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Pelle Ehn*
Morten Kyng

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Computer Science Department
AARHUS UNIVERSITY
Ny Munkegade – DK 8000 Aarhus C – DENMARK
Telephone: 06 – 12 83 55

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* Swedish Center for Working Life, Box 5606, S-114 86 Stockholm, Sweden

A TOOL PERSPECTIVE ON DESIGN OF INTERACTIVE COMPUTER SUPPORT FOR SKILLED WORKERS

Pelle Ehn* and Morten Kyng **

Abstract

This paper presents a conceptual framework, useful when designing computer support for skilled workers. We call this framework a tool perspective. It has emerged as a result of a growing dissatisfaction with the systems perspective, which tends to give an outwardly understanding, making men, machines and materials look alike and reducing work to algorithmic procedures, some of them candidates for inclusion into the edp programs.

The tool perspective takes the labour process as its origin rather than data or information flow, emphasising the development of tools to be used with skill by workers in control of the production. Development of professional education is in focus, rather than detailed analysis and description of the work.

Our main empirical illustration of the tool perspective is drawn from the Utopia-project†: the labour process of page make-up (pagination) in newspaper production.

Keywords and phrases: design principles, pagination, perspectives, professional education, systems, systems development, tools.

* Swedish Center for Working Life, Box 5606, S-114 86 Stockholm, Sweden.

** Aarhus University, Computer Science Department, DK-8000 Aarhus C, Denmark.

† In the Scandinavian languages, UTOPIA is an acronym for education, technology and product in a quality of work perspective. It is also the name of a research and development project on pagination and digital picture processing for newspaper production. The aims of the project is to develop powerful tools for skilled workers. The project is carried out jointly by graphic workers, computer and social scientists. It was initiated by the Nordic Graphic Trade Unions in 1980 [4].

1. THE SYSTEMS PERSPECTIVE

Systems, systems, systems

It is difficult to talk about edp applications without using the word "system" and without implying a systems perspective. There are many reasons for this. First of all the computer itself fits most definitions of the concept "system" nicely. Secondly, the computer, viewed in the systems perspective, is a powerful instrument in controlling large, hierarchical organizations.

For these reasons a number of highly successful edp systems have been constructed over the years. On the other hand, numerous remarkable failures have also occurred, e.g. in the field of management information systems.

To improve the quality of new edp systems much attention has been paid to the process of systems development. We adhere to much of the critique raised against traditional systems development and to some of the proposed remedies, e.g. prototyping and union based user involvement [1, 3, 15].

In some cases, however, the systems perspective itself is part of the problem. The development of edp support for skilled workers being one such case. The main purpose of this paper is to present and discuss a perspective on development and use of edp suited for this case. We call this a tool perspective.

In the rest of this section we present our interpretation of the systems perspective. Then we discuss some impacts of the systems perspective, and why these impacts may be undesirable in some cases. In section 2 we present the tool perspective and its application to the development of edp based "tools" for page make-up (pagination). In section 3 we discuss some implications of a tool perspective on analysis, design and the development process. Finally we point to some of the limitations of a tool perspective.

Some characteristics of systems

When we use the term system or systems perspective without further qualifications, it is meant in a rather broad sense, covering "schools" such as the Swedish Langefors/ISAC and the Norwegian Nygaard/Simula/Delta [9, 11].

Common to these schools is a strong influence from computers, programming and development of batch oriented edp-systems. (And also a strong influence on programming and systems development). According to these schools structure plays a dominant role. A system consists of a collection of objects and their relations. Processes occur within fixed boundaries; and the basic aspects of the objects and their relations are unaffected by the processes [12].

Computers and programs

A computer with peripherals is easily understood in systems terms: the system consists of the computer, auxiliary storage and input/output devices, all connected in well-defined ways. The processes in a computer system also fit nicely into the systems perspective. They occur within fixed boundaries according to a set of complete descriptions: the programs.

Influence from the systems perspective increased the quality of the products in the field of data processing during the last decades. Mainly because a large number of the edp-applications fitted well into the systems perspective. But as computer applications became more integrated into people's work, many applications simply didn't have the characteristics necessary to make the systems concepts applicable in a direct way. Often there were no one way to break a system into subsystems with well-defined boundaries, and in other cases it was not even possible to fix the system boundaries in the early stages of the development. Important aspects could not be described as properties of disjoint objects or as relations between such objects. This is for instance the case with the kind of interactive computer support for skilled workers discussed in the following sections.

In such cases one might expect the systems concepts to be abandoned, but this seldom happened.

First of all because of the lack of alternatives. Only recently have new ways of developing such applications been proposed for commercial use, and they often rely heavily on advanced workstations and programming environments, the cost of which were prohibitive only a few years ago. One of these alternatives is the exploratory programming environments [16], which are much closer to the tool perspective discussed below, than "traditional" structured methods.

Secondly because the systems perspective has some advantages from the point of view of (managerial) control.

Systems perspective and managerial control

A number of research projects have found the following general trends with respect to the jobs of most workers, when analysing the use of edp based information systems, especially production control systems [3, 15]:

- less need for experience and skill,
- less control over and understanding of the production process,
- increased division of labour, and
- less planning as a part of the job.

Clearly, this is not in the interest of organized labour, and a number of Scandinavian research projects have studied these questions during the last decade. Focus has been on knowledge about local and central trade union strategies for the development process, on theoretical understanding of the social forces that restrict the possible actions, and of course on finding out which aspects of the applications that are especially important [10,15].

But when it comes to perhaps the most fundamental concepts of the development and use of computer applications little has

been done. The systems concept has basically been accepted as the overall paradigm for design and construction. The new and important aspects that have been focused upon have mainly been integrated by an extension of the systems concept to new areas [9].

Our point here is that the systems perspective, although not the ultimate cause, facilitates the development of edp applicatons with the above mentioned impacts, because the perspective tends to:

- view the application from the top of the organization,
- view the organization as a structure, whose important aspects may - and should - be formally described,
- reduce the jobs of the workers to algorithmic procedures, and thus
- view men and computers as information processing systems, on which the described data processing has to be distributed.

Thus, what we will do in the rest of this paper is to bring attention to partly complementary and partly alternative concepts that for some labour processes could be a better conceptual basis for a labour oriented approach to the development of computer support: a tool perspective.

2. A TOOL PERSPECTIVE

On tools

Is the computer a tool? The question has been raised for many years now, and the answers are varied.

In Sigtuna, June 1979, a symposium tried to answer the question. One of the attenders summarised:

> "Weizenbaum, in a book quoted approvingly in several of the papers, explicitly adds to the axe, oar and spear of primitive man, the radio, steam-engine, telescope, clock and a whole host of other "prosthetic" or "autonomous" machines, including, finally, the computer itself (*Computer Power and Human Reason,* ch. I, "On Tools"). What accounts for the disparity in my "common-sense" assumption that "tool" denotes a limited set of simple artifacts designed for (relatively) simple purposes, and the apparent belief among members of the symposium that "tool" is virutally synonymous with "machine", no matter how complex that machine may be? [20, p. 116]."

Among possible explanations she mentioned the ideological one:

> "the oddness, in an everyday context, of calling an oil-tanker, a guided missile or a computer a tool, derives not from the particular characteristics of those artifacts but simply from the tension between their extreme mechanical complexity and the contrasting notions of technical simplicity and availability attaching to the ordinary concept of a tool. By calling such machines "tools", we are in effect assuring each other that in spite of their complexity, autonomy, and unforeseeable social consequences, they are after all *nothing but* fancier kinds of canoe, spear or abacus. And this metaphorical extension of the concept of a tool is perhaps most attractive when in reality the machines in question are slipping out of our control to an ever greater extent [20, p. 117]."

To calm us down assuring that the computer is no different than a hammer. This ideological use of the tool metaphor is far away from what we will propose in this paper.

Today the tool metaphor is also being used in discussions of products like the Xerox workstation, electronic spread-sheets like the VisiCalc program and programming environments like the Smalltalk setting. And the computer as a tool metaphor has a role in the debate on design of interactive systems, especially since the appearance of computer workstations with high resolution display combined with interaction devices such as the mouse [17, 18, 19]. Though important, that debate on man-machine interaction is not exactly what this paper is addressed to. The questions that we want to highlight are rather: is the tool perspective a good design principle in the interest of labour? What criterias have to be fulfilled to view the computer as a tool? And what are the consequences for the development process of applying a tool perspective? [8]

Let's return to the Sigtuna Symposium and look at tools from a craftman's view:

> "I am a master cabinet-maker in Stockholm, and have worked in the trade for 19 years. .... For at craftsman, a tool is an object which is used to fashion rawmaterial into a more refined product. By its weight, its hardness or its sharpness, the tool creates a more refined or practical product. The tool is a necessary condition for material production. For thousands of years, the tool has been wielded by the worker's hand, but often in combination with a machine. The lathe is one of the oldest machines in history. With it, the tool could both be incorporated into a machine and be guided by the worker's hand. ..... Today, I believe that the lathe is undergoing its ultimate development. Numerical control, which is programed in by computer, is the most that can be done with this mechanical device. In practice, the craft of lathework will disappear with this generation of craftsmen.

As a craftsman, I cannot see the computer as a tool based on what I have demonstrated and presented with my assistants. Not in any sense at all."[20, pp. 64 & 69]

Not in any sense at all! That is really a challenge. We will take it seriously, because we think that our intentions are the same as the craftman's: To maintain and develop the tradition of a craft, the qualifications and control of the worker, the quality of the products, and the knowledge,accumulated for ages, that gives tools their accurate shape. But our example will not be a CNC lathe though interresting efforts are carried out in this area [14]. It will be a computer supported "workbench" for make-up of newspaper pages.

Tools for newspaper make-up

In the labour process of newspaper make-up the worker gradually builds up the page or spread. The materials he uses are texts, pictures, logos etc. He also adds graphics such as lines, frames, ornaments, etc. The materials are composed (placed and adjusted) on a page ground, which among other features has help-devices for the placing of columns (galleys). The tools used by the worker are purposefully designed in a long tradition. The make-up work is based on the worker's skills in typography and graphical design, manual skills in handling the tools, and experience with the materials etc. As a basis for the work the make-up person has instructions from an editor, typically as a crude sketch on paper.

For hundreds of years, since the days of Gutenberg, the make-up work has been performed in lead (hot metal). But lead was more than a medium for the page material. Into the pieces of lead were built a powerful support for good graphical design developed as part of the evolving typographical tradition. The selected fonts and sizes as well as the types and engravings supported a well tested graphic design. Typographical firmness was one of the characteristics.

A special problem when working in lead was that the make-up person had to make his judgements from a mirrored image of the page. He learned this as a special skill.

Since the late 1960's hot metal make-up has gradually been replaced by paper paste-up technology. This follows from the introduction of photo typesetters and computer based text processing systems. The medium for texts, pictures and graphics are paper or film. The materials are placed and composed on a paper page-ground. The make-up person has in principle full flexibility in placing the materials on the page-ground, and the page is no longer mirrored. It gives him better control over the material. But flexibility is also a problem. The firmness inherent in the lead material is lost. Besides, the ease and flexibility to change the typography with the photo typesetter often leads to distortions. This example illustrates that flexibility is not an ultimate goal. More important are the processes of transposing skills and knowledge of a specific labour process, when shifting from one "generation" of tools to another.

There are significant similarities between the labour processes of hot metal make-up and paper paste-up, as well as differences. But regardless of technology, make-up is based on typographical skills and the tools and materials reflect the long tradition of typographical knowledge. Furthermore, in both cases the make-up person has direct control over the material he works with. He can immediately see the result of his work. (But of course, what he sees is not the printed page. He has to be able to make judgements on the printed page from the pre-press material he works with.)

We have described the tools for page make-up from the craftman's point of view. More generally we suggest, that to label some means of production as tools should require that they

- are means to fashion material into a more refined product,
- are under complete and continuous manual control of the worker,
- are fashioned for the use by a skilled worker to create products of good use quality,
- are extensions of the accumulated knowledge of tools and materials of a given labour process.

A tool perspective on pagination

Now, can computer support be fashioned this way? Can computer based tools for page make-up be developed and implemented? Is there a future for the make-up person in pagination, the new name for the old labour process of making newpaper pages? [6].

When trying to find answers to such questions you are working in a field of tension between technical possibilities and graphical demands:

- which media do we have to represent the page-material?
- which interaction devices are possible candidates for implementation of the tools? and
- which changes of/operations on the page-material are possible with the interaction-devices and media of present day computer technology?

Ideally we would like to represent and manipulate something directly corresponding to the result of the make-up - i.e. the printed page or a photo typeset full page. But with the technology of today (and tomorrow) this is not possible. For example the number of picture elements on a so-called high-resolution screen lacks a factor greater than 100 to be comparable to the output of a phototype-setter. (This and other examples are discussed in detail in the appendix). Given these limitations a possible solution consists of a two-level user model of material and tools. [2, 13]. A user model is a user oriented conceptual model linking concepts of a specific labour process to their technical realization. It serves as a basis for education as well as implementation.

The first level describes page-material, page-grounds, and a make-up table in a way that corresponds to the output of a phototype-setter (or a printed page). Furthermore, it describes tools with which to manipulate the material on the table. The tools are based on the traditions developed in lead and paper make-up, but takes advantage of the new possibilities offered when representing and manipulating the page material by digital equipment.

The second level describes how to adapt the first level model to the technical possibilities. A number of "lenses" are used to project parts of the make-up table and the material on a high-resolution screen (cf. the appendix). The tools are implemented as a combination of software and hardware, i.e. by interaction devices such as tracker ball, tablet and puck, associated with special concurrent programs for operations on texts, graphics, pictures, etc. When using one or more tools the effects on the material on the table can be followed on the display through the "lenses". In addition to the representation of the concepts of the first level, the second level includes the manipulation of the "lenses" and the assigning of tools to interaction devices.

The "lenses" and the "table" are of course abstractions. We need to introduce them in the model because of the shortcomings of current computer technology, which makes it impossible for the make-up person to directly manipulate the page in full size with sufficient resolution on the display screen. Without the "lenses" and the "table" some qualitative judgement that the worker can make in lead make-up and paper paste-up would be lost in pagination.

But using the abstractions in the model is not just a problem for the make-up person. The model helps him to remember that what he sees on the display screen is not the real page but a delineation. He always looks at the page through a "lense" which gives desired as well as undesired aberrations. It is the quality of the real page, not the delineation, he has to have in mind when making up the page.

(The main features of the model are elaborated in the appendix. In order to facilitate understanding and judgement of the following pages we recommend that you read the appendix first.)

Some remarks on the tool perspective

The user model presented in the appendix is a summary of specifications for pagination developed within the UTOPIA project [6]. The specification is derived from a tool perspective and it can technically be implemented [5]. The implementation may very well be done from a systems perspective, as long as the specifications are met. However detalied, it should be observed that the specification only covers a limited part of the analyzed labour process, i.e. the function of the tools. The craftman's skills are neither objectified nor formalized, they are the origin of specification. This is a normative statement in the tool perspective, but it is a practical necessity as well. Tacid knowledge is a substantial part of a craft and can be transferred only in practice from the master to the journeyman and to the apprentice. You learn by watching, trying yourself, from good advice, etc.

However, the described model is not just a means of specification. It also serves as a basis for training and education. It constitutes a development of the language and tools of the graphic workers adapted to and supplemented by concepts from electronic data processing.

In contrast to the above quoted master cabinet maker, our point is that computer support in some sense can be designed as a toolkit. And more important, the tool perspective proved to be a good design principle. It supports the development of the traditional skills and at the same time makes the shortcomings of the current computer technology very clear as demonstrated in the appendix.

3. DEVELOPING TOOLS

On tool designers

But applying the tool perspective, how to organize the development process and what methods to use? To these questions we have no definitive answers. Based on our experience with the development of computer based tools for page make-up we will however make the following comments.

Clearly the experienced end user, the skilled worker, must play an important role in the process. He posseses the tacit knowledge that forms the basis for analysis and design. The systems designer has to spend a lot of time trying to gain some insight into the specific labour process. Not to become, for instance, a make-up person, but to be able to contribute constructively in the development process. But of course, he also has to be a computer professional. Tools which for the skilled worker are simple, powerful and accurate to use are often technically very complex.

Here we face another problem: the traditional division of the systems development process into an application oriented phase (carried out by application oriented systems designers) followed by a computer oriented phase (carried out by computer oriented systems designers) [11].

It is true that the systems designers must be able to organize the development process, to master methods for description and analysis of work organization, to constribute to education and training etc. But this cannot be done in a first, isolated phase. Hardware considerations play an important role already in the initial stages of development. The communication with the graphic workers about existing technology, for instance screen resolution, response times and interaction devices, in the beginning of the development process were of major importance in designing the tools for pagination described in the appendix.

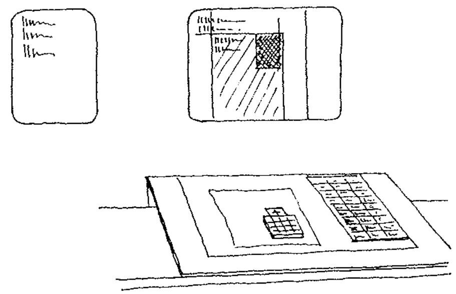
A Utopia development process

According to our experience it seems fruitful from the beginning of a development project to bring together a group of people with the necessary profession-oriented, technical, and organizational skills. This makes a process of mutual learning possible in which for instance graphical workers learn about the technical possibilities of computers, bit-mapped displays, lasers, etc., and the computer specialists learn about the work of the profession in question. Initially the group does not work with specification and construction but with building up a mutual understanding of the specific labour processes of the profession and of the technical possibilities and limitations [4].

Apart from discussions, visits to workplaces with different "generations" of technology as well as visits to research laboratories and vendors proved to be important activities in the mutual learning process.

When shifting towards more design-oriented activities we started out by using traditional, more or less formalized description methods ranging from scenarios to data flow. However, these did not function very well as a vehicle for communication for the graphical workers.

The situation was drastically improved when we built a mock-up to simulate computer supported page make-up. Sheets of paper, an empty matchbox and some plywood; and there was our workstation with a high resolution screen, tablet and puck. It allowed the graphical workers to start making up pages. Step by step the corresponding screen images were drawn. As the number of trails increased so did the quality of them. In the same way we worked with the design of the interaction devices and their use.



Simple mock-up.

At this stage of the work the computer specialists contributed with information on the possibilities and limitations of the corresponding "real" equipment, and by systematizing the accumulating experience, using traditional description methods. The important differences with respect to our earlier attempts was that now the graphical workers could articulate their demands and wishes in a concrete way by actually doing make-up work on the simulated equipment.

Later we developed our mock-up, so that it got a more realistic exterior, and in the simulation of the high-resolution and text screens paper was substituted by back-screen projection. We also used a real computer workstation with a high-resolution screen and a tablet with a puck to experiment with and illustrate aspects which were difficult to simulate with the mock-up such as coordination between puck movements and screen image changes.

These development tools are now being used in graphical education.

Mock-up with back-screen projection.

It is outside the scope of this paper to relate our experience to the current discussions in prototyping [1]. We just point to the experience that even the first extremely simple "paper and wood" mock-up allowed the graphical workers to play a very active role in the design work.

The described development process is utopian in a double sense. It reflects the way the development process was carried out within the Utopia project. But the preconditions for this process are not present in corporate business as we know it today. Resources for skilled workers, trade union people, computer and social scientists to work together over a long period of time developing tools in the interst of the end users do not exist as yet.

4. LIMITS OF THE TOOL PERSPECTIVE

The tool perspective was useful in our development of computer supported page make-up (and picture processing) [5,6,7]. We believe that it can be succesfully applied to a large number of other labour processes where some kind of material is refined by skilled workers.

Also in the area of office work products such as many of the good text editors seem to indicate that a tool perspective can be succesfully applied.

When we consider more formalized (or formalizable) dataprocessing with long sequences of predeterminable operations the perspective seems less valuable. But even in labour processes involving large amounts of dataprocessing the tool perspective can be useful if human judgement and selection are frequently needed as indicated by products such as VisiCalc. It must however be applied in a more abstract sense. Furthermore the labour processes in question have no tool tradition to draw upon.

When we move to computer support for communication the tool perspective doesn't seem to have anything to offer. If we consider the communication involved in controlling a large hierarchical organization, the systems perspective has important advantages as already mentioned. But fundamental aspects of human communication are not covered by the systems perspective, e.g. those related to non-algorithmic or structure changing processes. Furthermore, it supports organizational changes contradictory to labour interests (as discussed in section 1).

In summary: The hegemony of the systems perspective on analysis and design of computer support must be deeply questioned. There are situations where other perspectives offer good alternatives in the interest of labour. The tool perspective is such a candidate, as illustrated with the case of designing computer support for page make-up as tools for skilled workers. Furthermore, there are situations especially concerning communication, where none of the perspectives should be applied. Thus, what is needed is an openness for different analysis and design perspectives according to the characteristics of different situations.

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Appendix

Tools for Electronic Page Make-up: A User Model

(Extracted from the Utopia report: Utformning av datorstödd ombrytning för dagstidningar (Designing Newspaper Pagination)).

Technical Constraints

Page make-up means that the make-up person builds up a page or a whole spread from given material like text, pictures, logos, etc. The page make-up process also involves graphics (lines, frames, etc.). The material is usually divided into articles, advertisements, graphics, etc. The page is built up on a page ground which for instance contains column rules and certain pre-allocated material.

As a help to his work the make-up person may have a rough draft of the page and/or a list of the material which is to be used.

The make-up person prefers to work with the whole page or the whole spread in front of him in a resolution good enough to facilitate effortless reading of the body text. This is the only way in which it is possible to see what the page really looks like.

Thus the demands to the display are that

- it is large enough to hold the whole page or spread in natural size plus a little extra room for a work area,
- it has a resolution of a quality which makes the body text easy to read in its true size and in all details,
- it is non light-emitting which means that the display should have a variable degree of density, just like the printed page.

An important difference between the representation of the page on existing display screens and the final printed product is that the display screen emits light. A more ideal display screen should be based on a technique resembling liquid crystals. But it remains to be seen whether it will be possible to construct screens which have a resolution of sufficient quality and which are fast enough.

To obtain a basis which is realistic enough to estimate what the final product will look like, the material must appear in positive, i.e., black text on light background; (this is in contrast to the fact that a light-emitting display which occupies a large part of the user's visual field may dazzle him or her, and at worst disturb the eyes so much that it becomes difficult to estimate the material on the display screen. It should therefore be possible to change between dark text on light background and light text on dark background. Pictures should always be shown in positive).

The limited resolution of the display, even of modern so-called high-resolution displays, entails serious limitations to how close one can come to what the final page will eventually look like.

This limitation is true where pictures are concerned, but even more so concerning typography. We can illustrate this by pointing at the resolution necessary to show a full page of a newspaper in A2-format (560x410mm) of a quality which a phototype setter would offer. Typically 1500 lines or points per inch. To show the page with a similar resolution, a 27" display screen with 34000x25000 pixels would be necessary. The computer which controls the display would need an extremely fast memory of 1 Gbit (1 billion positions) with a refresh rate of 100 Hz (to eliminate flicker). Thus an ordinary processor should process each pixel in approx. 10 pikoseconds (trillionth second). This is the time it takes the light to travel 3 mm. The fastest computers developed so far have operation times of around 1 nanosecond (billionth second), and are at least a 100 times too slow. Other (parallel or partial) methods to fulfill this kind of calculation demands, may be developed in the future.

The best available resolution on a modern "high-resolution" raster display screen (display screen which generates pixels) is approx. 1400x2000, which means 130 pixels per inch (5 per mm) on a 19" screen (280x400mm). In the following we assume a screen size of approx. 19" which is a typical size today.

Thus it is unfortunately not possible to show the full newspaper page in natural size on the display screen. Furthermore the display screen usually has a resolution of such poor quality that the make-up person neither can nor should read the body text in real size. Therefore he or she is forced to choose between looking at a reduced version of the full page, or at a section of the page which is magnified sufficiently for the body text to be legible. Besides the page there must be room for work area, menues of operations, lists of material, and status information on the display screen.

Thus from a tool perspective we are forced to ascertain that not even with the most advanced available display technology can we realize a satisfactory representation of the page and its material as a basis for the make-up person's professional evaluation and processing. But does that mean that we have to give up? That computer based page make-up is altogether impossible? Are there ways and means to overcome the limitations, and are there new possibilities in the computer based page make-up process which can compensate the disadvantages?

Possible Advantages

Among the possible advantages of computer based page make-up the following can be mentioned:

- CHANGES IN THE TYPOGRAPHY and GRAPHICS can be executed more easily much later in the process, and carried out faster - for instance change the leading in headings and between the paragraphs, change the font-size in headings, change column width to make room for frames, change thickness of frame, etc.

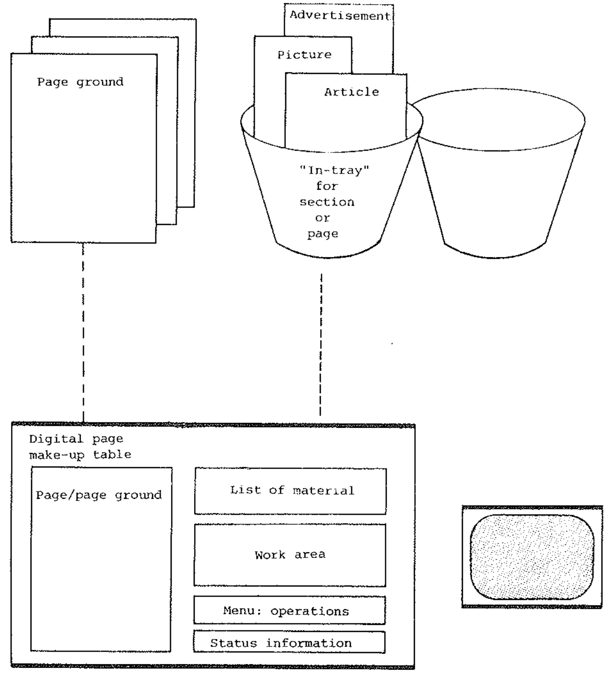
- The relative easiness of changing the typography makes it possible to TRY SEVERAL ALTERNATIVES without wasting too much time.
- Another consequence of this easiness of changing the typography is that THE PAGES MAY BE MADE UP AT A MUCH EARLIER STAGE IN THE PRODUCTION before all material is available, and then later be successively completed and corrected.
- The POSITIONING can be made more precise - all text can be exactly horizontal; it is possible to have exactly the same leading between all the paragraphs in the article, material in adjacent columns can be made exactly rectilinear, etc.

But what about the limited size and resolution of the display? In the following we will present a possible abstraction, a model for computer based page make-up, and later we will discuss its limitations.

A User Model

In the model we imagine that page ground, menues, material lists, and status information are placed on a "table". The table also contains a work area. As it is not possible to show the whole table on the display screen (unless it is drastically reduced) we must settle with looking at selected sections which are moderately magnified (reduced) on the display screen.

We therefore imagine that the make-up person has access to "lenses" through which he may look at different sections of the table.



Schematic figure of the things the make-up person needs to have in front of him. On the table there are: a page ground on which the page is pasted, a list of material, extra work area for the make-up process, a menu for operations, and status information. Next to this a 19" display screen which is obviously far too small.

The "lenses" are of different sizes.

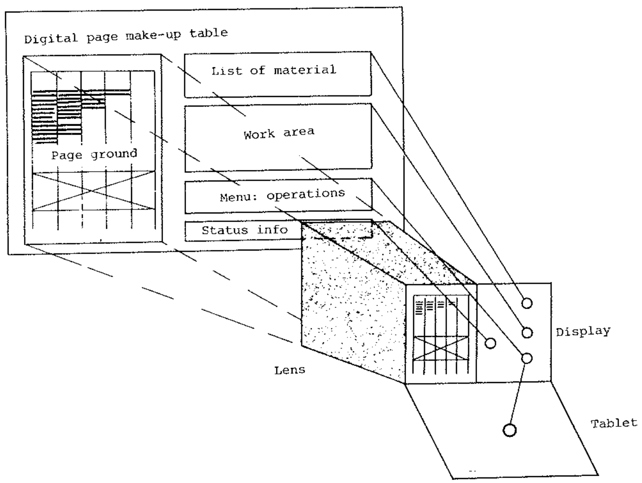
Each lens has a given "power" (natural size, magnified size, or reduced size).

Several lenses may be directed at the same section of the table.

Hence the make-up person may see the page in various sizes at the same time. He will normally look at menues, material lists, and status information in their natural sizes.

The make-up person may choose which lenses are to be used on the display screen, he may choose their position, and - when he looks at the page and work area, he may even choose the size and degree of enlargement.

The interaction is also supported by the fact that the make-up person may direct the "lenses" at different sections of the page ground, work area, and material, and also by the fact that the material watched through the "lenses" may be moved in all directions.



Schematic figure of display screen with lenses. The make-up person watches the table through the lens which can be displayed on the screen. The figure illustrates a lens on the display screen. The make-up person looks through the lens at the page on the table. The page is reduced so that it exactly fills the screen. The lenses for work area, menu of operations, and status information are merely suggested.

Often the page is shown on a smaller scale through one lens on the display screen, while part of the page is shown on a larger scale through another lens. In this case the small image of the page will indicate where the lens with the large copy will be. The make-up person may also point at some point on the page on the smaller scale, and ask to see the corresponding point and its surroundings on the larger scale.

The make-up person may wish to work on several pages simultaneously. In this case he places several pages on the table, and the pages may be seen through different lenses on the screen.

The scales are selected so that each scale fulfills at least one of the following criteria:

- the body text is easy to read (to facilitate precise allocation and changes in the text),
- real size scale (to facilitate estimation of light conditions, etc.),
- the page fills the whole display (to facilitate rough allocation),
- rough miniature sketch of the page (to facilitate orientation).

Using fixed scales instead of a more or less continious degree of enlargement makes it easier for the make-up person to estimate what the real page will look like.

Naturally the table and the lenses are abstractions which we have used to overcome the technical limitations of today's display screen technology which entails that the make-up person cannot work directly on the full page in natural size and in full resolution. The abstraction has been necessary to avoid that certain possibilities for qualitative assessments are lost in the computer based page make-up process.

But the abstraction with the lenses and the table is not merely an impediment in the page make-up process. It helps the make-up person to keep in mind that what is seen on the display is not the real page, but only an image. He always sees the page through a lens with both the intentional and unintentional distortions this implicates. The make-up person must always have the real page in mind. This is one of the reasons why it must be possible, for instance via a laser-printer, to get "proof prints" of the page as a basis for further evaluation. (The problem is an important one, but not really new. Neither in lead, nor in paper does the make-up person work on the printed page).

Make-up Tools

Hence the page make-up process takes place on the table which the page make-up person watches through lenses on the display. But how does he build up material, move material, measure material, etc.? I.e., how are the traditional page make-up tools realized? After all, they have been the tools of the printing trade, formed and refined through 500 years. In the model for computer based page make-up the appropriate counterparts of these tools are realized through a COMBINATION OF GENERAL INTERACTION TOOLS AND GRAPHIC OPERATIONS.

The maybe most important interaction tool is a tool to point with. It may be an electronic puck (or "mouse") which the make-up person holds and moves with his hand. Some kind of cursor on the screen follows and reproduces the make-up person's current application of the interaction tool. It is used to select graphical functions from MENUES which may be found both on a tablet in front of the display screen, and also on the display. The interaction tool is also applied to move and otherwise manipulate the material which the make-up person watches through the lenses. Other complementary interaction tools are for instance an ordinary KEYBOARD through which the make-up person can input text, numbers, or commands, and FUNCTION KEYS which activate certain graphical operations.

We cannot take a position on exactly with which interaction tools the model for computer based page make-up should be realized. The important thing is that they support a natural, visual, and firm working method for carrying out the graphical operations with the material on the table.

Hence the make-up person selects and carries out the GRAPHICAL OPERATIONS with the interaction tools.

Let us imagine that the make-up person is to pick up some material on the work area and place it on the page ground. He will point at the material with the puck, or rather, with the cursor which he controls with the puck, and then he in some way indicates that he wishes to carry out the graphical function MOVE. This makes the material move when the make-up person moves the puck, and he may place the material in the correct position on the page ground.

To support precise positioning up to a certain column rule the make-up person may furthermore choose the graphical support operation GRAVITATIONAL FIELD (/gravity pointing). If he does this it will be sufficient to direct the material close to the column rule. It will be "sucked" into the exact position.

If we compare this to paper paste-up, the puck and the choice of the operation MOVE corresponds to the make-up person processing a given material with a knife. The moving operation itself is done by manipulating the material directly with the hand in one case, and by manipulating it with the cursor/puck in the other. With the support operation GRAVITATIONAL FIELD the make-up person obtains the same parallel alignment as with lead. This is difficult to obtain with paper paste-up.

Let us also imagine that the material in question has to align against a logo, and the make-up person finds it difficult to see exactly where it should be positioned heightwise. He chooses the graphical operation for MAGNIFYING GLASS. He places it on the area of the page he is interested in, which then will appear in larger form. He may now position the material more accurately. This principle of applying several tools at the same time is an important aspect of our model.

The computer based graphical tools are thus obtained by applying suitable interaction tools to select and carry out graphical operations on the material.

The graphical operations may be classified as follows:

SELECTING AND POSITIONING THE MATERIAL. E.g., operations for selecting, moving, column setting, contour setting, centering, indenting, or leading.

SUPPORT OPERATIONS FOR PAGE MAKE-UP. E.g., gravitational field, aligning, magnifying, type gauge, and various types of construction lines and construction points. These operations are applied together with the main page make-up operations.

GRAPHICAL MATERIAL OPERATIONS. E.g., operations for creating lines, frames, and geometrical figures.

TEXT OPERATIONS. The page make-up process requires operations for changing column width, font and size, and for kerning and letter spacing. The make-up person may also need to make changes directly in the text.

PICTURE OPERATIONS. Most of the picture processing takes place before the page make-up process, but the make-up person must for instance have access to operations which change the size and crop the picture in the make-up process.

OPERATIONS FOR MAKE-UP OF ADVERTISEMENTS. The working method for making up an advertisement is in principle the same as for making up a page. However, the make-up person needs some additional operations to execute the imaginative typography which this requires.

ADMINISTRATIVE OPERATIONS. In our model of the computer based page make-up table, the make-up person needs access to a number of administrative operations. This includes allocating material from one page to another, the feasibility of filling in complementary material where this is needed, further status information about pages and articles, and requesting different types of proof prints.

DISPLAY SCREEN OPERATIONS. We have already established that the screen is too small, and its resolution too poor for the make-up person to be able to look at the page in its natural size and in full resolution. That is why we introduced the model with the lenses and the table. This means that the make-up person needs operations which enable him to display, direct (scroll), and change the size of the lenses through which he looks at the page ground and work area with material, as well as the operation menu, status information, and list of materials.

SUPPORT OPERATIONS FOR INTERACTION. The interaction itself must also be supported by special operations. The make-up person must for instance have help information if he is unsure of how a given operation is to be handled. It must also be possible to leave a given job, and later return and continue where it was interrupted. Furthermore the make-up person must have the possibility of correcting a mistake without having to do the whole job all over again. Certain properties must be adjustable. It must for instance be possible to change type faces, screen layouts, scales and units of measurement for the whole installation or group who works together. Another example is that each make-up person should be able to adjust how much help and status information he wishes.

The computer based make-up tools are often very powerful. But even though they are built upon a 500 year-old tradition, they are new and untested. A lot still has to be done to develop their functionality further. In our model of the computer based page make-up table we have assumed that a large part of this development can be done by the make-up person directly at the shop floor. At least he must have the possibility of combining existing graphical operations to create his own tools which may be added to the operation menues or implemented as function keys. In the long run the make-up person must have more advanced "programming tools" at his disposal to be able to modify existing, and create completely new graphical operations.

For our model of the computer based page make-up table to be fully realized, programs and equipment must also be designed so that the make-up person can service and maintain his tools himself.