specialists, e.g. what are the factors that determine a) *when* people read, b) *why* they read, and c) *how* they read (browsing, skimming, or studying)?

In a similar way, the use of word processors and desk top publishing equipment by documentation specialists can also raise interesting questions for cognitive psychologists, and challenge their understanding of the processes of writing.

For instance, new ways of designing information releases authors from the old constraints of pen and paper;

new skills are required, and the cognitive processes of creating and designing information are altered. As Wright [130] explains, even if technical authors seem to be using word processors much as they previously used pen and paper, computers are such unobtrusive monitors of their users that they often allow a clearer view of the dynamics of the composing process than is possible when authors work on paper. Therefore, studies of documentation specialists at work may have a direct relevance to the development of cognitive theories of writing.

Furthermore, although computers and associated software provide many new tools for technical authors (e.g. organizing, drafting and producing written materials), they also impose constraints on the design and the different styles that can be used. These constraints may only be temporary (software is improving all the time), but at present they are often critical features of the design problem since they create a bounded design space which is often more limited than before computers were available.

Research on the impact of information technology on reading and writing processes is currently taking place, and some specialists in the Information Technology field are now adding to the literature on documentation.

Ergonomists can also influence the design of written information by commenting on, and indeed specifying, the physical characteristics of the material used in documentation (e.g. size, colour, brightness, etc of paper and binding), and the way the physical form of the documentation relates to anthropometric data about the users (e.g. is the manual too heavy to be easily carried about?).

However, although documentation specialists can use ergonomic theory directly (there is a great deal of literature available), ergonomic guidelines seldom offer insights into alternative ways of achieving desirable goals.

For example, the ergonomic solution to a bulky manual would most likely be to distribute the material across several smaller manuals; whereas an information design solution might be to distribute the material *across different media*, leaving only a manageable amount on paper.

Although at first glance, research in documentation seems to offer nothing to ergonomics, the implicit challenge according to Wright [130] is 'whether ergonomists are more interested in the height of the desk than they are with the work done on the desk top'.

Wright (an ergonomist herself) believes that if ergonomists ignore the issues of reading and writing, a class of 'information managers' will emerge to specialize in the problems of documentation, and the future development of documentation will be in their hands rather than in the hands of Human Factors specialists. Fortunately, some ergonomists are aware of the opportunities that documentation offers, and are contributing to the body of knowledge on documentation.

Another important factor that needs to be stressed is that documentation need not be a 'once and for all' operation. Instead, following the comprehensive model described in Chapter 2, documentation can be an ongoing, dynamic, iterative process, capable of improving the efficiency and cost effectiveness of the system it supports. A process which starts when an author produces the best documentation possible, given all the information available, and continues during the life of the system, evolving with peoples' increasing awareness of the system's capabilities.

This increasing awareness may come through using the documentation (hence the importance of the measures described in this thesis) and/or through using the system <u>without</u> the benefit of documentation. For example, as people use documentation (at first during training, and then at work), their perceptions of the documentation are likely to change, possibly leading to revision of the documentation.

Similarly, although people may use documentation less as they become more familiar with the system, their awareness of how well the documentation supports the system is also likely to change and this too could lead to revision of the documentation. Either way, any new and potentially useful information about the documentation and the system should be disseminated as quickly as possible for the benefit of others.

To ensure rapid dissemination of information there needs to be an easily upgradable, centrally held, database for the documentation, and a quick and efficient method of information dissemination.

For an organisation operating either a local area network, or a distributed network, this could be fairly straightforward. For example, technicians could be instructed to check their E-mail box for information at the beginning of each shift. Perhaps a new and unusual fault has occurred at a particular site; the symptoms and the remedy are there for everyone to see! For other organisations, the fax or fax/modem may be the best way of sharing information.

Furthermore, requests from the field for amendments to documentation may in fact expose weaknesses in the system. Perhaps a maintenance routine is too difficult to implement because of system constraints. Or a troubleshooting solution does not work under certain conditions because of system characteristics that were not anticipated by the system designer. If the kind of liaison suggested by the human-documentation system in Chapter 4 is established and working well, feedback from technical author to system designer may lead to significant changes in system design.

Finally, the solution to the documentation problem described in Chapter 1 may lie in the education and training of everyone involved in the documentation process, at all levels. For the sake of simplicity, three broad groups may be identified; those who sponsor documentation, those who produce it, and those who use it.

Sponsors need to know how to recognise good documentation, the benefits it can bring, and the constraints under which producers work. Producers need to know how to satisfy the demands of sponsors <u>and</u> users, and the constraints under which sponsors and users have to work. Users not only need to know how to use documentation to the best advantage, but they also need to be persuaded that in the last analysis they have the responsibility for making documentation effective. At all levels, it may well be appropriate to use the attitude change techniques described in Chapter 5.

The training of documentation users has also been discussed in Chapter 5, and very little more needs to be said except to stress that education needs to play a key role in the training process. For training alone can never guarantee the shift in attitudes that is necessary for someone to use documentation voluntarily.

Documentation specialists are generally well served by a number of courses on how to practice their craft. There is a City and Guilds Course in Technical Authorship, and similar courses are run by local education authorities and private firms. These courses no doubt produce skilled practitioners, able to implement the type of documentation design and development process described in Chapter 2.

However, the notion of documentation as technical communication is being increasingly taught in higher education, and some universities in the USA have Departments of Technical Communication. In the USA particularly, courses tend to have an academic bias and this is a trend which must surely take hold in the UK before too long.

In addition to the academic bias, perhaps the time is now right for courses to include modules which strengthen the claim of the documentation specialist to be an equal partner in the team suggested by the human-documentation system model in Chapter 4.

For example, it has been suggested that technical writing is one-third writing proficiency, one-third problem solving skill and one-third ability to work with other people. Courses for documentation specialists should offer not only these skills, but also the specialist knowledge needed to work effectively with system designers (in engineering, computer science, etc.) and those involved in training. Ideally, a documentation specialist ought to be qualified in the discipline underlying the documentation.

But perhaps the most important people that need to be educated are those that can influence the future of documentation the most; those who provide the resources. Their co-operation is vital, because without support for documentation at the highest level it will always run the risk of being relegated to the margins of any activity. Perhaps it is now time for appropriate modules on different aspects of documentation to appear on higher education courses for engineers, computer scientists and managers.

If the experience in the USA is any indicator, people in the documentation field can look forward to an exciting period of professional development and expansion. No matter what form documentation takes in the future (e.g. whether it is on-line multi-media, or hard copy, or a mixture of both), there will always be a need to address the issues raised in this thesis. For the key question is not 'do we need documentation?', but 'how can we make it more effective?'.

Unfortunately, it is unlikely that documentation will become valued, and its practitioners respected, without some considerable effort on the part of the documentation community itself. Hopefully, this thesis has suggested ways to achieve these objectives. Perhaps the time has come for documentation specialists to take themselves and their domain more seriously, because until they do so, it is unlikely that anyone else will!

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Appendix 1

Some facts about the system in Chapter 4

1.1 History of development

Prototype development took place over a five year period, from 1984 until 1989, which included operational field trials at selected sites. This development work absorbed many thousands of man-hours, including an estimated 25 man-years of software development. In 1989, a £5m contract was placed for 16 production machines, which are currently in use.

1.2 General description

The machine measures approximately 8m long x 2.5m high x 1m wide. Its function is to sort items into designated receptacles according to an easily detectable visual characteristic possessed by each item (items without this characteristic are removed at a pre-sorting stage). Items to be sorted are the same shape, but they differ in size, from a minimum of 90 x 140mm to a maximum of 162 x 229mm. The thickness of the items also varies, but does not normally exceed 6mm.

One operator is required to load the machine with items prior to sorting, and one or two operators are necessary to remove the items after sorting, especially during busy periods. The operator interfaces with the machine through a sophisticated control panel which provides a range of diagnostic features (e.g. fault lights and status lights) as well as control buttons for various operating procedures. However, once the machine has been started by an operator it runs automatically until either a fault occurs or the machine is empty (the operator can, of course, stop the machine from the control panel if necessary, and there are emergency stop buttons around the machine). At its best, the machine can sort 30,000 items an hour, assuming that there are no interruptions.

Physically, the machine comprises two principal assemblies; the transport section and the control system cubicle. The transport section consists of various mechanical assemblies (e.g. belt systems) for transporting items from the input position to the output receptacles, power supplies, drive motors, electronic control hardware, wiring, switches and photobeam detectors for obtaining information on the progress of the items being sorted. There is also a detection unit for reading and interpreting the visual information carried by each item so that it may be directed to the correct receptacle.

Each functional section of the machine has its own associated electronic (microprocessor based) control system, with the microprocessor (known as a slave) located in the control cubicle. Each of 15 slave processors has an RS232 communications port so that it may send statistical and engineering data to the master computer (also housed in the control cubicle). This computer collects all data and stores it, for a limited period, in databases for the benefit of operational or engineering staff (for example, engineering staff use this information for diagnostic purposes). Access to this data may be obtained through a touch screen on the computer and subsequently through a printer interface if hard copy is required. Data may be entered into the computer (or the computer interrogated) through a conventional keyboard at the front of the control cubicle.

1.3 The documentation project

The documentation project also took many man-hours to complete (it lasted from 1989 to 1992) and resulted in an eleven volume manual set. Each manual covered an important aspect of the operation and maintenance of the system and was intended for a particular class of user (see Figure 19 on page 119). The statistics provided on the next page (excluding the piece parts manual) may give an indication of the magnitude of the project:

MANUAL (NORMALLY A4)	SECTIONS	PAGES	ILLUSTRATIONS
User Guide	8	67	7
Operator	3	24	4
Operations Manager	5	85	11
Engineering Manager (A5)	8	139	20
Troubleshooting (A5)	9	101	5
Maintenance	8	191	85
System Description [Material Flow]	9	37	19
System Description [Slave Processors]	10	107	23
System Description [Master Computer]	9	96	42
Electrical/Mechanical [Infrastructure]	8	156	110
	77	1003	326