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In this pilot study, two different ways of presenting information for industrial design students on the psychological aspects of the design of a go-cart were compared. The search for information from external sources and the use of this information in different phases of the design process were also studied. In the control group, students were only given general information on six psychological topics of their design problem, while in the experimental group, students received more detailed information using verbal and visual examples. In this way and by stimulating the students to actively 'work' with the information, proceduralization of the transferred declarative knowledge was supposed to take place.

Analysis of the students' reports describing their design process, information sources and decisions, showed that play-information was mainly used in the information phase of the design process. The main difference between the control and experimental groups was that students from the experimental group mentioned more specific information on play activities in their reports, while the control group mentioned more general information on the attitudes and taste of the users.

Comparison of the prototypes, working models of the go-cart, showed that the experimental group scored significantly higher on three child-related aspects: the carts trigger the child's fantasy, are multifunctional and are more suitable for social play-activities. On the other hand, the go-carts of the control group were judged to be more suitable for older children. These differences between the two groups cannot be explained by differences in design ability as measured by the educational staff, but appear to be related to the differences in conditions.

Keywords: design students' behaviour, information processing, selection of user information

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Designing three-dimensional artifacts is a very complex activity. The design problem itself is ill-structured in that there is no definite criterion to test the proposed solution, neither is the problem space defined in any meaningful way[1]. One of the consequences of this is that the information and knowledge, relevant for solving an actual design problem, seem inexhaustible. From the point of view of design methodology and design education it is important in design research to focus on the role of knowledge in the design process. Hence, questions are: how problem solvers select relevant information and how they represent and retrieve expert knowledge. Designers cannot meaningfully identify and search for relevant information without the orientation of a solution concept[2]. More specifically, this study is concerned with the question: under what conditions is information from external sources more accessible for designers, so that it influences the design output. This question is especially relevant in the conceptual phases of the design process. During these early phases the problem itself is stated and the constraints are identified. Information is gathered which appears to come from two sources: either knowledge from everyday, incidental experience, or as a result of intentional learning by deriving information from the presentation of specific design-related material[3]. But it is far from clear what information is processed and under what circumstances. We assume that within the learning process students acquire most knowledge on a operational or procedural level by being exposed to a large number of examples of solutions. In this way expertise grows by the development of operator schemata which are abstracted from example problems[4]. New information presented as examples in the context of the design problem, is often provided in a verbal or a pictorial form. There is some evidence from research on this topic that the access to and the use of knowledge from these two media differ. Two studies in the domain of design indicate that pictorial information, by way of examples added to the design assignment, can have a stronger effect on design[3-5]. It is hypothesized that this effect may reflect the preferred level of information processing for designers. Expert designers' knowledge structures could be particularly rich in terms of the representation of visual material because of greater, and more detailed, exposure to this material[3]. The stronger effect of visual information can also be explained by the fact that designers are strongly reluctant to consult written data[2].

In studies from other domains the differential effect of pictorial and verbal information is also observed. Palmiter *et al.*[6] found that in learning procedural computer tasks (graphical) animated demonstrations have a more powerful effect than written instructions. The difference with design studies is that in animated demonstrations motor components are also

1 Simon, H A 'The structure of ill structured problems' *Artificial Intelligence*, Vol 4 (1973) pp 181–201
2 Powell, J A 'Is architectural design a trivial pursuit?' *Design Studies* Vol 8 No 1 (1987) pp 187–205
3 Purcell, A T and Gero, J S 'The effects of examples on the results of a design activity', in: J S Gero (Ed.) *Artificial Intelligence in Design '91* Butterworth-Heinemann Ltd, Oxford, UK (1991) pp 525–542
4 Lewis, M W and Anderson, J R 'Discrimination of operator schemata in problem solving: learning from examples' *Cognitive Psychology* Vol 17 No 1 (1985) pp 26–65
5 Jansson, D G and Smith, S M 'Design fixation', in *Proceedings of the Engineering Design Conference*, University of Massachusetts, Amherst (1989) pp 53–76
6 Palmiter, S, Elkerton, J and Baggett, P 'Animated demonstrations vs written instructions for learning procedural tasks: a preliminary investigation' *International Journal of Man-Machine Studies* Vol 34 No 5 (1991) pp 687–701

included. Nevertheless, their theoretical assumptions may be useful in explaining the differential effect of pictorial versus verbal information. They hypothesize that the two media are encoded differently as a result of the different individual instructional characteristics. Also, the amount of cognitive processing with animation could be less because of reducing the additional load of forming a motor code. A possible side-effect could be that instructions are only superficially processed. LeFevre and Dixon[7] point out the danger that in using examples together with written instructions, subjects blindly mimic these procedures with very little processing and encoding. The same effect was found by Jansson and Smith[5] who called it 'design fixation'. Fixation is a concept used in psychology to explain the fact that past experience can interfere with the solution process for insight problems because the problem solver is fixated on the existing operation schemata[8]. Designers presented with a picture mimicked a number of aspects of the picture, even some incorrect ones. Purcell and Gero[3] only demonstrated this design fixation effect in relation to pictorial information with familiar examples. Familiarity is related to the prototypical default values in the existing knowledge structure. Besides, mimicking behaviour is less appreciated in the context of design skills acquisition than, for instance, in the context of mathematics skills acquisition.

In sum, the medium through which information is sent to the designer apparently influences the accessibility of the information. But the results of the studies mentioned here do not point to the same conclusions; moreover, the results are preliminary. In two of the studies the effect, found in the experimental group receiving the pictorial information, was explained by the fact that that group was exposed to a richer encoding medium; i.e. it contained verbal, visual and motor codes, while the control group had only verbal information. Nevertheless, on the basis of the results we can expect a greater impact on designing from pictorial information. This impact probably results in mimicking behaviour.

1 Information: the message

From the point of view of design methodology and especially in training and teaching students in design, it is important to know the kind of information used in different design phases. Because industrial designers always design products that are meant to be used by human beings, it is especially interesting to pay attention to relevant information from disciplines such as psychology on the behaviour and attitudes of potential users of the products to be designed. Designers are not always educated to, or used to looking for information in those other disciplines. Sometimes they also think they have enough knowledge from their own

7 LeFevre, J A and Dixon, P 'Do written instructions need examples?' *Cognition and Instruction* Vol 3 No 1 (1986) pp 1–30
8 Weisberg, R W and Alba, J W 'An examination of the alleged role of 'fixation' in the solution of several 'insight' problems' *Journal of Experimental Psychology* Vol 110 No 2 (1981) pp 169–192

experience, thereby excluding systematic information based on empirical research.

It is therefore important to discuss the relationship between researchers from the social sciences (i.e. psychologists) and technical designers. In these relationships it is always important to translate the psychological knowledge for noncolleagues, as each group has its own background and differing views on reality. Generalizing, one could say that designers often assume that researchers study the wrong questions in the wrong way; that the results are at best irrelevant and mostly inaccurate and misleading; and that the conclusions of research are always already known beforehand. Of course reality is different. 'The designer' and 'the researcher' do not exist and various studies have given evidence contrary to 'the obvious'. On the other hand, there are a number of differences between designers and researchers, in methods and approach to problems, that make the above-mentioned communication problems more understandable.

The following aspects of the differences are often mentioned[9]: point of view (behaviour versus products); method (analytical versus synthetical); presentation (words versus images); pattern of values (theoretical versus ideological); role conception (advisor versus integrator). All these differences between designers and researchers each offer a partial explanation of the 'communication gap'. The analysis of these differences can also help to search for possibilities to transfer knowledge from psychology in a better and more efficient way. Improvement is possible in a number of ways.

Real co-operation between designer and researcher is especially useful in the orientation phase by incorporating the needs and wishes of the users in the assignment and involving them in the design process; during the design by implementing design guidelines focusing on the behaviour and experiences of the users; and when the product is finished, by conducting an evaluation study, examining the effectiveness for human users of the product. By interacting closely, researcher and designer will be able to get to know each other's possibilities and ways of thinking and speaking. Researchers will learn the ins and outs of the design process, while designers will be more involved in the research process. Both sides of this interaction are equally important, but in this paper most attention is given to the transfer of information from social science research to designers.

Researchers should also pay more attention to the integration, structuring, relating, and presentation of the existing body of knowledge based on research on a certain subject. This could, among other things, be realized by not only publishing in scientific journals, aimed at fellow researchers, but also in applied and design-oriented journals. In these kinds of articles and other presentations aimed at designers, it is recommended that the content, style, and form be modified, for instance, by using much more visual media such as slides, illustrations, and graphics.

Furthermore it is very important to be aware of the different kinds of information and knowledge that are needed by designers, in different stages of the design process. This is especially true when considering the possibilities of using new developments, such as computerized information systems and even expert systems, to enable a better transfer of knowledge from social scientists to designers. Hence, it is necessary to focus on the design process itself and pay attention to the different kinds of knowledge and information which are involved in this process. Therefore, the two main questions of this pilot study were: firstly, if relevant information is provided to design students, what role does it play in the various phases of the design process and what is the impact on the end result, the design? And secondly, what is the effect of the medium in which the information is presented on the accessability of this information and on its use in designing?

2 Method

2.1 Subjects

The sample consisted of 20 students enrolled in the second-year undergraduate design course (1989–1990) of the School of Industrial Design Engineering at Delft University of Technology. All students participated in the same design project, an obligatory subject in the curriculum. The project task was to redesign a so-called 'flying Dutchman', a four-wheel hand-driven go-cart for children (see Figure 1).

The rider takes a sitting position, with a lever between his legs. A hinged suspension of the lever in a frame permits a forward translating movement, which is transferred into a rotating movement by means of a crank on the back axle. To steer the cart the rider puts his feet on a hinged front axle. The go-cart is meant to be used by five to eight-year olds[10]. The project took one and a half days a week for two ten-week terms. During the first phases of the process, when information was gathered and requirements were written down, students worked in groups of four. From the conceptual phase to the end of the project, resulting in a working prototype, they worked individually.

9 **van Andel, J** 'Expert systems in environmental psychology', in: **H. van Hoogdalem et al** (Eds) *Looking back in the future. Proceedings IAPS10 conference*, Delft University Press, Delft, The Netherlands (1988) pp 303–321
10 **Muller W** 'Design disciplines and the significance of visuo-spatial thinking' *Design Studies* Vol 10 No 1 (1989) pp 12–23

Figure 1 Current design of a 'flying Dutchman'

2.2 Design

In relation to the study aims the experimental information should be different from the regular material that is presented as a part of the design problem. In the early phases of the design process, students are expected to gather information and to select possibly relevant items from this information. The problem space can thus be enlarged, while, on the other hand, constraints can be discerned in order to exclude some solutions. Right from the start the staff gave the students various sources of information on domain knowledge like manufacturing, costs, ergonomics, marketing, and construction. In this phase the staff paid hardly any attention to psychological aspects linked to the use of the vehicle, in this case by children aged four to eight. Because of the importance of these aspects it was decided to use knowledge on the play-behaviour of children as additional information input in the experiment. The information on play-behaviour was split into six topics: kinds of play and play activities, social activities, sex differences, age-group differences, kinds of play-things, and play environment. Because knowledge in the experimental condition was presented partly on a procedural level, it was expected that students would give more attention to it in the conceptual phase of the design process.

2.3 Procedure

Three of the five groups of students (12 subjects) were randomly assigned to the experimental condition and two groups (8 subjects) to the control condition. In order to avoid any interaction with the normal instruction in the project the information on play-behaviour of children was presented three weeks after the start of the project. At that time students were still engaged in gathering and analysing information.

Subjects were run in two separate groups according to the experimental condition. In order to keep subjects in ignorance of these conditions the information to the groups was presented at the same time in different locations. In both groups the information was given by a lecture, but the way of transferring this knowledge both in presentation and content was different for the two groups. In both conditions the experimenter gave a verbal instruction on each of the six topics using an overhead projector. The importance of the information for the design of a 'flying Dutchman' was stressed. While in the control condition only overall background information on the six topics was given, in the experimental condition the information was detailed using verbal and visual examples. Pictures, presented as slides, of different activities by children were shown. Verbal examples of other vehicles for children, in which knowledge of play-behaviour was integrated in the design, were also given. After finishing the presentation the experimenter instructed the subjects of the experimental group to describe or draw some ideas, based on the theoretical notion on play-behaviour that they had just heard. The purpose of this task was to start the proceduralization of the transferred declarative knowledge. Subjects in both groups ended the session by completing an questionnaire, concerning the sources of information they had consulted during the first three weeks. After seven weeks, the end of the conceptual phase, subjects were again asked to complete a second questionnaire concerning the information used in the design process. They were also requested to rank-order the sources they mentioned, according to relevance.

Supplementary to the judgement by the staff the end results in the form of a prototype of a flying Dutchman were judged by six environmental psychologists. They were asked to assess the products on nine aspects: suitability for the consumer group for which it was made, challenging fantasy, child friendliness, multifunctionality, suitable to carry more than one child, suitable for girls, suitable for boys, suitable for older children, suitable for younger children. The 20 prototypes were randomly put side-by-side in a hall of the design studio. Each judge was asked to assess individually the prototypes on a ten-point scale, one aspect at a time, without any time limit. After completing the assessment for one aspect the judge handed the list to the experimenter, after which he completed the assessment on the next aspect, and so on. The order of the aspects to be assessed differed for different judges.

2.4 Data analysis

Studies on information processing in relation to the medium in which information is provided are so scarce, that hardly any theory is available for testing hypotheses. Therefore, this study tries to explore the use of knowledge in design by way of a preliminary investigation.

In the analyses the data were derived from three sources.

Questionnaires

A quantitative analysis of the number and kind of sources of information in relation to the experimental conditions. A qualitative analysis of them by subject indicated application of information on play-behaviour in the design process, and of the priority given by subjects to the various sources of information.

Design process

As a normal part of the design task students write two technical reports, one after finishing the conceptual phase (after ten weeks), and the second one at the end of the project. Both reports were taken as material for research purposes. Wherever in the reports the subject made any reference to knowledge on play-behaviour the verbalization was transcribed and segmented into chunks of information. Next the verbalizations were encoded according to the following procedure. Based on the above information topics on play-behaviour, while adding two other topics, eight codes were defined. They included:

1) play activities (e.g. rest, movement, fantasy, construction)
2) social activities (e.g. playing alone or in a group)
3) differences between girls and boys (e.g. role confirming behaviour)
4) differences between age groups (in relation to play activities)
5) toys/play-equipment (e.g. game of skill, party game, puzzle)
6) play environment (e.g. inside and outside, playground)
7) argumentation for colour use (e.g. in relation to sex differences or age group)
8) attitudes and preferences (e.g. the impact of the design on fantasy)

Two judges (the authors of this article) independently assigned one of eight codes to each chunk of information, without knowing whether the reports belonged to one or the other experimental condition. The degree of interjudge agreement, measured by Cohen's *kappa*[11] was high ($k = 0.77$).

11 Cohen J 'A coefficient of agreement for nominal scales' *Educational and Psychological Measurement* Vol 20 No 1 (1960) pp 37–46

Design
The influence of the presented play-behaviour information on cart designs will be analysed by comparing the judgements on the above dimensions of the prototypes for the two experimental conditions. The assessments of the expert judges will be compared with those of the regular project staff.

3 *Results*

3.1 *Questionnaires*
The answers from both questionnaires show, that knowledge on play-behaviour is derived from different sources. In questionnaire 1 subjects were asked what information sources they had explored during the first weeks of the project. Explicit information on play behaviour was provided during the same session. In questionnaire 2 subjects were asked what sources they actually used and what relevance each of the sources had in the context of the design problem.

In the information phase written documents like books and articles on the topic were mentioned by four subjects; two subjects explicitly mention the information given by the experimenters; three subjects said that with regard to behavioural aspects they relied on their own experience. In the evaluation phase of the design process, two subjects drew attention to the user trial. As subjects indicate, knowledge acquired in this way is mainly applied to the modelling of the vehicle, and to the choice of colours. Only one subject says that the instruction on play-behaviour had enlarged his problem-space through which he gained flexibility in designing. Within the total range of information sources on all kinds of basic knowledge the information on play-behaviour is only a minor part. Moreover, the priority given to information sources concerning play-behaviour is low compared to sources concerned with technical and ergonomic information.

Analysis of sources used, concerning information on play behaviour and other subjects, was done separately for both experimental and control group. The results are shown in Table 1. It illustrates that information on play behaviour is apparently of minor importance. There are no significant differences between the control group and the experimental group, neither in the first nor in the second questionnaire.

3.2 *Design process*
Tables 2a and 2b show the number of times subjects, in their technical reports, gave information on or used arguments based on 'play-

Table 1 Mean number of information sources, as mentioned in questionnaires 1 and 2

Questionnaire 1	*Control group*	*Experimental group*
Play information	2.50	2.00
Nonplay information	6.00	4.75
Total	8.50	6.75
N	8	12
Questionnaire 2	Control group	Experimental group
Play information	4.83	5.27
Nonplay information	1.33	1.91
Total	6.17	7.18
N	6	11

information'. In total, both groups mentioned the same number of times an item related to play.

From Table 2a it is clear that subjects in the experimental group mentioned significantly more information on play activities and significantly less information on more abstract and general topics like the attitudes, taste and preferences of the users of their product. All other topics were mentioned to the same extent by the both groups.

The experimental and control groups showed no significant difference with regard to the phase of the design process in which the information was used and mentioned (see Table 2b). As can be expected, information about the play-behaviour of the users was most important in the very beginning of the process, the information phase.

Table 2a Mean number of times 'play-information' is mentioned in reports of design process, by information category. Differences tested with *t*-test (: $\alpha = 0.01$)**

Information category	*Control*	*Experimental*	*Sign.**
1 Play activities	2.0	6.8	**
2 Social activities	1.5	1.1	–
3 Differences boys-girls	2.0	1.8	–
4 Differences age groups	3.1	2.2	–
5 Toys/play equipment	0.3	1.0	–
6 Play environment	2.0	2.0	–
7 Use of colour	1.5	0.9	–
8 Attitudes and preferences	6.9	3.8	**
All categories	19	20	
N	8	12	

Table 2b Mean number of times 'play-information' is mentioned in reports of design process, by phase of process. Differences tested with *t*-test

Phase in design process	*Control*	*Experimental*	*Sign.*
A Information	6.3	7.8	–
B Problem definition	3.4	4.8	–
C Design constraints	0.6	0.5	–
D Idea generation	1.6	1.0	–
E Description of concepts	1.6	1.5	–
F Choice of concept	2.4	2.0	–
G Materialization	0.5	0.0	–
H User test	0.6	0.7	–
I Adjustment of prototype	0.4	0.3	–
J Evaluation	1.9	1.1	–
All phases	19	20	
N	8	12	

3.3 Design

Individual judgements by the expert panel of the eight prototypes in the control group (N_c) and the 12 prototypes in the experimental group (N_e) were averaged per group. Table 3 shows the means and standard deviations for each dimension of the judgement. On three dimensions – *triggers fantasy*, *multifunctional* and *suitable for more than one child* – the differences are significantly in favour of the experimental group. On the

Table 3 Judgements of designs on nine dimensions; means, standard deviations, and significance level. N_c = 8, N_e = 12. Differences tested with *t*-test (: α = 0.01; *: α = 0.05)**

Category		*Control*	*Experimental*	*Sign.*
Triggers fantasy	*x*	3.75	4.71	**
	sd	1.4	1.5	
Child-friendly	*x*	4.52	4.06	–
	sd	1.6	1.4	
Multifunctional	*x*	3.42	4.60	**
	sd	1.4	1.5	
Suitable for:				
4–8 years group	*x*	4.55	4.57	–
	sd	1.5	1.7	
More than one child	*x*	3.67	4.72	**
	sd	1.6	1.7	
Younger children	*x*	4.48	4.56	–
	sd	1.4	1.6	
Older children	*x*	4.58	3.88	*
	sd	1.7	1.6	
Girls	*x*	3.94	4.17	–
	sd	1.6	1.5	
Boys	*x*	4.46	4.44	–
	sd	1.4	1.3	

Table 4 Official marks given by project staff, on three assessment criteria half-way (1) and at end (2) of project. Differences tested with *t*-test (: $\alpha = 0.01$; *: $\alpha = 0.05$)**

Assessment		*Control*	*Experimental*	*Sign.*
Process 1	*x*	6.94	6.46	–
	sd	0.7	0.9	
Product 1	*x*	7.00	6.46	–
	sd	0.6	0.6	
Presentation 1	*x*	6.69	6.75	–
	sd	1.0	0.8	
Process 2	*x*	6.94	6.29	–
	sd	0.7	0.9	
Product 2	*x*	7.31	6.67	*
	sd	0.5	0.4	
Presentation 2	*x*	7.00	6.25	–
	sd	0.7	1.3	
Overall assessment	*x*	7.00	6.17	*
	sd	0.6	0.8	

other hand the mean score of the control group for *suitable for older children* is significantly higher.

For two reasons a comparison with the official marks, given by the project staff, is relevant. Firstly, these marks give a control on differences in design abilities between the control and the experimental group. Secondly, especially the final overall assessment may reflect the importance that staff members are attaching to child-directed aspects of designing.

As Table 4 shows, nearly all the average scores of the control group were higher than those of the experimental group, and were significant for the final overall assessment. Hence, differences between the two groups in assessments of the go-carts on child-related aspects cannot be explained by differences in official assessments. Moreover, the official marks seem to reflect the minor attention given by the educational staff to psychological aspects of play equipment. A more detailed view on this relation is provided in Table 5, showing the correlations between the official product assessment 1 and 2, as well as the overall assessment on the one hand, and the categories on play-activities on the other.

3.4 *Fixation-effect*

One of the examples used in the instruction on play-behaviour of children was a tricycle, for young children, equipped with a small loading tray on the back (see Figure 2). Although only verbally described, this example appeared to be quite appealing because in the conceptual phase five out of twelve subjects in the experimental group reproduced the tray as part of

Table 5 Product-moment correlations between assessments on categories of play behaviour (by 6 expert judges) and official marks (by project staff)

	Official marks		
Category	*Product 1*	*Product 2*	*Overall mark*
Fantasy	−0.66	−0.53	−0.15
Child-friendly	0.30	0.43	0.34
Multifunctional	−0.14	−0.53	−0.33
4–8 years group	−0.11	0.24	0.22
More than one child	0.05	−0.44	−0.14
Younger children	0.21	−0.21	0.22
Older children	−0.07	0.27	0.04
Girls	−0.01	0.24	0.04
Boys	−0.06	0.23	0.06

the go-cart. Three of them used the idea in their final design. Two other members of the experimental group seemed to derive inspiration from the same example in that they sketched small carriers on the back of the go-cart. This idea disappeared in their final design.

3.5 *Message*

Subjects were confronted with different psychological categories of children's play behaviour. These categories were also used as assessment dimensions. An analysis of the relations between categories could be of help in determining the underlying factors of the content in the context of designing. A factor analysis was not possible because of the small number of judges. Only preliminary conclusions can be drawn from correlations between the categories. The correlations between assessment dimensions are presented in Table 6. Some clusters can be distinguished. Firstly,

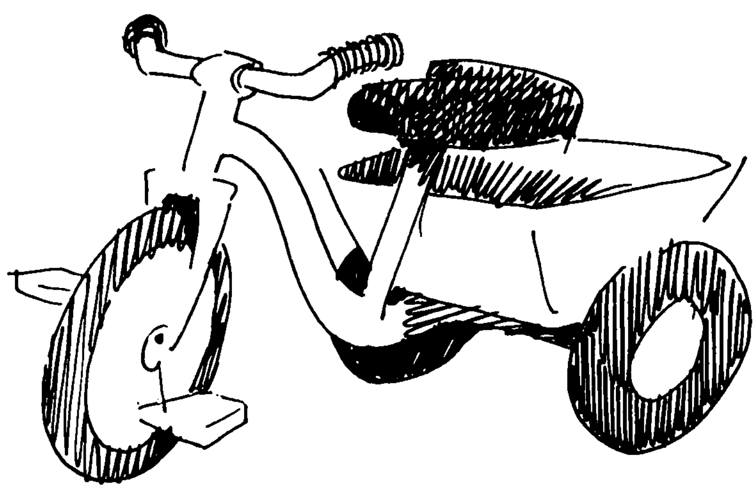

Figure 2 Tricycle as an instruction example

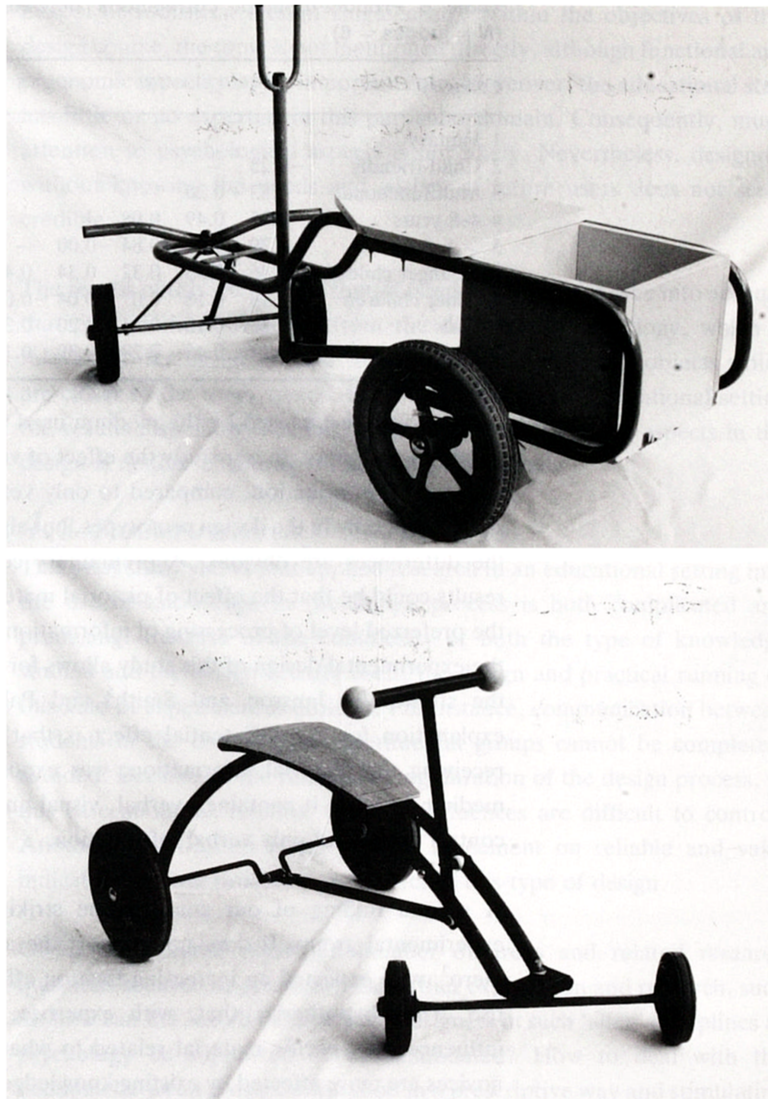

Figure 3 Two design models of a 'flying Dutchman'

correlations are high between *fantasy*, *multifunctional*, *more than one child*. A second cluster is defined by *girls*, *young children*, and, to some extent, *fantasy*; finally the dimensions *boys* and *older children* are closely related. As seen before, the experimental group differs on the first cluster of dimensions.

4 Discussion

4.1 Medium

Jansson and Smith[5] and Purcell and Gero[3] showed, under some circum-

Table 6 Product-moment correlations between assessment-dimensions (N = judges = 6)

Category	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1 Fantasy	–								
2 Child-friendly	−0.25	–							
3 Multifunctional	0.83	−0.26	–						
4 4–8 years	−0.05	0.49	0.08	–					
5 > 1 child	0.79	−0.07	0.84	−0.00	–				
6 Younger children	0.46	0.33	0.32	0.34	0.40	–			
7 Older children	−0.18	0.18	0.07	−0.04	−0.02	−0.46	–		
8 Girls	0.33	0.15	0.24	0.20	0.32	0.69	−0.34	–	
9 Boys	0.12	0.46	0.29	0.39	0.17	0.05	0.66	0.11	–

stances, an effect caused by the medium used to transfer information to (student) designers. In our study the effect of visual information together with verbal information, compared to only verbal information is rather strong. Not only in the design prototypes, but also in the technical reports, the differences are obvious. A preliminary conclusion based on these results could be that the effect of pictorial material on design may reflect the preferred level of processing of information for designers[3]. However, the experimental design of this study allows for other explanations. As in the studies by Jansson and Smith[5] and Palmiter *et al.*[7] a possible explanation for the differential effect is that the experimental group, receiving the pictorial information, was exposed to a richer encoding medium because it contained verbal, visual and motor codes, while the control group had only verbal information.

A second finding of our study is the striking fixation effect in the experimental group. It does not support the assumption of Purcell and Gero[3], who expected an increasing fixation effect with increasing expertise. They hypothesize that, with expertise, designers become more influenced by specific material related to what is to be designed, while novices are more affected by existing knowledge based on experience, i.e. on the most familiar examples. On the other hand they mention another factor that may contribute to the presence or absence of the design fixation effect, i.e. the familiarity of the example. One of the results of their study is that aspects of unfamiliar designs are hardly reproduced in contrast with aspects of the familiar. Probably it explains the effect in our study because the example which was reproduced, is a familiar design in The Netherlands.

4.2 Message

Providing behavioural or psychological aspects in the context of the design assignment is a rather new phenomenon in the design course of the Delft

School of Industrial Design Engineering. Within the objectives of this design course, the topic is not mentioned directly, although functional and ergonomic aspects play an important role. Moreover, the educational staff has little or no expertise in this particular domain. Consequently, much attention to psychological aspects is not likely. Nevertheless, designing without knowing the needs and wishes of future users does not seem credible.

The results of this study show that, if (student) designers take into account that part of the knowledge from the domain of psychology, which is relevant to the design context, they will be able to design objects which are closer to the users' needs. But within the current educational setting the results also show that the integration of child-related aspects in the design is neither encouraged nor positively valued.

4.3 *Further research*

This pilot study shows that applied research in an educational setting into the use of knowledge in the design process is both complicated and promising. Because of the complexity of both the type of knowledge studied and the design activity itself, the design and practical running of this kind of experiment is difficult. For instance, communication between students in the control and experimental groups cannot be completely avoided. Because of the relatively long duration of the design process, in this case about six months, external influences are difficult to control. Another complication is the lack of agreement on reliable and valid indicators of both process and product in this type of design.

Given these initial results, a number of areas and related research questions seem to be promising for further exploration and research, such as: how can the search behaviour of designers in such 'alien' disciplines as psychology be supported or accommodated? How to deal with the dilemma between giving information in a prescriptive way and stimulating the creativity of designers? Is our knowledge of the design process complete and detailed enough to develop an effective information system? Given the developments in areas like artificial intelligence, neural networking and computer simulation, is it worthwhile developing an expert system for designers, or should we aim at some form of decision-support system? Although Powell[2] has provided some promising starting points for (architectural) 'design information transfer', these questions must still be answered.

The organization of the information seems to be an important factor in this respect. In this pilot study the content and scope of the information was relatively easy and small. But as soon as the amount of information and the number of subjects and topics grows, an efficient and flexible organization is necessary. deVries *et al.*[12] have described the first results of a study into the organization of information for architectural designers. Both a hierarchical and a hypertext structure are compared in combination with a computer-aided way of guiding users through the available information.

In addition to the structure of the information, the presentation appears to be important. The strong effect of an appealing example such as the tricycle in the our pilot study, makes clear that the use of this kind of 'image' can have a powerful effect on design students. Is it really true that designers are much more used to communicating in visual images rather than in textual information. And if so, should we replace all verbal information by graphical, or is it more effective to combine both ways of communication? What are the implications and applications of this kind of development both in educational and professional settings in industrial and architectural design?

12 **deVries, E, van Andel, J and de Jong, T** 'Computer-aided transfer of information on environment and behaviour: Network versus hierarchical structures', in: *Proceedings EDRA 23 Conference*, University of Colorado, Boulder (1992)

5 *Acknowledgment*

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