Product Instructions in the Digital Age

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The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

We are nowadays surrounded and sometimes overwhelmed by exciting and fast changing products. Designers and manufacturers are very enthusiastic about inventing and redesigning them, but many are not very keen to create good instructions and teach users how to use the products correctly and safely.

Many product instructions like these are not as useful as they should be. They are not effective or inclusive enough and sometimes are out of reach. This research recognised the problems with product instructions and aimed at finding solutions to enhance their performance, especially in this digital age. Related literature was reviewed, questionnaires were sent out to gather opinions and experiments were carried out to look for solutions.

A product was chosen according to criteria related to experimental requirements. The instructions which accompanied the product were very poorly designed. These instructions were re-designed in a traditional printed format and then an interactive multimedia format. These formats were tested using a group of Digital Natives (those who have grown up with digital devices) and a group of Digital immigrants (those who learnt to use digital devices as an adult). Conclusions are drawn in the end and recommendations are given for instruction planners.

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Chapter 1. Introduction

1.1 Motivation

Product instructions are guides with the purpose of helping consumers to use products properly. They are usually "on the product itself or its packaging or in accompanying materials" (ISO/IEC GUIDE 37, 1995, iv). They perform many different tasks and the good ones benefit both the users and the manufacturers. For consumers, instructions are vital to use their products properly. For manufacturers, well designed and presented instructions make good business sense.

Although product instructions are important and not replaceable, evidence suggests that existing product instructions are not as good as they should be. The fact is that user satisfaction rates on product instructions is very low according to the author's survey in a 2006 questionnaire. It is also reported that less people read instructions in recent years (Gräfe, 2004). This statement is backed up by other investigations from Userview in 1995 and 2007. The results show that the number of people who always read instructions dropped from 47% in 1995 to 30% in 2007 (Filer, 2007). Also, people complain about many problems with product instructions such as they are either too wordy or difficult to understand, hold unusual technical terms, contain bad translations and they are easy to lose. These criticisms suggest that many instructions are not effective and they are not designed for all. Moreover, more problems can be identified for instructions in accompanying materials, which are very often in physical forms like leaflets, manuals, CD and videotapes etc.

Figure 1: Examples of paper based product instructions.

Some product instructions take a huge amount of space to store and are not easy to be kept. For example, some products, such as office machines and equipment, are shared or passed

around, and instruction manuals become lost in the process. On the other hand, for manufacturers, it is expensive to have these accompanying materials produced. Paper based product instructions such as leaflets and manuals are typical examples. Some of them contain many pages as all useful information has to be included (Figure 1). Costs for producing them have been continuously increasing in recent years since the price of paper increased. According to published news (Kiernan, 2007), the price of paper rose between 2.5% and 8% in the UK in 2007. Then paper producers expected another increase after energy and materials hikes (Morris, 2008). Well into 2011, global demand on paper continued to be strong and manufacturing input expenses were even higher; merchants had to keep passing the price on. Consequently the costs for printing product instructions are assumed to go up again. Similar problems apply to other forms of instructions, for example CDs and videotapes.

Facing all these problems with product instructions, some actions have been taken to alleviate the frustrations. To make product instructions more comprehensible and effective, standards for formulating instructions are available and textual materials on how to write instructions are provided. Meanwhile, info-graphics have been studied by some designers and academic researchers so that graphics can be used to aid the presentation of information in product instructions. However, available standards are limited and dated; research focused on product instruction design is still very rare; problems of product instructions are not completely and successfully solved and users are continuing to suffer from annoyance caused by poor product instructions. The problems proved that it is necessary to carry out a systematic and up to date study to improve the performance of product instructions, especially in this digital age.

The author perceives the design of product instructions as very complex and requires a collective knowledge of information design, graphic design, product design, cognition and learning and human factors as well as modern media. Thus it should be systematically studied with a combination of knowledge from these different fields.

1.2 Aim

In this research, the author investigates problems of product instructions as well as suggesting possible explanations for these problems. The study aims to find solutions to

enhance the effective and inclusive performance of product instructions in a commercial environment in this digital age. The ideal is to find a method to produce durable product instructions that can be easily updated and stored, can be accessed and understood by all; meanwhile fulfilling the requirements of being cheap to produce and environmentally friendly. Inspiration is taken from fields like information design, product design, graphic design, and instructional design in education plus cognitive and ergonomic science.

1.3 Research strategy

For this study, a problem-driven design strategy was adopted. The research focused on current problems with product instructions; then found needed information and knowledge to solve them. By referring to a general system for problem solving design process (Shadrin, 1992), this research was planned to be constant and followed the following steps:

- Analysing problems (what is the problem with product instructions?)
- Planning purpose of the outcome (How they should be?)
- Examining current solutions (How was it done before?)
- Creating hypothesis (What might work?)
- Designing prototypes (How will the designs to be made? What skills do I need and how can it communicate?)
- Testing prototypes (Will this work?)
- Result analysis and evaluation (Is this the best solution?)

To follow these steps, some research questions were studied and answers were found out and concluded:

- Are product instructions still necessary?
- What are the main problems with product instructions?
- What solutions are currently used to solve problems in product instructions?
- Is it possible to make instructions effective, easy to access, universal, sustainable and cheap to produce at the same time? And are multimedia instructions the better choice?
- Is there a preferred method/media of producing successful product instructions?

1.4 Overview of the research

This thesis describes and discusses findings in each research step (see 1.3). It includes 8

chapters. Literature review from the existing research that this work was built upon is presented in chapter2. Chapter 3 describes the methodologies that were involved in this study, which mainly includes questionnaire, user testing, protocol dialogue analysis and interview. Chapter 4 discusses the current solutions for product instruction problems as well possible future solutions. Chapter 5 and 6 records the making and testing of the product instruction prototypes and chapter 7 discusses and interprets the results therefore conclusions are drawn in chapter 8.

Chapter 2. Literature Review

This study is built upon many previous research studies. Literature from the areas of product design, information design, graphic design, cognition and learning, human factors plus design media and their users are reviewed in this chapter.

2.1 Product instructions

2.1.1 Definition

In the Oxford English online dictionary (2006), the word "product" is defined as "that which is produced by any action, operation, or work; a production; the result. Now that which is produced commercially for sale". Another word "Instruction" is described as "making known to a person what he is required to do; a direction, an order, a mandate (oral or written) (OED, 2006)". Thus the term "Product instructions" refers to the guides associated with products to provide detailed operating instructions. In one of these international standards, "Instructions for the use of products of consumer interest" are defined as:

> *"the means of conveying information to the user on how to use the product in a correct and safe manner. As a means of communication, texts, words, signs, symbols, diagrams, illustrations and audible or visible information are used, separately or in combination. They may be on the product itself or its packaging or in accompanying materials, for example, leaflets, manuals, audio and video tapes, and computerized information" (ISO/IEC GUIDE 37, 1995, iv).*

2.1.2 Purposes, functions, forms, legal value and benefits

The initial purpose of instructions is to communicate vital information to users, and help them to use products correctly when this cannot be achieved through the design of products themselves. They are crucial parts of products and they should allow and promote proper use of manufactured goods also offer direct help to avoid mishandling, which may lead to danger. Although they should not compensate for flaws of product design, instructions should be able to reduce risks of damaging products, consequent failures or inefficient

operations.

The function of product instructions can vary widely. It is believed by FcFoss Associates (2006) that instructions can be used as procedural guides to help people assemble, install, and operate products. They also are able to provide troubleshooting suggestions to assist users to isolate problems and find the resources they need to make repairs. Furthermore, in some situations, instructions may work as decision aids to help users to choose among a few alternative applications or actions.

As product instructions fulfil different tasks, they can take any form to accomplish their aims. The familiar instruction sheets or manuals packaged with many products are only one of many ways to provide information to users. Other common ways include the presentation of product information through control labels and symbols, stickers, tags, dial markings, nameplates, and other signs and marks on products. Likewise, warnings, cautions, notices, can be affixed to devices or mounted in their vicinity to instruct users. Moreover, product instructions can take the form of embedded aids. This form is widely used in software applications. Similar techniques are available for non-computer uses. Last but not least, product information can be delivered through non-visual stimuli. For example, auditory tones or brief spoken messages can be instructional. Even tactile stimuli have been used to successfully communicate needed information.

Under the conditions of the Consumer Protection Act (1987), instructions intended for use by consumers must be without serious shortcomings. Information that could be misinterpreted leading to damage or injury could be considered to be a “serious shortcoming”. Consumers have the “hidden” rights to take legal action if inadequate instructions waste their time or were a contributing factor in causing injury.

In some ways, product instructions are not only documents to indicate to users how to use products correctly, they also have legal value. The explanations listed in product instructions are actually part of the contracts signed between the manufacturers and the consumers. As a consequence, some product instructions have caused legal or other problems.

The case of Ikea was one of the special cases concerning product instructions. Ikea’s furniture instructions were mainly well planned. However, as reported in the Evening

Standard (Mintowt, 2005), Ikea was accused of sexism because it had included some images of women in its instructions but admitted most were of men. Later, Ikea reviewed its instruction leaflets to get a more even balance between men and women.

Product instructions can be seen as aid tools for consumers to use products properly. Like any other good tool, instructions must be designed for use. Well designed and presented high quality instructions make good business sense. As a technical writing and information design consultancy stated, good documentation always lights the users' way (Human Computer Interface, 2006). For customers, they are the keys to keep the products in order, for safely and appropriately use (Ricability, 2003). Furthermore, good product instructions unlock the product's functions, build customers' confidence in product quality and are delivered as part of the company's promise so that they create a positive impression of the company.

2.1.3 Product instructions are necessary

Product instructions perform many different tasks and the good ones benefit both the users and the manufacturers. For consumers, instructions are vital. As proved by the TCeurope (the European umbrella organisation for technical communication) in 2004, 88-98% of users recognise product instructions either as very important or important. They help users to operate products properly. They are also safe and procedural guides to help people assemble, install, and dispose of products and to provide basic troubleshooting suggestions. For manufacturers, well designed and presented instructions make good business sense. At the point of sale, instructions may work as decision aids, which can help people to make a purchase decision among alternative products. They also build customer's confidence in product quality and reduce time spent supporting the products (Human Computer Interface, 2006).

In recent years, products tend to be designed for intuitive use, which implies products should be able to be used easily without instruction. However, they are not accessible to every user and for every product. Thus product instructions are still necessary and have their unique values. According to Blackler, Popovic and Mahar (2003), a user's relevant past experience is the key to intuitive use of the features of products. The intuitive usability of a product relies on how many familiar features are included in that product according to the

user's past experience. Also, as new technology allows designers to include more functions in one product, many newly developed products are very complex and involve multiple functions; these functions are experimented with only when necessary and when the user guides are available. Thus, instructions for these products have to be carefully prepared if the current trends are to continue.

2.1.4 Product instructions in this research

Products are very different from one to another. Some of them are designed for general users to operate, including novices; others are for professionals, which should require specific knowledge of certain areas. Consequently, product instructions differ from each other; depend on the nature of the products and their target users. Requirements of instructions for professional products should be very different from those for general products. Manuals for experts should also be different from those for common users.

Also, instructions could be in several forms. Each of them requires different considerations. It is difficult to set a one for all solution to plan all types of instructions in all forms. In this research, ideas are focused on the design of instructions for general products; especially those that come with products to provide universal help. The term "product instructions" in this thesis mainly refers to those accompanying guides that provide instructions to consumer products.

2.1.5 Base disciplines

It is believed by Pettersson (1998) that the design of product instructions is the design of instructional messages and this is one sub area of Instruction Design. The major purpose of instructional message design is to produce courses, lessons and materials intended for learning. It is closely related to information design and it is an interdisciplinary subject. It takes influences from many established areas of research. The main areas may involve language, art and aesthetics, information discipline, communication, behavioural and cognitive study and so on.

2.1.6 Design process

Pettersson (2002) suggests a design process for instructional messages, which comes with six steps:

Analyse requirements

This initial plan involves the understanding of the product design and any consideration from the business point of view.

Plan contents

Cognitive and information ergonomics rules are followed to design contents.

Design language of messages to communicate

Communication theory, instructional design and information design disciplines can be referred to in this stage to make sure messages can communicate.

Deliver and present messages

This production step needs aspirations from some or all of the following disciplines: aesthetics, film, illustration, computer science, information science and media study…

Testing

Designs are tested by target users to identify problems.

Refine designs

Designs are refined according to feedback from the testing process.

The outline gives an overview of what to do when dealing with instruction design but further details are not explained. Two aspects of these steps, the design of language and testing are also recognised as important by other researchers. Sherman& Craig (2003) used case studies to understand the design of user documentations and instructions. Their study involved both the language communication and evaluating/ testing of documentations; the overall design processes were not mentioned. Similarly, ISO/IEC GUIDE 37(1995) suggested two types of assessing methods for general user instructions: desk research and interactive penal testing. Again it did not make suggestions on the design process of general instructions.

2.1.7 Information in instructions

It is believed that designers need to “minimise the amount of explicit instructional material” (Boyle, 1997, p13). Carroll (1990) used the word ‘minimalist’ and suggested that instruction planners should make the training experience efficient “by providing less overtraining structure” (Carroll, 1990, p78).

In Carroll's minimalist instructional theory, a set of teaching strategies can be referred to as a minimalist approach. It emphasized three major aspects:

- Allowing learners to start immediately on meaningfully realistic tasks;
- Reducing the amount of reading and other passive activity in training;
- Helping to make errors and error recovery less traumatic and more pedagogically productive.

Minimalist instruction is learner and task oriented. To minimise information, designers need to take the learners' needs as the primary considerations. The learners' requirements for activities and sense making are used as information resource for design to ensure effective training. There are strong links between training materials and realistic situation. Learners read the minimum of documents then start from projects involving meaningful tasks.

This idea of allowing users to learn by doing rather than reading is agreed by many others. For example, Lindgaard (1994) believed it is particularly useful in computer documentation designs to minimise the content and encourage users to interact with systems more. While interacting with a minimised instruction, learners are encouraged to think and understand what they are doing, not simply follow instructional materials. Also, errors during performance are expected and very often can turn into learning experiences.

In terms of reading order, Carroll (1990) observed that traditional systematic instructions work poorly when people use paper based instructions to learn IT tools. During the process, many were trying to understand the situation rather than following a rigid series of steps. Carroll suggests reading materials to be designed interactive rather than linear, and can be read by choice, in random order. Although the minimalist ideas are primarily intended for instructions of the novice learners, the principles can be also useful for those experienced users who have stronger prior knowledge to shorten the amount of time on reading instructions.

Meij and Carroll (1995) believed that ideas are suited for optimizing instructions in general and they also believe that the theory could be applied to either paper manuals or online instructions.

After a set of research, Carroll (1998) proved that minimalist instruction is generally effective.

It avoids two extremes: 'under-teaching' and 'over-teaching'. The theory is now the subject of many papers in the human factors and documentation fields. It can be very practical in designing quick start manuals for mobiles, computers and other complex products. However, it is not going to be useful in settings where the material is highly structured or the learners can possibly miss important information unless the instruction is intentionally systematic, for example, installation instructions for flat pack furniture. A combination of minimalist and systematically complete instructions might be realistic to offer the most productive learning experience.

2.1.8 Standards for product instructions

Some standards provide beneficial suggestions for creating product instructions. They share solutions to common problems and make the development of product instructions more efficient and fair between regions, countries and companies.

These standards are written by generally recognized and accepted authorities, so called standards organizations and they establish uniform criteria, methods, processes and practices for using or testing many subjects to address the interests of a wide base of users. Some standards are mandatory while others are voluntary.

By geographic designation and influence, there are international, regional, and national standards bodies. International standards are standards developed by international standards organisations; for example the ISO (International Organisation for Standardisation), the IEC(International Electrotechnical Commission) or the ITU (International Telecommunication Union). They are available for consideration and use worldwide. For example, ISO is a network of the national standards institutes of 157 countries, on the basis of one member per country. Adopting international standards is one way of overcoming barriers in international commerce caused by differences among countries or companies.

Regional standards bodies also exist. As a Regional regulation in Europe, CEN (Committee for European Standardization) has reached over 460 million people from 30 European countries (CEN, 2008). Sometimes international standards and regional standards are represented and modified to suit local conditions through National Standards Bodies. For example the UK's

National Standards Body, BSI (British Standard institution) is responsible for producing and publishing British Standards and for representing UK interests at international standards like ISO, IEC, CEN and CENELEC (European Committee for Electrotechnical Standardization). There are over 27,000 current British standards and 1,700 new or revised British, European or international standards are produced by BSI British Standards each year.

Among all types of standards, some provide relevant suggestions to the design and formulation of product instructions. The solutions are given for many common problems from the general principles of instruction materials to detailed recommendations like designing for older persons and drawing universal understandable symbols (Table 1).

Table 1: Standards related to the creation of product instructions.

Standard number	Year	Proved by	Influential arena	Title
IEC 417: 1973 (and supplements)	1973	IEC	International	Graphical symbols for use on equipment - Index, survey and compilation of the single sheets.
ISO 3864	1984	ISO	International	Safety colours and safety signs
ISO/IEC Guide 50	1987	ISO IEC	International	Child safety and standards - General guidelines
ISO 7001	1990	ISO	International	Public information symbols
ISO 1000	1992	ISO	International	SI units and recommendations for the use of their multiples and of certain other units
IEC 61310-1	1995	IEC	International	Safety of machinery - Indication, marking and actuation
ISO/IEC GUIDE 37:1995(E)	1995	ISO	International	Instructions for use of products of consumer interest
BS EN 81714-2:1999	1999	BSI	National/ UK	Graphical symbols for use in the technical documentation of products specification for graphical symbols in a computer sensible form
ISO/IEC GUIDE 71:2000(E)	2000	ISO IEC	International	Guidelines for standardization to address the needs of older persons and people with disabilities
BS EN 62079:2001 / IEC 62079:2001	2001	BSI	National/ UK	Preparation of instructions - Structuring, content and presentation
CEN/CENELEC Guide 6	2002	CEN CENELEC	Regional/ European	Guidelines for standards developers to address the needs of older persons and persons with disabilities

BS EN 60417-1:1999 IEC 60417-1:1998	2002	BSI	National/ UK	Graphic symbols for use on equipment-part1
BS EN 60417-2:1999 IEC 60417-2:1998	2002	BSI	National/ UK	Graphical symbols for use on equipment-part2-Symbol originals
BS ISO 7000:2004	2004	BSI ISO	National/ UK	Graphical symbols for use on equipment- Index and synopsis
CEN Guide 11	2005	CEN	International l	Product information relevant to consumers- Guidelines for standard developers

Standards provide general principles and detailed suggestions for the formulation of all types of product instructions. The ISO/IEC GUIDE 37(1995) and the BS EN 62079:2001/ IEC 62079 (2001) are examples. They provide wide-ranging rules to be followed when creating instructions for users of general products and they are mostly intended for application by product manufacturers, technical writers or other people engaged in the work of conceiving and drafting such instructions. They aim to be helpful in contract negotiations between the product supplier and the customer. Because the amount of documentation required very much depends on the complexity of the product, both the ISO/IEC GUIDE 37(1995) and the BS EN 62079:2001/ IEC 62079 (2001) do not establish a fixed amount of documentation for each special case.

The ISO/IEC GUIDE 37 is an international standard developed by the ISO in combination with the IEC while the BS EN 62079/ IEC 62079 is a national standard body created by BSI. As a national standard body in UK, the BS EN 62079/ IEC 62079 is drafted based on the ISO/IEC GUIDE 37 and other references therefore its regulations are in some way similar to the ISO/IEC GUIDE in majority sections. Through the IEC and the CENELEC, it is also available in the European region. Furthermore, the BS EN 62079:2001/ IEC 62079 (2001) contains extra contents so that it suits the needs of drafting industrial product instructions in addition to consumer ones.

2.1.8.1 The general principles of product instructions

Although the ISO/IEC GUIDE 37 and the BS EN 62079:2001/ IEC 62079 are structured differently, they have a high level of agreement on the basic principles for creating product instructions. Both of them recommend that instructions are recognised as an integral part of the delivery of the product. They suggest that instructions are an essential for the safe use of a product; instructions should help to avoid an intolerable risk for the user, damage to the

product or malfunction and/or inefficient operation but they are not intended to compensate for design deficiencies. According to the standards, an instruction should:

- clearly identify the product;
- recognise the type of user and his/her capabilities;
- provide all necessary information for correct and safe use of the product;
- present warnings about hazards or restrictions effectively;
- provide special handling information, warning notices for particular groups when necessary;
- give information on the year of manufacture and/or of expiry and warning for products with a limited safe or effective life;
- be readily available at the point of sale if they are necessary to make a reasoned purchasing decision among products;
- be consistent with all other material about the same product such as advertising or packaging.
- repeat the information with which the product is marked, i.e. name and address of the manufacturer, designation of series or type, serial number;
- express information in consistent terms and units.

When designing instructions, product elements such as risks, complexity, environmental, and legal or similar requirements are considered to determine the location and media which is most appropriate. Moreover, depending on the environment and the intended place of application and the expected lifetime of the product, durability issues also need to be taken into account. Also, the recommendations for using uniform units internationally are also given in another standard, ISO 1000 (1992).

2.1.8.2 The contents of product instructions

The ISO/IEC GUIDE 37 and the BS EN 62079:2001/ IEC 62079 provide recommendations on the contents of product instructions. The ISO/IEC GUIDE 37 concisely gives direction on what information should be presented in a product instruction. As well as these suggestions, the British and European standard, BS EN 62079:2001/ IEC 62079, lists all possible contents a product instruction could include in detail. Commonly, depending on the type of product, an instruction should include (Table 2):

Table 2: Suggested instruction contents by standards.

	ISO/IEC GUIDE 37:1995(E)	**BS EN 62079:2001/ IEC 62079:2001**
ID and specification	ID and specification of the product.	product names, serial numbers, model and versions or type numbers to match the exact

		product.
General description	a general overview of requirements, plus its performance and capacity: type of user, overall dimensions of the product, supply data for power, energy consumption and conditions, amount of noise, gas, waste water, any warranty conditions and messages to persuade users to keep instructions for the life of the product.	a list of spare parts, modification of products, intended environment, declaration of conformity, indication description and how to use the instruction when applicable.
Warning	adequate warning messages on what to do, what to avoid; warning on hazard radiation; for the use or disposal of products; restricted to the essentials; be available at the point of sale if necessary for example the need for protective clothing and warnings to parents on restrictions of use by children.	same as ISO/IEC GUIDE 37:1995(E)
Prepare instructions for use	necessary information, separately or in combination, on transport, assembly and installation.	same as ISO/IEC GUIDE 37:1995(E)
function and operation	no detail.	information for normal and safe operation, fault detection and exceptional functions/situations; instructions for automatic & remote controlled products should have indications to be observed and protection of persons.
maintenance	cleaning, maintenance, fault diagnosis and repairs.	maintenance instructions provided for unskilled persons should be clearly separated from instructions for skilled persons.
taking the product out of operation	destruction, recycling and disposal, as far as it is relevant.	
Index, lists and definitions	any instruction beyond four pages should have a table of contents and/or an index. It is crucial that definitions for unavoidable technical terms should be provided and signs and symbols should be defined if they are not readily understandable or not unambiguous.	Same as ISO/IEC GUIDE 37:1995(E)

Contents for function and operation vary with the design of products when creating instructions. For this reason, the international standard ISO/IEC GUIDE 37 does not address any detail on what to include when writing function and operation instructions. The BS EN 62079:2001/ IEC 62079 suggests that product user guides should include information for fault detection and exceptional functions/situations. It also gives other recommendations on content of instructions such as automatic & remote controlled products, indications to be observed and protection of persons. However, it is believed by the author that these extra suggestions are not suitable for a wide range of products and some are repeated in other sections of this standard therefore they are not necessary for designing general product instructions.

BS EN /IEC 62079 also emphasises that the type of maintenance instructions provided for unskilled persons should be clearly separated from instructions for skilled persons. The author believes that this would be better solved if different instructions could be designed for intended user groups.

The ISO/IEC GUIDE 37 and the BS EN 62079:2001/ IEC 62079 agree that product instructions should contain information relating to taking the product out of operation and taking further steps, for example, safe disassembly of the product, and for recycling or disposal of waste materials. As these contents are very important to users and environmental protection, they might deserve more attention and should be considered seriously when the product requires related information.

To sum up, recommendations on organising contents of product instructions given by BS EN 62079:2001/ IEC 62079 and ISO/IEC GUIDE 37 cover areas such as product ID, general description, warnings, preparing the product for use, function and operation, maintenance, taking the product out of operation, index, lists and definitions etc. Suggestions in the ISO/IEC GUIDE 37 concern instructions for general consumer products. These guides are very useful to sort out sufficient information for instruction contents. BS EN 62079:2001/ IEC 62079 repeats all these regulations and puts them in more detailed guides. The majority of its added suggestions are very useful for organising the contents of product instructions. The minority of them are repeated or suitable for large or industrial products only, thus they are not applicable for many general products. When presenting regulations, checking lists are

adopted in both standards and these show all the useful contents of a product instruction with a minimum of reading. These lists clearly present possible contents of product instructions. They are easily understandable and make perfect sense.

2.1.8.3 The communication of product instructions

In ISO/IEC GUIDE 37, suggestions are listed regarding communication principles, wording, use of technical terms and use of languages. It states that product instructions should be simple, precise and easily understandable. To communicate successfully, product instructions should be written following the communication process and offer users a continuously improved understanding. Basic functions should go first. Most importantly, product instructions should anticipate user's questions WHERE? WHO? WHAT? WHEN? HOW? WHY? and provide answers to them. According to the ISO/IEC GUIDE 37, wording and technical terms in instructions should be simple and brief and follow the rule of "one sentence, one command"(BS EN 62079:2001/ IEC 62079,P27). When creating instructions, commands should be written in a style that is clear, direct, and unambiguous. BS EN 62079:2001/ IEC 62079 summarises, reorganises all above statements in the ISO/IEC GUIDE 37 and provides two more suggestions- to use standardized phrases and signs for important messages and to follow ergonomic principles, especially when instruction materials are presented using electronic media. These suggestions on writing are beneficial to improve the effectiveness of product instructions.

In many countries there is a legal requirement that Instructions for use should be given in the official language(s) of the country of sale. Regarding the use of languages in instructions, the ISO/IEC GUIDE 37 and the BS EN 62079:2001/ IEC 62079 discuss that because of the limited space generally available, giving instructions on a product may present problems in relation to languages, especially when the country for sale has more than one official language. It may also be impossible to know the country of sale at the time of manufacture. The standards suggest that a possible solution for the problems is to use clearly understandable graphical symbols, numerals with explanation, and/or certain internationally acceptable words (for example STOP, MAX). The author believes that it is a waste to produce translations in all languages if instructional materials are printed. Also, this will increase the length of product instructions. Additionally, a solution for saving space for different

languages is very restricted and limited in print media. However this could be easily solved by developing instructions across digital media. For example, product instructions in different languages for different target groups can be delivered separately and digitally for different needs and devices.

2.1.8.4 Suggestions on appearances of product instructions

It is widely agreed that the type and size of on-product information, of printed material and of computerized information should be as clear as practicable to ensure the best possible legibility. In practice, the recommendations are confusing. ISO/IEC GUIDE 37 and BS EN 62079/ IEC 62079 present different recommendations regarding type sizes and line spacing etc on printed media and no suggestions are given for instructions on digital media (Table 3).

	ISO/IEC GUIDE 37:1995(E)	**BS EN 62079:2001/ IEC 62079:2001**
x-height of type faces	I.5 mm(4 points) or larger	
continuous text in printed instructions	between3.2 mm and 5.6 mm (8 points and 14 points)	not less than 9 points (1 Pica point = 0.351 mm)
minimum line spacing		not less than 120 % of the type size
headings in printed media	about 4 mm or larger (at the top of the 10 point to 14 point scale), depending on the reading distance.	Not less than 12 point.

Table 3: Regulations on legibility of product instructions

For continuous text in printed instructions, ISO/IEC GUIDE 37 suggests that type should be set larger than 8 points while the minimum is 9 points in BS EN 62079/ IEC 62079. However, from the graphic design point of view, the required size of font for information, warnings and labelling of controls, relates to the probable viewing distance, level of illumination and colour contrast of the text against its background. “The choice of font, whether with or without serif, in upright form or italics and light, medium or bold appearance has a significant impact on legibility as well” (ISO/IEC GUIDE 37, 1995, p16). The designer should also be aware that text written in CAPITAL letters is more difficult to read. Generally it is believed that on print media, a font size of 11 could be legible for the majority of readers and a font size of 14 would be suitable for users between age 40 -60 years (Lupton, 2004). However, this differs for those with visual impairment and the impact is significant. The

requirement varies in each case. Consideration should be given to specifying size and style of font and symbols for warnings for a more inclusive result. Additionally, requirements for font size and style are very different on digital media such as computer screens. In the catalogue of on screen typography, the required size of font for information relates to the probable viewing distance and the quality of output devices. Thus, for digital media, font size could be adjustable for users to fulfil different legibility requirements in each case.

Regarding the design of product instructions, the ISO/IEC GUIDE 37 and the BS EN 62079/ IEC 62079 give the same suggestions on brightness contrast. Brightness contrast means the difference between the percentage of light reflected from the background and the percentage of light reflected from the content. According to the standards, when designing product instructions, the brightness contrast should be at least 70 % and it is as great as possible for the best legibility (BS EN 62079/ IEC 62079, 2001). This is true for print media because good quality black print on white paper provides a contrast of about 80 % (ISO/IEC GUIDE 37, 1995). However this is not applicable for digital designs on screen. On screens, colours consist of light, thus the contrasts are with greater intensity than they would in print (Götz, 2003). For example, black type on a white background is a combination that we are used to seeing in traditional print format but it is of limited suitability for use on a screen. On screen, white is represented by means of the additive colour system, that is to say by each colour emitting light at full intensity, when black is used as text against this very bright background, the result is a stark contrast similar to the colour complementary contrast. Both factors are hard on the eye and therefore make the legibility low. The author believes that the regulations for this section in the ISO/IEC GUIDE 37 and the BS EN 62079/ IEC 62079 should be updated to take digital media into consideration.

It is advised by the standards that instructions “should be consistent with all other material about the same product issued by the supplier such as advertising or packaging” (ISO/IEC GUIDE 37, P2). The author believes that this applies to both content and appearance of instructions. When designing warning messages in instructions, ISO 3864 provides guides for using safety colours and safety signs.

Media for product instructions is considered in both standards. They both agree that audible or visible information can be used, separately or in combination and they can be on the

product itself or its packaging or in accompanying materials. According to the standards, instructions could be in different forms including traditional ones like print, videotape and new media, digital form. However, the suggestions for presenting instructions on digital media are very minimal. BS EN 62079/ IEC 62079, published in 2001 starts taking electrical media more seriously but suggestions for digital instructions particularly though multimedia are still not adequate.

2.2 Information design and development

2.2.1 Information Design

Information design is not a new term, but its popularity has certainly increased in recent years. The term is defined in a variety of ways, ranging from general in tone to highly specific and the subject is often known by other names.

A glance at recent publications shows that information design involves multi-disciplinary, multi-dimensional and worldwide concern. It has influences from many areas such as language, art and aesthetics, information, communication, behaviour and cognition, business and law, as well as media production technologies. The phrase is used by some people as an umbrella term, which covers the planning of almost everything, from warning signs to traffic instructions, from official forms to timetables and invoices.

Rune Pettersson, a professor of information design from Sweden describes information design in the following way:

> *In order to satisfy the information needs of the intended receivers information design comprises analysis, planning, presentation and understanding of a message- its content, language and form. Regardless of the selected medium, a well designed information set will satisfy aesthetic, economic, ergonomic, as well as subject matter requirements (Pettersson, 2002, preface).*

Similarly, Romedi Passini claims that information design is communication-oriented. In Passini's understanding, "the term information design means communication by words, pictures, charts, graphs, maps, pictograms, and cartoons, whether by conventional or electronic means" (Passini, 1999, p84). According to him, in every field of design more and more of our work depends on the effective use of information and 'there is nothing else to

sell but information'. Sless (1994) sees information design as a newly emerged design practice, which is widely required.

However, not every designer accepts information design as a new idea. To challenge this suggestion, Dervin (1999) recognizes information design as 'Something New, Something Old'. She states that information itself is not natural, but has always been designed to instruct us about the nature of the world we live in. To her, information design is not only about keeping messages in order, but also deliver human senses.

On the opposite of Dervin, Raskin indicates that information is natural. He even provides a statement that 'there is no such thing as Information design' and later he explains that 'Information cannot be designed; what can be designed are the modes of transfer and the representations of information. This is inherent in the nature of information, and it is important for designers to keep the concept of information and meaning distinct' (Raskin, 1999, p342). This statement brings the focus point back to communication.

Some other designers such as Jacobson find it very difficult to conceptualize information design. Jacobson's own belief is that there is a unique design practice to be identified as information design. It intents to use communication carriers systematically to arrange a conversation therefore enhance the understanding of information. Jacobson (1999) also claimed that studies of information design were too few; little has been carried out to support any broad generalizations about the practice of information design.

According to Jacobson's opinion, the theory of information design is still sketchy and case studies are scarce. The debate on the definition of information design is still ongoing. However, there is no doubt, information designers create communication, clarity and render complicated matters understandable for users. Or in short, as Wuran (1997) says, they 'make themselves clear'.

2.2.2 The origin and the development of Information design

Howard Wainer (2009) recommends the origins of visualization as the root of information design. He traces back to William Playfair, the inventor of basic charts in the nineteenth century, to Jacques Bertin, who introduced the first systematic theory of graphic representation and laid the foundation for modern graphics research. Other practitioners

argue that information design is not yet a fully integrated profession; they hold different views of the profession and the debates have never stopped. From a discussion held by David Sless (1998), it becomes accepted that there is no single history of information design.

2.2.2.1 The contributors

There are many possible histories for information design. Also as a profession, many people have contributed to its development. Unlike the other professions, people working in the information design area come from very different backgrounds. Some are writers, some are ergonomic specialists, graphic designers or engineers and others may have a background in human factors or cognitive science. Each of these origins offers practitioners a different history to trace one of information design's origins.

Robert Jacobson, a UK based Information designer is one of the people who have researched the history of the information design movement in each original profession. He suggests that many have contributed magnificently to the formation of the information design profession (Figure 2).

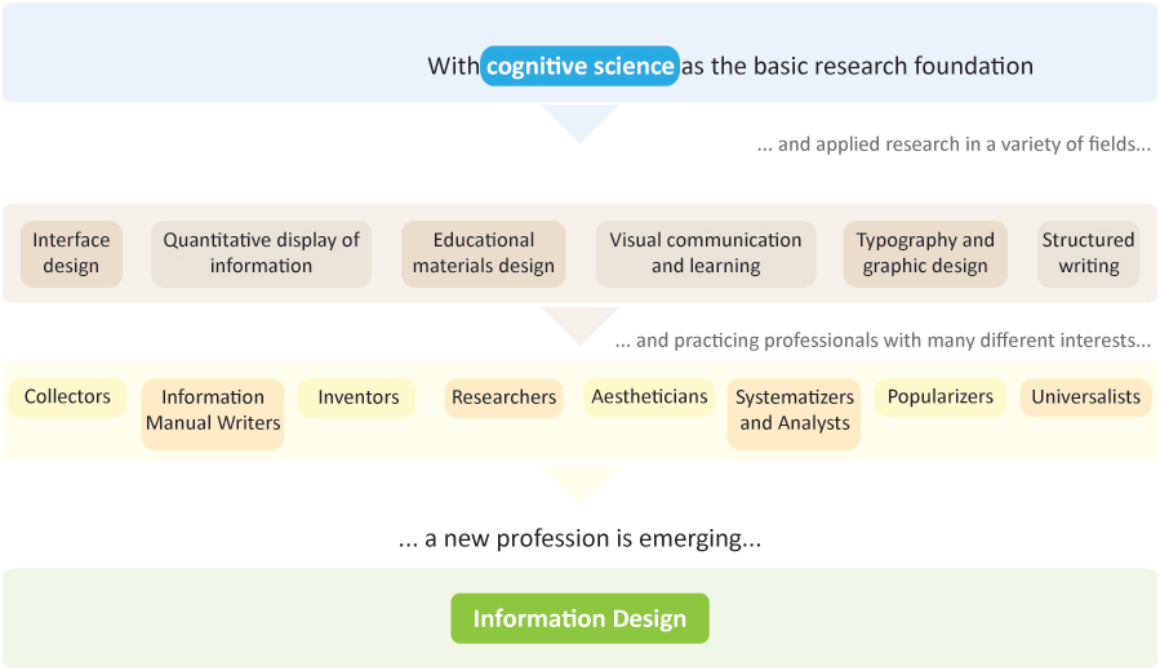


Figure 2: Contributors to the Emerging Information Design Profession (Jacobson, 1999)

In Jacobson's study, information design was practiced by small bands of believers concentrated in the UK and the Netherlands and the name of Information Design was little known in North America, Asia, and Europe by 1994. He believed that the term was still

exciting in 1999. However, the practice of applying design to information was becoming widespread.

2.2.2.2 The transitions

The history of information design also can be constructed as a story of transitions according to David Sless (1998), who started his study on information design science in the 1960s largely within the Australian context.

In the early part of the 20th century, a transition from crafting single objects to planning for mass productions occurred. Objective scientific evidence was widely used to help judging whether a design works or not. In the mid seventies, it was aware that the type of evidence we used was not necessarily either objective or scientific. Many important designs by then were connected with social influence and political ideas and they were not within the framework of user-entered design.

By the mid 20th century, the concept of design became broader. Designers started to take the usability of objects in to consideration. Then in the eighties, the idea expended even further. The relationships between people and institutions were taken into account. Eventually, in the nineties, information designers planned some rules. They set up systems to produce customised information and the social rule systems were also planned so that good information design became more common rather than the exceptions.

2.2.3 Information design in practice

Information design is concerned with many difference things in practice. It can be presented as diverse as maps, way-finding systems in stations, instructions, labels, websites and sometime as visualizations of complex data. The key for information design is to deal with meaning rather than materials and forms, in other words to make sense. Edward Tufte is a pioneer for working with mass information and his work shows the effectiveness of good design on the display of quantitative information (Tufte, 1983). Harry Back's map of the London underground (Figure 3) is another example for excellent information design. Instead of tracing the actual location of stations, the map uses simple lines and colour codes to reveal their linear relationships. The original map was produced in 1933 and the concept has been influential ever since.

Figure 3: London Underground map by Harry Beck, 1933

2.2.4 Information design and product instructions

The author believes that many similarities can be found between the design of product instructions and information design. Both areas are apparently not clearly defined, the histories are difficult to trace. They need to comprise the analysis and planning of a message, also consider presenting and understanding the message through the selected medium. Also, they both involve multi-disciplinary, multi-dimensional and worldwide concerns with influences from similar areas and need to satisfy the information needs of the intended receivers.

When designing product instructions, inspiration can be taken from the information design field. For example, the priority for designing product instructions should be ‘ to make sense’. Instructions should be communication-oriented by all possible means and materials, for example by words, pictures, charts, graphs, maps, pictograms, and cartoons, whether by conventional or electronic means.

2.3 Product design and development

2.3.1 Product development

Developing new products is a vital ingredient of business success. The statistics on business success show clear trends in product innovation between 1976 and 1995.

Year	% Innovations as total sales	% Profits
1976-1980	33	22
1981-1986	40	33
1985-1990	42	-
Projected 1995	52	46

Table 4: The statistics on business success and clear trends in product innovation (Baxter, 1995).

As shown in Table 4, the percentages of the total company sales and profits generated by new products were very high. In recent years, the innovation of new products has been even more important. For example, in the second quarter of 2011, Apple nearly doubled their quarterly net profits of what it made in the previous year, driven by their newly designed products. The company sold 18.65 million iPhones in a quarter, up by 113% from a year ago. Sales of the improved MacBook Pro were also strongly higher, with a rise of 28% (Apple, 2011). But, the company's profits were not equally positive with all products; sales for the older product, the one-time star iPods appeared to be in decline by 17%. Also, the company's operating system iOS, faced huge challenges from the newly developed platforms like Google's Android. It had to continue innovating new products to occupy the market. Therefore the newer version of iOS system was out quickly and other fresh products were also on the way. Companies like Apple continually introduced up to date products. They used new products to prevent other competitors taking away their market share. For designers this became exciting news. Design was the vehicle for product change and the more products change, the more design was needed. However, it was not all good news. To develop a new product was very risky. According to Baxter (1995), among every 10 ideas, 3 of them were further developed; 1.3 could be turned into products and launched. Eventually, only 1 of them might make any profit.

To meet the market needs, in the act of designing, designers gave primary consideration to the needs of the users. All human factors were translated as "a series of subsets pertaining to the purpose or use, physical substance, and appearance" (Lindbeck, 1994). This normally

involved special functions, material, and visual requirements of the users.

To produce successful new products, designers aimed at creating products that not only work and durable but also look nice. They experimented with new technology, use new materials and create new appearances for products to meet functional, material, and visual requirements.

2.3.2 Product functions

Designers adopt new technologies to enable the emergence of new products which function better. The design of early refrigerators is one of these cases.

In classical antiquity and later centuries, people used ice-safe devices to preserve food. A "new" finding in 1805, a vapour-cooling system, encouraged the design of the very first refrigerator. However, the early domestic refrigerators were unnecessary luxuries for many people because of their cost. To make big sales, designers kept seeking new technologies. They tried to use electricity, gas or paraffin to operate refrigerators from the late 1920s onwards. Consequently refrigerators went into common people's homes and were a big success. The design of refrigerators is not a single case. The adoption of up-to-date technologies is vital for many new products in the process of inventing and designing.

The invention of new products is not always easily acceptable. People's reactions to new products are often ambivalent: they want the improvements and comforts that new products provide, but when it forces upon them the loss of things they value and makes them adjust to the new and unfamiliar, they are inclined to resist. Forty (1995) observes that design has been most important to make things seem other than they are to achieve acceptance of the changes they brought about.

2.3.3 Appearance and Styling of products

The change of a product's appearance stimulates people to accept new ideas and alter the way people see commodities. According to Bloch (1995), 60% of senior marketing managers in a survey voted appearance as the most critical determinant of new products.

Historically, people style a product either to disguise its mechanical aspect or to highlight it through exaggerated forms (Fiell & Fiell, 2000). The example of refrigerators could be

considered again for this process. Refrigerators in the early days (Figure 4) adopted the form of cabinets and they were built as or within furniture. The Electrolux refrigerator (Figure 5) which became available in 1930 achieved its own character as a stand alone device. Later, The Bosch models (Figure 6), which included a cylindrical design with a circular door, were more compact and stylish.

Figure 4: Self-feeding ice-safe made by the piston Freezing Machine& Ice Company, 1875 (Fiell &Fiell, 2000).

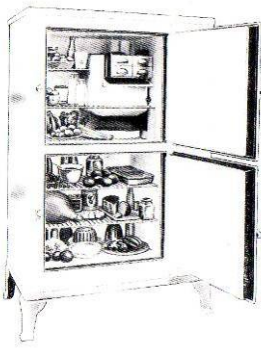


Figure 5: Electrolux refrigerator, 1930 (Fiell & Fiell, 2000).

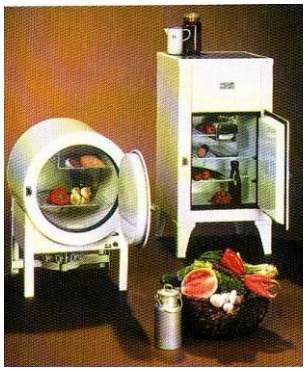


Figure 6: Bosh refrigerators, 1933 (Fiell & Fiell, 2000).

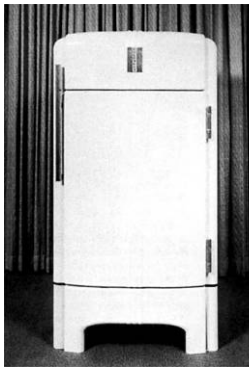


Figure 7: "Coldspot" refrigerator for Sears & Roebuck, 1935 (www.idsa-la.org).

Products' surface and appearance are treated as ''adding value'' to products (Charlotte & Fiell, 2001). Very often, they can dramatically enhance consumer appeal and increase product differentiation. In America, industrial design consultants began using streamlined styling to make their refrigerators more visually appealing, as illustrated by Raymond Loewy's well-known coldspot (1935) for Sears, Roebuck & Co. - the first domestic appliance to be marketed on the strength of its looks (Figure 7).

Raymond Loewy insightfully noted: "Between two products equal in price, function, and quality, the better looking will outsell the other" (Loewy, 1941, p227). Designers such as Loewy spent much of their time providing attractive and serviceable facelifts for existing mechanisms.

Figure 8: The glass bottles for Coca-Cola, 1894-1975 (www.referenceforbusiness.com).

The best-known example of this could be the restyling of the Coke bottle (Figure 8) to incorporate its famous curved form. The improvements on appearances enable products to be differentiated dramatically. Potential customers immediately considered their previous product models to be outdated once a restyled design is out. Although in many cases essential alteration on styling improve product performance at the same time, Bryson (2004) believes customers are often persuaded by styling rather than improvements in product performance.

2.3.4 Design trends

2.3.4.1 Miniaturization

After meeting basic functional, material, and visual requirements, designers start look for other ways to make their products outstanding and make businesses successful. As technology is evolved, there comes this increasing trend towards miniaturization.

The benefits of reducing the scale of industrially manufactured products are clear. Weight, volume, unit costs to the manufacturer, costs to the consumer and the amount of waste generated can all be significantly decreased. The automobile industry was among the first to explore the potential of miniaturization. In the 1930s, cars such as the Volkswagen Beetle (Figure 9) were not only among the smallest cars produced in their time, but were also the least expensive.

Figure 9: Volkswagen Beetle, 1938 (www.nkifhe.ac.uk).

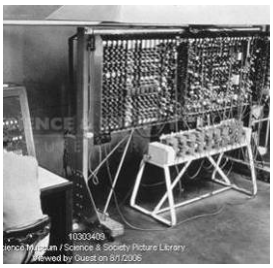


Figure 10: The general control console and chassis of the pilot ACE computer, 1950 (www.scienceand society.co.uk).

Figure11: IBM PC, 1980 (www.computerhistory.org).

Figure 12: MIT Media Lab -Hundred Dollar LapTop 2006 (www.laptop.org).

During the mid-20th century, the extraordinary advances made in the field of semiconductors allowed the development of more compact electronic devices such as small transistors. These advances lead to the fundamental miniaturization of consumer electronics. Another turning-point came with the development of the first integrated circuit in 1958. Such revolutionary microchip technology enabled appliances to become more compact, easier to handle, transport and store. The room-filling mainframe computers of the 1950s and early 1960s (Figure 10) gave way to desktop personal computers in the 1980s (Figure11) and eventually to laptop computers after the 1990s (Figure12). Minimal designs were not being made possible only by new technologies, but also by new materials, such as the strong but lightweight titanium employed in eyewear. Today, we are surrounded by mini-versions of every imaginable product, from micro-vehicles such as the Smart Car (Figure13) to MP3 players like the Ipod Nano (Figure14).

Figure 13: Smart For Two (www.smart.com,2011).

Figure 14: iPod (www.apple.com, 2011).

It has been predicted that, with the rapid development of ''molecular electronics'' and nanotechnology, the reduction in size of electronic devices will open the door to whole new

classes of ultra-miniaturized products and information systems (Charlotte & Fiell, 2000).

2.3.4.2 Simplicity

Redhead (2000) considers shiny plastic as the icon for the pop culture of the 1960s and "basic" as the symbol of the early 1990s. He considers the domination of rationalism tends as a consequence of economic downturns:

> *The British media were full of prophecies of rebirth of community and family values. High interest rates and the property slump were taking their toll and many people suddenly had no money to spend. Understandably, the prevailing mood seemed to be anti-brand and anti-excess. The furniture that went along with the mood- plain, simple, easy to manufacture and useful (Redhead, 2000, p18).*

Form then was designed to follow function back in those days. It appeared to be the cheapest way to mass-produce basic designs for the maximum number of people. However, simplicity is often not as cheap to produce as what it appears to be. Sometimes, 'back to basics' products cost similar to the ones that look complex and sculptured. For this reason, the trend was initially held. In 1995, Ikea launched its very popular PS Collection, which combined good form, function and at affordable prices. Eventually, the entry of global retailers like Ikea and Muji powered the development of simplicity.

It isn't just simple furniture that has been such a success. All around us, simplicity has begun to mean big business. Trends come and go, but the simplicity culture and styling taste remains. Even now, we still accept 'less is more' and surround ourselves with modern and basic designs. As Bono (1990) believes, simplicity should become a permanent fashion.

2.3.5 Products of our time

According to Redhead (2000), designers argued for making products more distinctive, useful and profitable for half a century. In 1990s, analysts eventually researched in the commercial world and discovered that creative design is not replaceable and the conventional business has been introduced into a design culture. Increased efficiency, restructuring, downsizing and cost cutting were the values of the early 1990s, but increased efficiency alone is not the best business solution. Also companies can always find cheaper places to manufacture their products somewhere around the world. This makes price no longer a selling point for many

products. Attractive and revolutionary designs are becoming more important for sales than ever.

Clark and Freeman (2003) stated that digital technology is going to cause devices that we are familiar with to merge, and this will be a design challenge. They also predicted that the computer, TV and VCR will soon merge together in a single device. Three years later, the mobile telephone has already become a device that enables consumers to talk to and see, even find maps from anywhere in the world. In 2010, there were 500 million smartphones sold worldwide. It was also predicted that the sales will exceed 800 million in 2015(Relaxnews, 2011).

In technological terms, the past three decades have been the fastest developing period of the century and have brought extraordinary changes to the world. Almost overnight, new industries, for example, the internet and biotechnology, have become big business. Information, new products and redesigned products are more evident than ever. More production plus more technology and speed creates more possibilities, possessions and profits. We live in times that are as confusing as they are exciting.

Today, customer's choices have never been wider. From PCs to tea bags, consumer products are being rethought from scratch. That's the way things work in this design driven age of techno capitalism. As experienced high technology consumers, people demand control and personalisation. They want products to be "more seductive, more personal, more available" (Redhead, 2000). 'Mass customisation' allows customers to personalise their products. In 2005, Apple's products such as ipod and I shuffle allow customers to have their own name on the back of the product. Similarly, Nike let the buyers decide the colour, detail and the ID of their own trainers. On google's search engine, August 06, the keywords 'personalised products' brought out 4,300,000 matched web pages. In July 2011, there were about 5,920,000 results on the same key words. Personalised products are developed not only in the fashion industry; they also range from computer to stationary, even picture frames. The evidence is around us everywhere.

2.3.6 Product development and instructions

People's demands on product instructions more or less depend on how much information

they need for the operation of the products. Therefore the design of product instructions is closely related to the design and development of products. In the product design field, products are restructured and redesigned from time to time to follow different trends. Thus, the author believes that product instructions should also be redesigned and updated quickly to catch up with emerging new products and their new requirements. Products are varying in different styles and sizes sometime very complicated to use by intuition. Also new technology allows products to become more and more complex. The merge of devices make products combine more functions and be more complicated to use. Users are overwhelmed by new technology, products and information in our time. This requires product instructions to be clearer, quicker to access and easier to understand. Like other products, instructions should have values of efficiency, simplicity and possibly they can enable more control by users in the future.

2.4 Graphic design and communication

2.4.1 Graphic design

Graphic design is in all parts of our life. From small items like cloth labels to huge objects like billboards. It locates and stimulates information, identifies and organizes messages, informs and persuades us, attracts our attention even provides pleasure (Poggenpohl, 1993). Graphic design also plays a substantial role in the way we perceive things. It shapes the perceptions of society, and has a significant impact on how people perceive and react to the messages carried by documents and signage.

> *Graphic design is a sophisticated communication activity, usually carried out by professionals, that involves the integration of text and images in materials of all kinds (Hunter, 2005, p63).*

Hollis (2001) believes that graphic design has its roles: to identify, to inform and instruct and to present and promote. Also it constitutes a kind of language with a certain grammar and a continuously expanding vocabulary. Its visual language makes messages recognizable and understandable by its intended audience, most usually by integrating words and images together. For example, meaningful graphic images are sometime used along with the context. Text used to have the limitation of losing expression and inflection when printed. Contemporary graphic designers break this limitation by changing sizes, weights and position

of the letters to give a voice to the text.

Similarly, Gill (2003) recognized graphic design as a second language, which communicates. He defines design as a way of organizing things and the solution to problems. Also, Lester (2003) thinks that graphic design is a kind of art and craft, which brings organized structures to groups of verbal and visual elements.

Giard (2005) emphasizes the communication purpose in graphic design. He states that graphic design is all about visual communication. Totally agreeing with Giard, Barnard suggests graphic design as a means of communication, an innocent medium.

Barnard (2005) believes that graphic production performs four basic functions. The first function is the informative function. Graphics play the role of imparting knowledge or intelligence. Manuals, pub signs, shop fonts, company logos and packaging are examples of graphics where one of the roles performed is that of providing information. Secondly, graphics have a persuasive or rhetorical function. Graphics can persuade to convince or affect a change in thought or behaviour. Advertising is one of the most conspicuous examples. Additionally, graphics could be decorative or aesthetic and finally, according to Barnard, graphic design has a magical function. It can make something different from what it truly is.

Graphic design can be applied cross almost any medium, from posters on paper to wooden signs. Graphic design has expanded to include the use of words, pictures, on television, and through computers. Lester (2003) predicts that graphic design will be used by every individual to express the individual's personality. The design studio will be a trend and digital design output will increase. Multimedia and cyberspace will link the world's citizens into one giant community.

2.4.2 Design and communication

"Most certainly! Design is communication" (Giard, 2005,p165). It can be a sign or a set of signs, which signifies something. A design can also be a symbol, which can symbolize values that are more implicit. As a combination of signs and symbols designs are a form of potent communication.

2.4.2.1 Communication

What is communication? Communication is a process. It is a form of signal transmission in which signals are created, sent, received and responded to. Communication is the production and exchange of messages. Radio and television are two well-known examples of communication. Like communication, design is also a form of signal transmission.

Most modern theories of communication are based on four principal components or variables. These are senders, signals, channels and receivers. They are a message, such as a signal or a code; an output or transmission; an input or reception; and a response. Moreover, the four components operate in a linear fashion, that is: a signal is created, transmitted, received and responded to, in that order (Figure15). The communication is only successful when the response matches the signal. The closer the match, the better the communication. The signal message is subject to potential 'noise' which is a 'distortion' of, or an 'interference' with that signal.

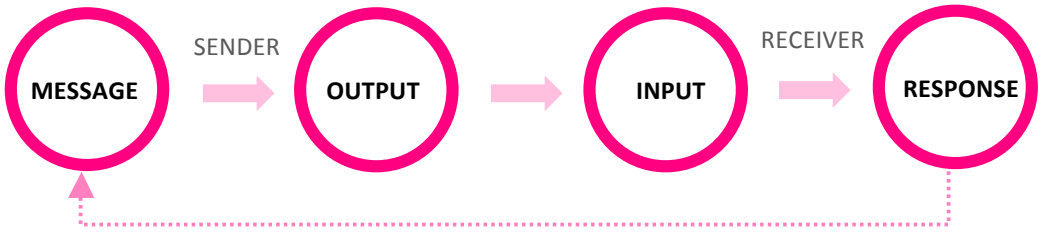


Figure 15: An example of a successful communication (Giard, 2005)

For example, in scenario 1, the message is sent and responded to as anticipated. The design is understood by the end user exactly as the designer wanted. This is a case of successful communication (Figure 15). However, in scenario 2, the message is sent but not received. It is an example of unsuccessful communication (Figure 16).

Figure 16: An example of unsuccessful communication (Giard, 2005)

Graphic design is a means of communication. The production of meaning in graphic design is

related to culture and communication via codes and signs. There are two types of meaning, denotation and connotation. Both types of meaning require some cultural knowledge or membership in order to be constructed and understood, but connotation requires far more than denotation.

2.4.2.2 How graphic design communicates

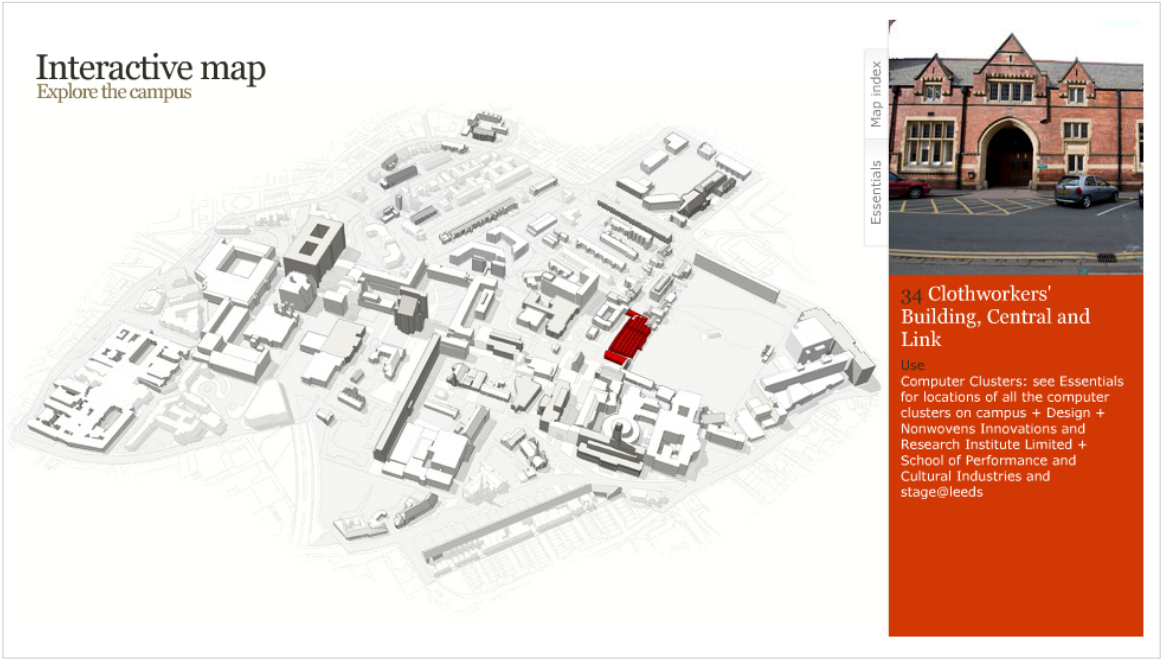


Figure 17: University of Leeds Campus Map (www.leeds.ac.uk)

You are here! Graphic design directs, explains and entertains us in our day life (Figure 17).

How do graphics communicate? First of all, a good picture is worth a thousand words. Graphic images, as kinds of visual statements, speak with form and shape the raw materials into purposeful visual ideas depending on the communicative aim. They have the potential to communicate the basic questions of what, how, how much and where, towards which design is aimed. Figures could explain clear information of appearance, structures, and organizations of parts; illustrate physical movements, systems and processes. They reference the sizes, trends, divisions and quantitative analysis of subjects and also describe their areas, locations and positions (Bowman, 1968).

Images also visualize concepts through visual language elements-form, space and visual interaction. The procedures of visualization include three steps. Initially, typical subjects are translated into visual concepts, and then formed into design models. After refinement

through video editing, word and number elements are integrated into the designs. Finally, the graphic process is the concluding step in the production of the graphic statement.

Text and graphics have always been combined to provide complementary sources of information. When text itself cannot completely represent visuospatial information, a suitable graphic can often improve communication significantly and reduce potential misunderstanding (Lowe & Promono, 2006; Bieger & Glock, 1986).

Layout is also meaningful as a result of culturally specific codes concerning left-right, top-bottom and centre-margin structures and the ways in which those codes could be manipulated in order to explore the content (Barnard, 2005). Moreover, other graphic elements, like type and colour contribute to the delivery of information. For example, a combination of yellow and black colour passes the message of danger.

2.4.2.3 The audience in visual communication

As the goal of all communication is to persuade an audience to adopt a belief, audience considerations are integral components of the process of visual communication (Tyler, 1992). During the process, the designer attempts to persuade the audience to take some action, to educate the audience and to provide the audience with an experience through the display of values.

The relationship between audience and communication goals reveals how belief is shaped through design. It is viewed in widely different ways.

In one perspective, the object is seen as isolated, as a formal aesthetic expression, with the audience regarded as a spectator. For example, within design competitions and exhibitions, objects are often displayed with little or no commentary. Another view characterizes the audience as a passive reader in the communication process. The audience decodes or interprets a visual statement but is not an active participant in the formation of meaning. Scientific aspects of design are emphasized over the aesthetic ones. The third view, Semiotics, recognises the specificity of the audience. The audience reads the literal message within visual communication, thereby becoming an active reader. The cultural beliefs of the audience are involved in particularizing the symbolic message. Another view is a rhetorical analysis of design. The audience within this theory is not a reader but a dynamic participant

in the argument. To persuade an audience, designers need to reference established or accepted values then attribute them to their new subject. Plus, the specific audience's experiences are essential to the communication goal.

Tyler (1992) believes that communication needs to be directed toward a specific audience and designers must discover the way of persuading a particular audience.

2.4.2.4 Visual language and elements

There are many different languages we use during communication, verbal, sound, sign and visual. As a means of communication, graphic design uses its own visual language to communicate. According to Dabner (2004), visual language means a set of design elements for example dots, lines, textures and colours organized by a "grammar" of contrasts. Images, words and objects communicate their cultural meaning quickly so that the "language" is inclusively understood.

In practice, designers often turn meaningful images into abstract elements. Type, and photographs are cropped, rotated and re-coloured into pleasing arrangements. Although modern design theories focus on perception, graphic designers are more interested in culture interpretation in their works. Words are often used as pictures and pictures are used as words. They are put together to produce new contents. The barrier between visual and verbal expressions is not strict. The structure of a picture plane can be compared to the grammar of verbal language and sometime, visual literacy, the capability to perceive visual forms also depends on the verbal literacy sometime (Lupton, 1996). By connecting rather than separating visual and verbal expressions, we can make the cultural meaning of our graphic work.

2.4.3 Info-graphics

2.4.3.1 Using graphics to make sense

In info-graphics, important messages are communicated by visuals clearly, precisely and effectively (Lester, 2003). Tufte (1990) believes that the messages themselves are more important than the presentation and visuals should always reflect the truth even with complex data. In the process of visualising mass information, all visual elements can be used. Arrows and dotted lines can be used to demonstrate direction and space. Lines can be used

for different purposes. In technical drawing, lines are vital parts. The variations of their weight differentiate parts and illustrate a sense of depth. For example, exterior lines can be thick, interior edge lines can be of medium and internal join lines can be thin.

Szlichcinski (1984) thinks when creating information-oriented graphics, the amount of details is essential. Over use or lack of details can both cause problems of interpretation. When designing for a sequence of graphics, contextual details should be kept for consistency.

2.4.3.2 Info graphics and users' Spatial Visualisation Ability

McGee(1979) suggests that every person has an ability to mentally interpret the pictorial stimuli of objects. We use this Spatial Visualisation Ability (SVA) to rotate, twist, or invert pictures in our minds and some of us are better than others. While reading info-graphics, especially technical drawings for assembly tasks, strong Spatial Visualisation Ability (SVA) from users is required to interpret visual information. Information designers cannot help users to establish this ability, but good designs can improve the performance of those with low SVA scores (Heiser & Tyversky, 2002, cited in SCHWARTZ & HEISER, 2006).

2.4.3.3 Effective graphics for dynamic information:

Research of Lowe & Promono (2006) proves that well-designed static graphics are capable of representing dynamic subjects effectively but this requires a great deal of consideration. For example, ancillary markings and arrows can be used in a static image to guide users for interpreting situational dynamics, but these elements can also be misleading if they are not carefully arranged. When static graphics are ineffective, animations can be considered to present dynamic information more effectively (Table 5). They are ideal for showing sequence of subjects and Lowe & Promono (2006) believe that they will gradually replace static illustrations for presenting dynamic information.

Approach	Success of this approach
Multiple graphics of key states from an event	Depend on the selection of suitable states.
A single graphic	Rely on its design and the Spatial Visualisation Ability of the viewer.
Animation	Visuospatial information and dynamic representation should be balanced.

Table 5: Difference choices for representing dynamic information (Low & Promono, 2006).

However, we cannot insist animations are definitely more efficient yet because the research on how people interpret information from animations is still in its early stages. Still, when

using animations to present dynamic information, they need to be well designed to ensure the effectiveness of communication.

2.4.4 Graphic designers and research of information

Graphic design plays a substantial role in the way we perceive things. However, graphic design communities do not pay substantial attention to information design research on technical issues in communication. Graphic designers rarely create or find the raw material that forms the basic content of their final design. The designer is often the last person to be involved in the information. He or she seldom understands the material of a factual nature when asked to display it. Some designers in this field think such a situation is normal. They use their art expertise to make the numbers look nicer and happily "design" without explaining them. Many graphic designers are only interested in attracting readers to look at the design, rather than taking the responsibility to inform them (Holmes, 1993).

Hunter (2005) interviewed British graphic designers working in the commercial mainstream; none of the interviewees were influenced by academic research or resources of information when they made design decisions. He claims that Information designers are interested in readability and legibility issues while graphic design generalists tend to proceed by intuition and experience. They build their own understanding of how design communicates with audiences to suit their aesthetic and working practices without any firm evidence. Hunter (2005) believes that it is necessary to do research on how audiences react to particular design strategies. Designers should get involved in this kind of research and realise that habitual approaches may not actually work. To get designers involved, guidelines concluded from research should not be too rigid because the nature of design. The subjectivity and surprise and the human factors in graphic communication very often make it attractive, persuasive, meaningful and memorable for the viewer. They should not be restricted by rigid rules.

2.4.5 Graphic design and product instructions

Although some graphic designers concentrate more on catching the attention of readers than informing them, graphic design has its informative function. It integrates text and images to play the role of providing information as well attracting and persuading the viewer. When designing product instructions, it is used to communicate instructional messages to

readers.

Graphic design uses its visual language to 'talk' to viewers across countries in materials of all kinds. This helps product instructions to be more comprehensible and inclusive. Benefiting from the increases of digital technology and cyberspace, graphic information is shared by all citizens around the world. The author believes that similar advantages should be taken by product instructions as well. Digital design, multimedia and the internet should be used for producing and sharing product instructions internationally.

2.5 Understanding people

In this research, the author is interested in understanding and predicting the human behaviour of using product instructions in order to design them. As a human being is complicated, everybody responds to the same situation in different ways. It is not possible to predict each individual's behaviour. Still, we can at least understand some thinking and actions we have in common. For example, Norman (1988) suggests that we all finish any action in seven stages: We begin with a goal, then form a set of intentions to achieve this goal , then transfer them into a set of actions followed by the execution. Then we perceive the new state of the world, interpret it then compare it to what we intended to change. Finally repeat this until the goal is met. This model in cognitive study is useful for planning tasks in product instructions. The other underlying cognitive and learning theories are also studied in this section to recognise how people perceive information and learn to do something.

2.5.1 Memory

Memory usually involves different memory stores and memory processes (Figure 18). The two major components of memories are working memory (short-term memory) and long-term memory.

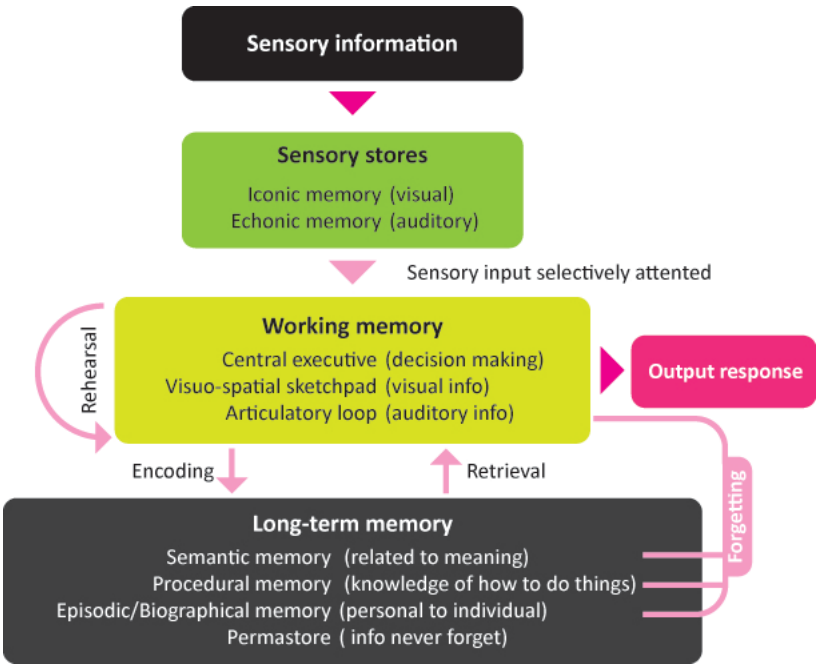


Figure 18: The structure of multi-store memory (Atkinson and Shiffrin, 1968).

Working memory holds materials of a very limited size for up to 30 seconds. Then the information fades away and is lost. It mainly supports two modalities: visual information (in visuo-spatial sketchpad) and verbal information (in articulatory loop). Long- term memory has an unlimited capacity compared to working memory. It stores more complicated information; we can remember sounds and feels, colours and smells etc. Some long-term memories can last for our lifetime (Baddeley, 1997).

2.5.2 Attention

Attention means “the focusing of mental resources at or on a particular task or object” (Benyon et al, 2005, p107). It can be targeted on one task or be divided among different tasks. People require attention in terms of learning and perceiving the world thus it is a vital part of human ability. In the process of human machine interaction, failure on attentions can be a frequent reason for accidents. While displaying instructional messages, designers should reduce information noises and make sure important safety messages get enough user attention.

2.5.3 Mental models

A mental model is a set of cognitive structures that store and represent our understanding For example, our knowledge of how to use a computer is stored as a mental model. It is in our heads and we can use it to visualise how that thing works when we need it. It is very

important for designing interactive systems. Norman (1983) reveals that mental models are not stable; people tend to forget about details of how to do things. He also finds it interesting that mental models do not have firm boundaries. Knowledge of similar devices and operations can be mixed and confused from one to the other, which means that when a user uses a new product, it could be easier if this person has a mental model of a similar product.

2.5.4 Learning

2.5.4.1 Experiential learning

Kolb's learning model is created out of four elements: concrete experience, reflective observation, abstract conceptualization and active experimentation. They are represented in the experiential learning circle.

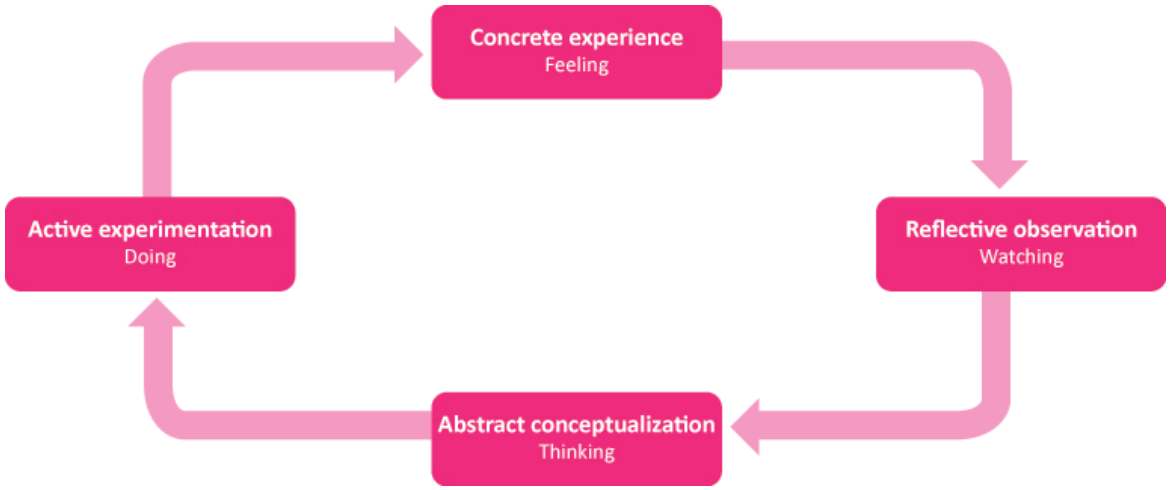


Figure 19: Kolb's experiential learning circle (1984)

In Kolb's model (Figure 19), concrete or immediate experiences lead to observations and reflections. Then the reflections are translated into abstract concepts with implications for action, which the person can actively test and experiment with. This in turn enables the creation of new experiences. Kolb (1984) says that ideally this represents a learning cycle or spiral where the learner is involved in a cycle of experiencing, reflecting, thinking, and acting. This cycle of learning is regarded as the central principle of his experiential learning theory, which applies to us all.

2.5.4.2 Learning styles

Kolb explains that different people prefer a certain learning style. The learning style

preference itself is actually the product of two pairs of variables, or two separate choices that we make. Kolb presented the preferred learning styles as lines of axis and placed people on a line between concrete experience and abstract conceptualization; and active experimentation and reflective observation (Figure 20). The Processing Continuum, the east-west axis, shows how we approach a task, or doing and watching. The north-south axis is called the Perception Continuum. It involves our emotional response, how we think or feel.

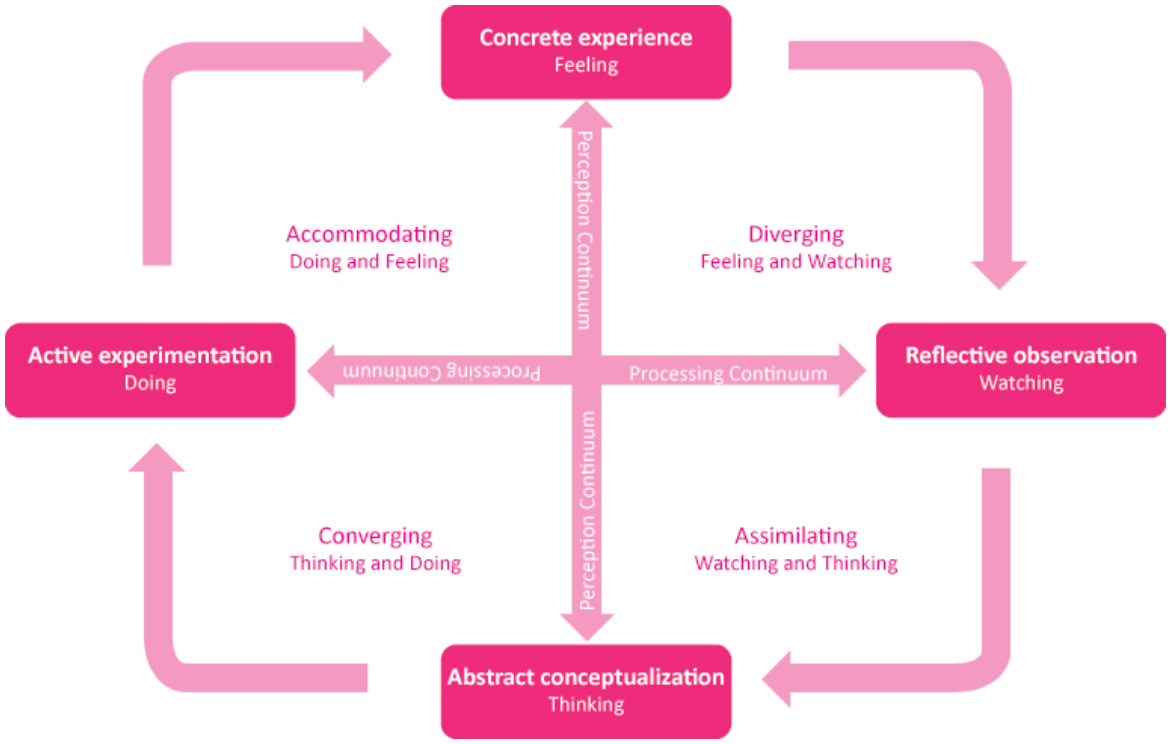


Figure 20: Kolb's learning styles

Kolb (1976) identifies four basic learning styles: Diverging, Assimilating, Converging and Accommodating. Each type of learning style represents the combination of two preferred styles.

People with a diverging learning style prefer feeling and watching. These people are sensitive, tending to gather information and use imagination to solve problems and prefer to watch rather than do. The assimilating learning preference is for a concise, logical approach. These people are more attracted to logical theories than approaches based on practical value. They prefer watching and thinking, readings, lectures and exploring analytical models.

They require good clear explanation rather than practical opportunity. Very differently, people with a converging learning style are best at finding practical uses for ideas and theories. They like to use their learning to find solutions to practical issues and solve problems. They like technical tasks and practical applications. The Accommodating learning style is 'hands-on', relies on intuition rather than logic. People with this learning style like new challenges, experiences and carrying out plans. They prefer to take a practical, experiential approach (Kolb, 1981).

According to Kolb (1984), most people have clear strong preferences for a learning style. People who have a clear learning style preference tend to learn more effectively if learning is adjusted according to their preference. Therefore, when using products, people with different learning style preferences should respond to production instructions differently. People who prefer the assimilating learning style will expect more instructions. People who prefer to use an accommodating learning style, on the contrary, maybe will be annoyed if they are forced to read lots of instructions, instead of getting hands on experience as soon as possible.

2.5.5 Multiple intelligence

Howard Gardner's theory of Multiple Intelligence uses features of cognitive and developmental psychology and sociology to explain the human brainpower. His theory challenges traditional and earlier views of intelligence. Previously accepted ideas of human intellectual capacity argue that an individual's intelligence is fixed for a lifetime and that intelligence can be measured through an individual's language and logical abilities. According to Gardner's theory, intelligence is “a bio psychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in culture” (Gardner, 1999, p34). It cannot been seen or counted.

Gardner’s original Multiple Intelligence theory (1983) proposed seven separate human intelligences: linguistic intelligence, logical-mathematical intelligence, musical intelligence, bodily-kinesthetic intelligence, spatial intelligence, interpersonal intelligence and intrapersonal intelligence.

Gardner (1983, 1993) believes that the first two intelligences, linguistic and

logical-mathematical are the ones which have typically been valued by people. He judges linguistic intelligence as the one which "involves sensitivity to spoken and written language, the ability to learn languages, and the capacity to use language to accomplish certain goals" (Gardner, 1999, p42). Everyone is considered to possess this intelligence at some level. Logical-mathematical intelligence involves the ability to examine problems logically, take mathematical operations and explore issues scientifically. Logical-mathematical talented individuals would be contemplative problem solvers.

The next three intelligences, musical, bodily-kinesthetic and spatial are particularly distinguished in the arts, although they can be put into other uses. Musical intelligence refers to the ability to produce and appreciate music. Musically inclined individuals think in sounds, rhythms and patterns. Many of them are extremely sensitive to environmental sounds. Bodily-kinesthetic intelligence means the ability to control body movements and handle objects skilfully. Bodily-kinesthetic capable individuals have a good sense of balance and eye-hand co-ordination. Through interacting with the space around them, they are able to remember and process information. "Spatial intelligence features the potential to recognize and manipulate the patterns of wide space as well as the patterns of more confined areas" (Gardner, 1999, p42). This is the ability to form and manipulate a mental model, hold the world visually in the mind. This gives people the ability to know where you are in space. Individuals with strength in this area depend on visual thinking and are very imaginative. They tend to learn most from visual presentations.

The other two intelligences, Interpersonal intelligence and Intrapersonal intelligence are often linked together for their close association in most cultures. Interpersonal intelligence is "concerned with a person's capacity to understand the intentions, motivations and desires of other people and to work effectively with others" (Gardner, 1999, p43). It requires good communication and interaction skills. Intrapersonal intelligence, as an internalized version of Interpersonal Intelligence, involves the capacity to understand oneself, to appreciate one's own feelings, fears and motivations. In Gardner's view, intrapersonal intelligence engages having an effective working model of ourselves, and to be able to use such information to regulate our lives.

Gardner and his colleagues carried on subsequent research and reflection since his originally

listed seven intelligences and in 1999, considered another three potential intelligences: a naturalist intelligence, a spiritual intelligence and an existential intelligence. Those three additional intelligences were not discussed as much as the original ones.

Figure 21: Multiple intelligence.

Gardner believes that all discovered intelligences rarely operate independently (Figure 21) and every person has all the intelligences. Some intelligence is more dominant than others but most people can develop all intelligences to a certain level of capability. They are used at the same time and tend to complement each other as the person develops skills or solves problems. When we use them for learning, we blend them differently. Everyone born with certain preferences toward particular intelligence, and then culture, experience, and development influence these preferences. Each person receives, perceives, processes, interacts with and responds to new information through senses in different ways depending on one's intelligence preferences and learning styles (Figure 22).

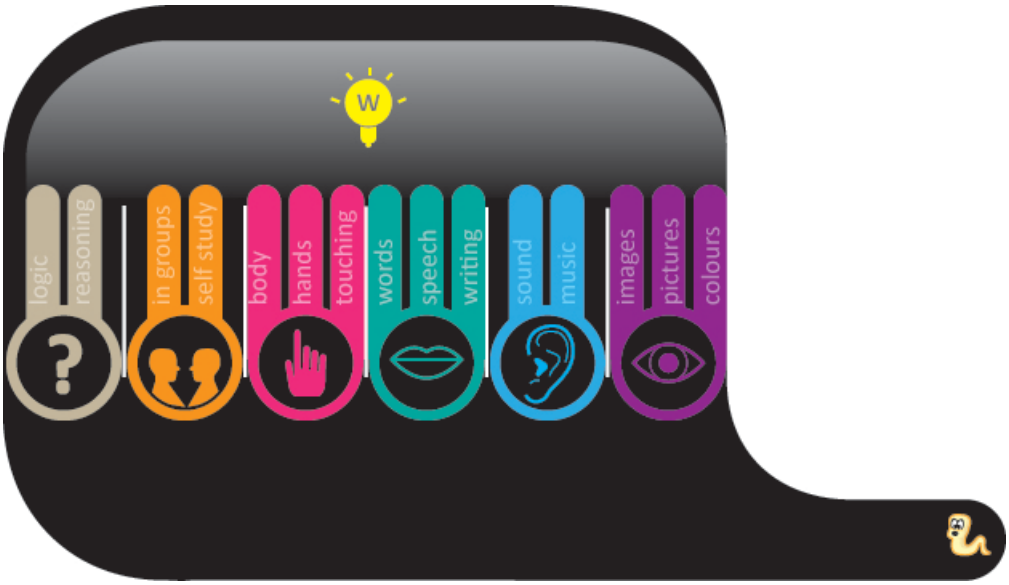


Figure 22: Intelligences and learning-styles.

For example, most people are classified as visual learners if they are spatial/ visual intelligence talented. These people process information most effectively when the information is visualised. Very differently, aural learners have a preference on musical intelligence, they process information most effectively when spoken or heard. Reading/writing learners, who are linguistic intelligence talented, process information most effectively when information is presented in a written language format. Kinesthetic learners process information actively through physical means. They are poor listeners, and lose interest in reading, but they learn quickly through the sense of touch.

2.5.6 Learning styles and instructions

As Dunn (1984) recognises, everyone has strengths, but different people have different strengths. Instructional environments, resources and approaches should respond to diversified strengths. When designing instructional materials for products, this idea should be taken into account. For example, product instructions dominated by text certainly enable aural learners to follow easily however they are not as straightforward to use for other readers with different strengths. Instructions full of pictures and charts can help visual learners to process information effectively and use products quickly but yet again they might not be the best choice for other users, for example, kinesthetic learners. To plan product instructions for all, designers should integrate different media together and enable all users to use the instructions effectively.

2.6 Human factors

Human factors, in another word Ergonomics, is “the scientific discipline concerned with the interaction between humans and artefacts and design of systems where people participate” (Helander, 1997, p3). It “focuses on human beings and their interaction with products, equipment, facilities, procedures and environments used in work and everyday living” (Sanders and McCormic, 1987, p4), “discovers and applies information about human behaviour, abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, jobs and environments” (Chapanis, 1975,p11). Ergonomics and Human factors enable interaction with systems, enhance performance, increase safety and increase user satisfaction. Ideally, based on ergonomics and human factors, systems could be designed too be used intuitively and not require special training or education. However, in reality, a complementary way is needed to make a system function, and to train and educate the operator or the user of the system.

Ergonomics and Human Factors are essential for the design of systems therefore they are investigated in this section for an understanding of how people interact with products and how people learn about using new products.

2.6.1 Fundamentals

2.6.1.1 Perception and Information processing

Human machine interaction involves a continuous exchange of information between the operators and the machine. Therefore how people perceive the information is crucial for the study of human factors.

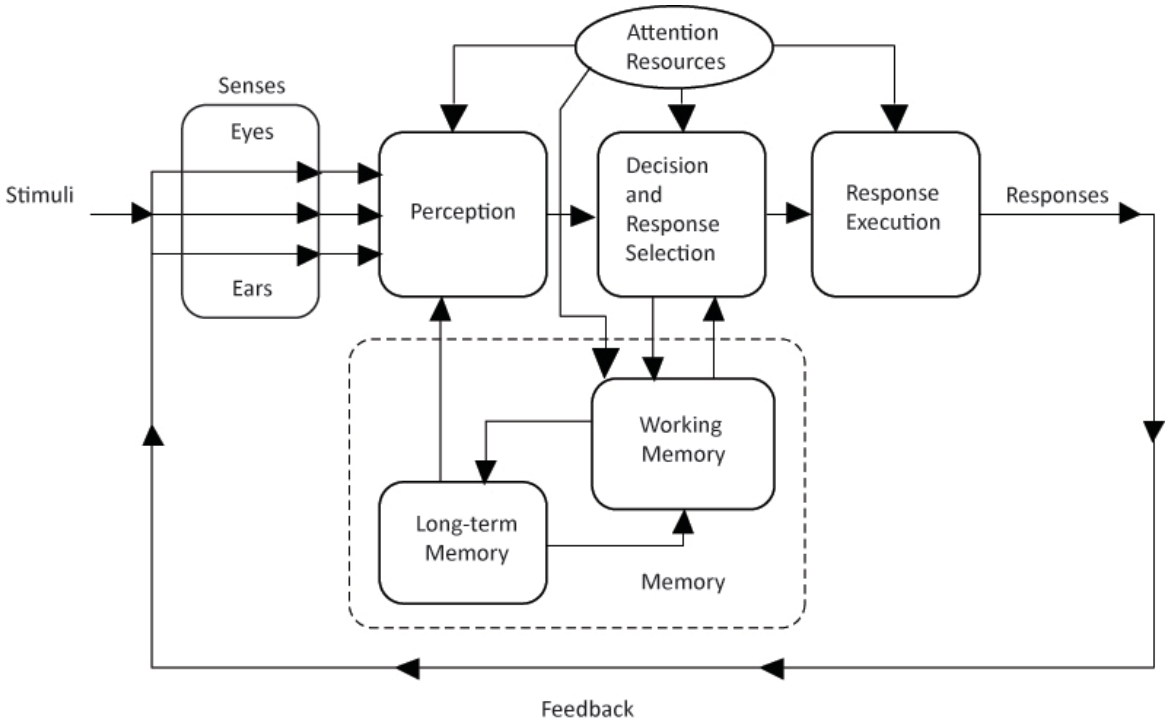


Figure 23: A model of human information processing (Wickens & Carswell, 1997).

Firstly, all displayed information on the machine must be sensed accurately to ensure correct communications (Proctor & Proctor, 1997). When sensed, the information is processed and interpreted to the next level (Figure 23). It is transformed into different forms so that operators can take actions on the basis of the perceived and transformed information (Wickens & Carswell, 1997). When interact with the machine, operators recognise the environment within a volume of time and space, understand the current situation and get the projection of the environment in the near future. In other words, the operators create their situation awareness. Consequently the operators must keep track of a huge number of changing dynamic stimuli in their environment and find out the relevance of those stimuli to their current task and overall goals. Of the factors affecting situation awareness, the working memory plays an important role. “The integration of information in working memory about earlier phases of the task, along with the operator’s general knowledge of system functioning (the mental model) determines understanding of the current situation, and prediction of the future” (Wickens & Carswell, 1997, p107).

Unlike situation awareness, the information processing tasks of planning and problem solving are much less directly tied to perceptual processing. They are more critically dependent on the interaction between information available in long-term memory, and

information processing transformations carried out in working memory. The planner may depend on scripts of typical sequences of operations that they have stored in long-term memory, on the basis of past experience. Alternatively, planning may involve a greater degree of guesswork and some level of mental simulation of the intended future activities. The other three cognitive activities of problem solving, diagnosis and troubleshooting are very similar. They share the characteristic that there is a goal to be obtained by the human operator and the information or knowledge necessary to achieve that goal is currently missing. They involve some mixture of two extreme approaches. On one hand, sometimes situations can be diagnosed by a direct match between the features of the problem observed and patterns previously experienced and stored in long-term memory. On the other hand, when solving complex problems, which one has never experienced, a series of diagnostic tests are often performed, their outcomes will be considered and based on these outcomes, new tests or actions taken, until the existing situation is identified or the problem is solved. In between these two extremes are hybrid approaches, which depend on varying degrees of information already stored in long-term memory on the basis of experience.

The joint cognitive processes of planning and problem solving or troubleshooting, depending as they do on the interaction between working memory and long-term memory, reflect both the strengths and the weaknesses of human information processing. The output of each process is typically a decision, to undertake a particular course of action, to follow the plan, to choose a treatment based upon the diagnosis, or to formulate a solution to the problem.

2.6.1.2 Learning in human factors

Knowledge is normally classified into either declarative, conceptual type or procedural knowledge. “Declarative knowledge is considered to be stable factual knowledge regarding the world” (Koubeck et al. , 1997, p131). Conceptual knowledge consists of core concepts for a specific domain and the interrelations between those concepts. Finally, procedural knowledge is knowledge of “how to do things”. It is typically modelled as production rules, which represent the steps, than an individual performance to complete a task. “We are better at remembering and retaining procedural knowledge than declarative knowledge” (Koubeck et al. , 1997, p132).

When learning, novices usually begin with only declarative knowledge, which is in working

memory. Over time, they learn by linking declarative facts together in order to successfully complete a task or attain a goal. Generally, novices require more information directly in their working memory during task completion so that they take longer to answer a problem than experts. The main difference between novices and experts is that experts can identify many patterns from their long-term memory therefore to determine the problem solving techniques almost instantaneously.

There are various approaches to learning. Koubek, Benysh and Tang (1997) suggest that a successful training programme should understand the types of knowledge and skills that are to be acquired, and their interactions. Then develop technologies for efficiently executing the learning materials. However, as believed by Park (1997), errors can not be completely avoided when humans are involved in a system, no matter how much training is given, or how experience or skilful the people are.

2.1.1 Models in training and instruction

2.6.1.3 Models

The term "model" has a variety of meanings. "Basically, a model is a representation of a phenomenon, an event, process, or physical entity" (Swezey & Llaneras, 1997, p515). Models of all kinds are important tools for use in considering training-oriented developments. The major advantage is that one has a real world representation at some acceptable level of fidelity; he can then manipulate the representation and measure it instead of the real world. In general, theoretical models are used to help guide research; other types of models provide a way of performing activities that minimize the penalty for error.

2.6.1.4 Model of skill acquisition

The literature on learning and skill acquisition is broad. Numerous attempts to quantify the literature in this area have been conducted. As shown in Figure 24, a learning curve has been drawn. In this curve, functions for describing performance changes during learning. These are termed the exponential function, the power function, the hyperbolic function and the logistic function. Newell (1981) concluded that although both exponential and power functions are negatively accelerated, the rate of improvement described by the power

function accurately characterizes learning in most contexts examined. Swezey and Llaneras, (1997) suggested that models of the acquisition processes must consider asymptote and experience parameters. This implies that the learning never stops entirely, but as practice continues, smaller and smaller benefits are realized. The power law is generalizes to many types of cognitive data. It is viewed as associated with acquisition of perceptual skills and it also holds for learning of other kinds, including memory tasks and problem solving.

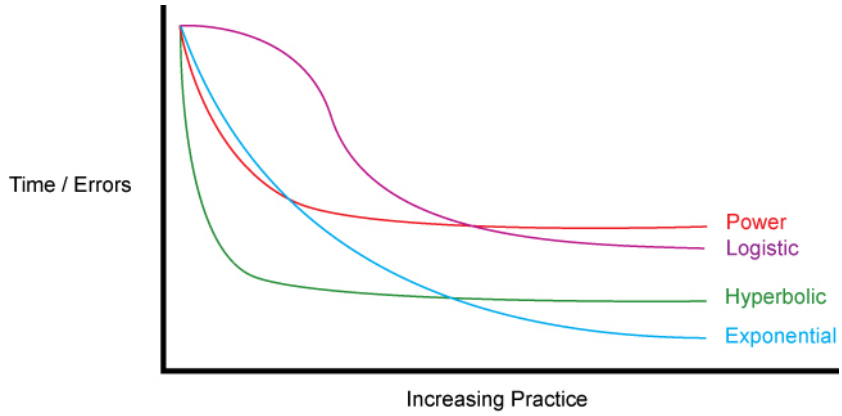


Figure 24: Comparison of theoretical learning curve functions.(Swezey and Llaneras, 1997)

Although the power law continues as the most readily interpretable model for describing performance changes with practice, it does not characterize data from all learning situations. Acquisition curves are frequently affected by other factors including the nature and difficulty of the task, the degree of prior leaning, the type of training method employed, the point of time or level of performance chosen to terminate a training period and the distribution of practice. Further, acquisition curves can vary when performance involves integration of multiple-task components. More importantly, individual differences make it very difficult to derive general laws of acquisition concerns.

Believed by many, skill acquisition proceeds in accordance with a number of stages or phrases of improvement. The number of stages and their labels differ among researchers. Traditionally, research in learning and memory conceived a three-stage model for learning, which involved stimulus discrimination, response learning and association. Then, Anderson (1982) proposed a three-stage model of skill acquisition, which contained “cognitive”, “associative” and “autonomous” stages. This production system has been successfully used to model the acquisition and transfer to procedural information acquired from written

instructions in textual formats. Similarly, Rumehart and Norman (1978) recognized three qualitatively different phases of the learning process. In the first phase, which involves acquisition of facts in declarative memory (accretion), the learner acquires facts and information, accumulating more structures onto the already existing knowledge structures. In a second phase, the learner must work out new memory structures to interpret the material that is to be acquired. This needs the initial acquisition of procedures in procedural memory (restructuring). The third phase of learning involves the modification of existing procedures to enhance reliability and efficiency (tuning). This stage of learning does not increase the formal content of one's knowledge, but it makes the use of the knowledge more efficient. Further, Rasmussen (1979) distinguished three categories of skilled behaviour, which are skill based, rule based and knowledge based. According to (Swezey and Llaneras, 1997), all these models and rules would eventually integrated into a set of task performance procedures.

2.6.1.5 Model of Retention

A successful training should not only offer rapid, high-quality understanding, but also endures after acquisition. What has been learnt should be able to be successfully transferred or applied to a wide range of tasks and job specific setting. However, a list of variables could influence the rate of forgetting of learnt knowledge. It includes degree of original learning, characteristics of the learning task and the instructional strategies used during initial acquisition.

2.6.1.6 Model of instruction

The “System Approach” (Goldstein, 1993), which provides a generic frame of reference for developing procedural techniques in instructional design, has been used as a source for many models. Based on it, the Instructional Systems Development (ISD) model is comprehensively developed and widely used in the instructional design field. This ISD model consists of five basic phases: analysis, design, development, implementation and control. Its outcome (Table 6) is extremely helpful for planning effective training materials.

Phase 1: Analysis	1. A list of tasks performed in a particular job. 2. A list of tasks selected for training. 3. A job performance measure for each task selected for instruction. 4. An analysis of the job analysis, task selection and performance measure construction for any existing instruction to determine if these courses are usable in whole or in part. 5. Selection of the instructional setting for task selected for instruction.
Phase 2: Design, development, implementation and control	1. A learning objective for and a learning analysis of each task selected for instruction. 2. Test items to measure each learning objective. 3. A test of entry behaviours to see if the original assumptions were correct. 4. The sequencing of all dependent tasks.
Phase 3: Development	1. The classification of learning objectives by learning category and the identification of appropriate learning guidelines. 2. The media selections for instructional development and the instructional management plan for conducting the instruction. 3. The analysis of packages of any existing instruction that meets the given leaning objective. 4. The development of instruction for all learning objectives where existing materials are not available. 5. Field-tested and revised instructional material.
Phase 4: Implementation and control	1. Documents containing information on time, space, student and instructional resources and staff trained to conduct the instruction. 2. A completed cycle of instruction with information needed to improve it for the succeeding cycle.
Phase 5: Control	1. Data on instructional effectiveness. 2. Data on job performance in the field. 3. Instructional system revised on basis of empirical data.

Table 6: ISD Model outcomes (SWEZEY & LLANERAS, 1997)

2.6.2 Task Analysis

Task analysis is important for system development. It involves some essential elements: goals, tasks and actions. “A goal is a state of the application that a work system wishes to achieve” (Benyon et al., 2005, p505). It very often is at some levels of abstraction. To achieve a goal, structured sets of activities are required; they are tasks. A task might involve activities like choosing between alternative actions, repeating some actions a few times and sequencing actions. It normally can be broken down to more detailed level: sub tasks. If sub

tasks are continued and broken down to more detailed level, actions are eventually defined. An action means a simple task, which does not involve any control structure and/ or problem solving. Task analysis can be used for requirements generation and evaluation in a design process and normally results in a task model. Methods for task analysis and task design are found in different styles. They focus on different concerns: logic, cognition or structure knowledge. The following are three commonly accepted task analysis techniques (Table 7):

Method	Concern
Hierarchical task analysis (HTA)	Logic of a task
GOMS based on goals, operators, methods, and selection rules	Cognition; the procedural knowledge; "how to do it"
ERMIA	Structural knowledge; "what it is"

Table 7: Three commonly used task analysis techniques.

In this research, Hierarchical task analysis (HTA) was employed. It engages activities including: "appraising the problem, collecting information, organising information and representing the task, modelling behaviour, suggesting solutions" (Wilson & Corleet, 2005, p136). By using HTA, a main goal is expressed as tasks then sub-tasks then finally described as detailed actions. This clearly presents all actions that needed for a goal then it is easy to plan the ideal solution and alternative solutions for each action.

2.6.3 Human Error

2.6.3.1 Nature of Human Error

> *"Error will be taken as a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some change agency" (Reason, 1990, p9).*

Human error means incidence in a man-task system (Rasmussen, 1987), when operators fail to achieve the planned goal. The failure may appear in two different ways (Hollnagel, 1993): the plan is adequate, but the actions are deficient; or actions carry out as planned, but the intention is unsatisfactory. Aims or intentional behaviours are not possible to be ignored or separated from human error. For example, to define or classify human error, three questions could be asked (Reason, 1990), and they are all tightly related to intentions:

- Are actions directed by prior goal?

- Did actions proceed as planed?
- Was the desired end achieved?

The questions investigate relationships between active intentions, expectations and subjective goals. They can be used to categorize human error into three main kinds: slips, lapses and mistakes.

2.6.3.2 Types of Human Errors

2.6.3.2.1 Slips and lapses

Both slips and lapses are errors that happen in the execution process so that operators fail to achieve the desired goals (Figure 25). The plan that guided them may be or may not be adequate to achieve its prior aims. If the intention is proper, but results are not right, then there is a slip. A slip mainly involves actions that are not happening as planned, while lapses are the errors that caused by failures of memory.

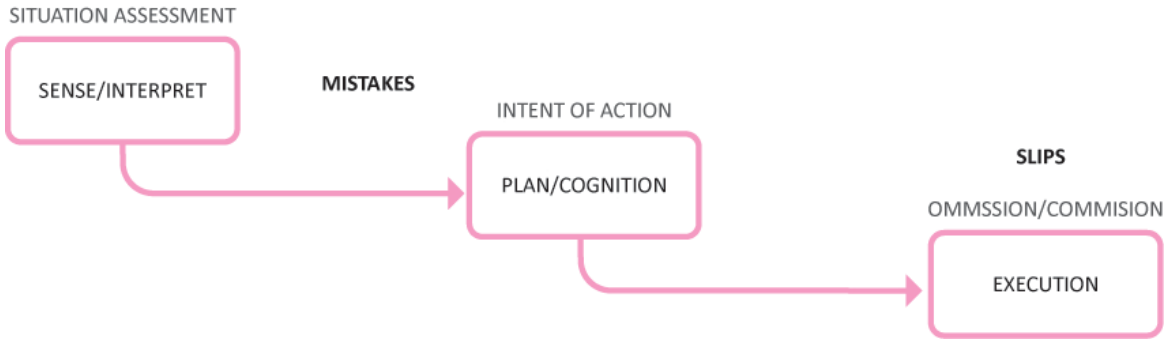


Figure 25: Human error performance (Norman, 1983)

2.6.3.2.2 Mistakes

Mistakes refer to failures in the planning and/or judgemental processes; they are errors in the intention (Norman, 1983). They may involve the selection of objectives, or the decisions of means, even actions for achieving the objectives. Mistakes are normally caused by either a failure of expertise or lacking of expertise (Reason, 1990).

2.6.3.3 Skill-based, Rule-based and Knowledge-based Errors

In the Generic Error Modelling System (Figure26), different types of errors are distributed onto three levels, according to the control behaviour in each case. They are the skill-based errors, the rule-based errors and the knowledge-based errors. On the skill-based level,

performance is controlled by automatic behaviours and subconscious routines. Activities carried out rely on stored patterns thus random slips and/ or lapses belong to this level. Rule-based errors share some factors with slips, for example, they both take place under familiar situation (Rasmussen, 1982, 1987), but rule-based errors are mistakes; they run by stored systems rather than patterns. Failures start from the intention planning, which then lead to wrong actions. On the other level, knowledge-based performances also fail in the intention. They involve the usage of mental models in unfamiliar situations. Operators may have to carry out activities like planning a new sequence of actions, setting their own goals, or even finding resources (Rizzo et al., 1987) therefore knowledge-based mistakes are very often unique.

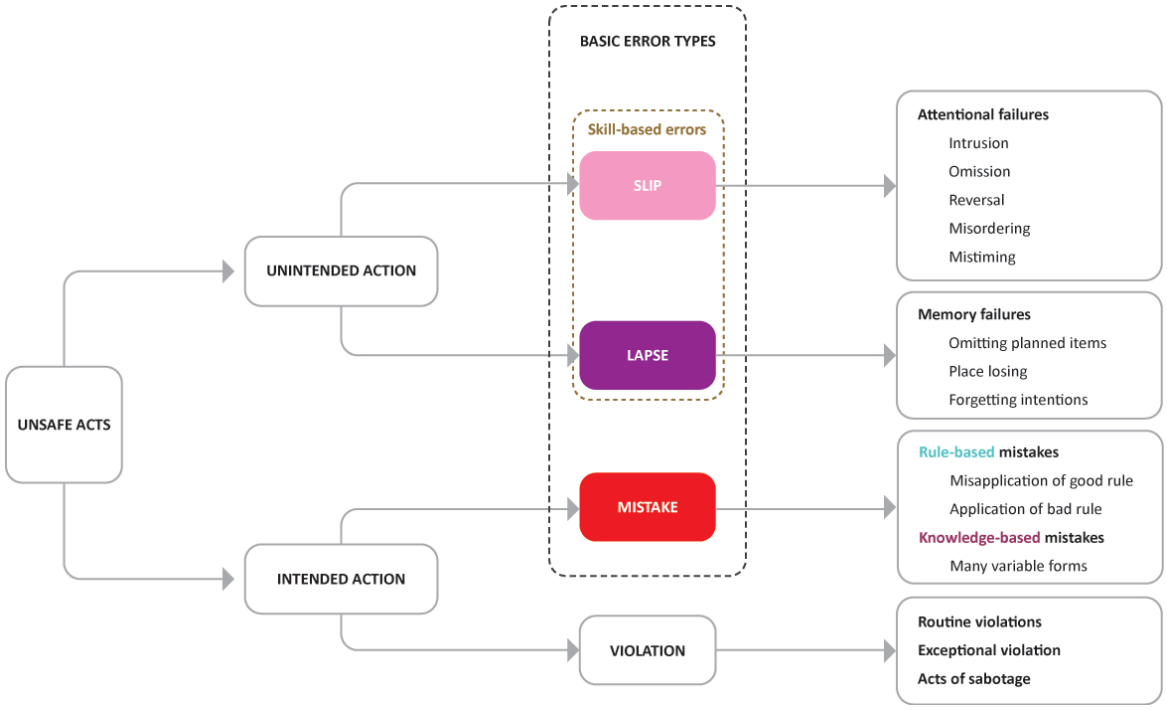


Figure 26: Generic Error Modelling System (GEMS) (Reason, 1990)

2.6.3.4 Human Error Identification

2.6.3.4.1 Methods of testing

According to Reason (1990), three methods can be employed to identify an error: self-assessment, response to a questionnaire and making a direct observation. He believes that self-reports perform well in terms of accuracy; observations are easy to carry out but

operators might be exposed to stress while being watched, therefore this influence should be taken into account while analysing the results. In 2006, Reason suggested to view human error by two new means: one through a person approach and another from a system approach. A person approach focuses on unsafe activities of people, which might involve forgetfulness, inattention, poor motivation etc. A system approach mainly reviews the rest of the expected errors. Reason recognised these errors as consequences of failure rather than causes.

Similarly but from a slightly different perspective, Norman suggests that there are essentially two ways to detect errors: "Self monitoring (feedback)" and "Deleterious outcome". When using the self-monitoring method, actions can be compared with expectations and errors can be detected when actions do not match the plan. This detection mostly relates to slips and very often is difficult to specify. "Deleterious outcome" means that if inconsistency occurs in the next activity, then the error may be detected. This method can be used to detect mistakes. It suggests that something has been done wrongly, when a wrong action produces some difference in the outcome (Norman, 1984, cited in Rizzo et al., 1995).

2.6.3.4.2 Testing Models

The use of human error identification (HEI) techniques is recommended as a possible alternative to observation studies for product evaluation (Baber & Stanton, 1996). The techniques could include Task Analysis for Error Identification (TAFEI) or Predictive Human Error Analysis (PHEA). In this research, Hierarchical task analysis (HTA) and part of Predictive human error analysis (Figure 27) methods are adopted and used in combination to detect and identify errors.

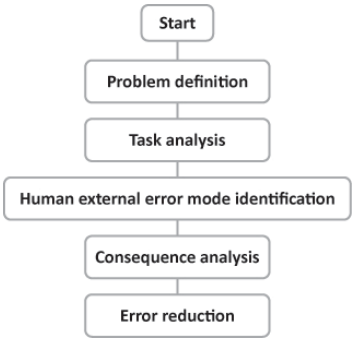


Figure 27: PHEA flowchart (Baber & Stanton, 1996)

2.7 Digital media, users and instructions

2.7.1 'Digital Natives' and 'Digital Immigrants'

The term 'Digital Natives' was offered by Prensky (2001). It refers to those people who have grown up with digital technology. For their entire life, Digital Natives are surrounded by digital and interactive media, toys and tools of the digital age. They are 'native speakers' of the digital languages which have been used by computers, video games, mobile phones and the internet. They also have several alternative names including The Net Generation, Generation Y, Echo Boomers, Millennials and iGeneration etc..

The rest of people "were not born into the digital world but have, at some later point in their lives, become fascinated by and adopted many or most aspects of the new technologies" (Prensky, 2001, p1). They are 'Digital Immigrants'. Digital Immigrants learned to use the digital languages and tried to adapt to this new digital environment gradually. Like all immigrants, some of them learned better than others. However, to some degree, they retained their 'pre digital' accent; for example, printing out emails or being afraid of pressing buttons on an unfamiliar digital device.

2.7.1.1 Age of Digital Natives

There is no precise agreement to which year the first Digital Natives were born. Tapscott (2009) suggested that the people born between 1977 and 1997 were the first generation born in the digital age. Oblinger& Oblinger (2005) believed that 1982 is the earliest year for this group . They both agree that age maybe is not everything. Heavy users of IT could have the same characteristics as the Net Generation even if they were born earlier. Thus, instead of a generation, the author understood Digital natives as a group of people who have grown up within a digital environment and therefore share similar characteristics.

The age of the oldest Digital Natives could vary between different countries and areas depending on the development of digital technologies in that area. Age should not necessarily be the first and only criteria to judge if a person is a Digital Native or a Digital Immigrant. Moreover, most Digital Immigrants gradually assumed some Digital Natives' characteristics while learning new technologies.

2.7.1.2 Characteristics of Digital Natives

The Digital Natives have been exposed to mass information within a rich and interactive media environment. Growing up in a completely new interactive learning environment, they are very different from the Digital Immigrants as to how they perceive, learn and act. To them, technologies, for example, the web are like air, they do not see them as technologies. Instead, they consider these technologies as tools for learning or entertaining.

They like freedom and customization more than ever. They have a fresh understanding of scrutiny and integrity. They are used to collaboration. Entertainment is a part of their life and they have higher expectations of innovation compared to Digital Immigrants. They also like to receive and respond to information very fast. For example, while replying to an instant message, they sometime may focus on speed rather than on accuracy.

2.7.1.3 Digital Natives as learners

The brains of the Digital Natives have been developed differently than Digital Immigrants. They are better at switching attention, parallel processing and multi-tasking. They are used to receiving information fast and they can process information quicker. They make sense of the mass of information by scanning. They like to have random access to information, learn in an interactive environment and many of them are visual experts.

Being exposed to multiple media from a young age, they prefer video games, interactions and random access, like hypertext. They like to navigate between non-sequential information to explore, discover and make their own judgments. They are very kinesthetic, like experimenting and doing things, not just thinking or talking about things. When using a new product, they tend to try it straight away rather than follow sequential instructions or ask for help. For Digital Natives, how things work is intuitive; learning to use a product is situated in action, knotted with judgment and exploration. Overall, they learn better with customized contents, by discovery and within a group.

According to Kress (2004), all kinds of contemporary texts we access from the screens require readers to personalise their own reading order of the text. Readers decide their own entry point of the content and plan their own reading path, purely determined by readers'

interests. The designer then, is responsible for assembling 'information' for the visitor to be accessed in any order. Therefore there should be better choices for the Digital Natives to read I their customized order.

2.7.2 Using different media and instructions

It is believed by Romiszowski (1974) that there are two factors which effect quality and effectiveness of training. They are the devices used to deliver the instruction (media) and the methods or strategies used to convey the instructional content. It is also commented on by Goldstein (1993) that one of the main tasks in the development of training is the selection and implementation of appropriate instructional methods and media.

Although media effectiveness is not a new issue, it continues to be of considerable interest due to the heightened promise associated with new instructional technologies. It is believed by Clark (1983) that there are no learning benefits to be gained from media, only economic benefits. He concluded that no media have any influence on learning effectiveness in their own right and media are only vehicles for well-designed instruction. Similarly, Schramm (1977) commented that learning is affected more by what is delivered than by the delivery system. On the other hand, many researchers have contributed different ideas regarding media effectiveness. Fletcher (1990) reviewed that video instruction is often more effective than conventional instruction, with respect to both knowledge acquisition and job performance. It is suggested that the more interactive features that are included, the greater its effectiveness. Further, Fletcher believed that interactive video instruction has sufficient utility in terms of effectiveness and cost. Park and Gittelman (1992) compared the performance of electronic troubleshooting problems between individuals trained with an animated and a static graphic lesson on basic electronic circuit theory. The animated displays were found to be more effective than static visual displays and the animated instruction resulted in fewer errors than the static version in the test. Rieber (1990) also reviewed the effectiveness of animated visuals in instruction, then recommended that animation should be incorporated into instruction when its attributes are congruent to the learning task and when learners are novices or unfamiliar with the content area.

Conventionally, media selection models vary with regard to the physical form they take, the ways in which they classify media and the media factors they consider. The factors which

influence the media selection process include the instructional content, type of learning task, characteristics of trainees, practical design considerations as well as instructional method or strategy. According to Swezey and Llaneras (1997), information regarding the usefulness of media selection models is limited.

Although similar instruction can in many cases be delivered by a variety of media, it is not always possible to implement specific instructional methods across media. Teaching methods are important variables in the effectiveness of instructional delivery systems. Swezey and Llaneras (1997) recommend that the choice of a particular instructional method often limits the choice of presentation media. Therefore "media selection decisions should be guided by the capacity of the media to accommodate the instructional method as well as compatibility of the media with the user environment, plus trade-offs that must be made between media effectiveness and costs" (Swezey & Llaneras, 1997). Very importantly, technology issues or predetermined opinions should not drive training decisions and the content domain is without doubt the primary issue of importance in instructional delivery.

2.8 Summary

Literature proves that product instructions are still important and necessary. They should be further developed as old products are updated and new products are constantly emerging. They also should be communication-oriented by all possible means and materials to make clearer sense for all users, quicker to access and easier to understand. To do this, standards could be followed to plan effective contents. Graphic design, digital design, multimedia and the Internet could be used for producing and sharing product instructions internationally for an easy access. To plan product instructions for all, designers should integrate different media to satisfy users with different learning styles and requirements.

Chapter 3. Methodology

In Chapter 2, literature on product instructions and related disciplines were reviewed. They clearly identify the purpose and functions of product instructions and other ground theories. In this chapter, other methods used in this study are introduced. As Babbie (1990) believes, a comprehensive inquiry would profit from the use of different methods. Accordingly, mixed methods approach are involved in this study, which mainly include: questionnaires, observed user testing and interviews (Table 8). Protocol dialogue analysis is also involved in the diagnostic testing on prototypes.

Research stage and question	**Methodology**

Analysing problems
// Are product instructions still necessary?
// What are the key problems of product instructions?
	Literature review and questionnaire

Examining current solutions // What solutions are currently used to solve problems in product instructions?	Literature review
Testing prototypes	Questionnaire, user testing, protocol dialogue analysis and interview

Table 8: Research methods involved in this study.

3.1 Research methods

3.1.1 Questionnaire

According to Sapsford (2007), surveys are useful tools for counting and describing the situation of 'what is out there' in a population.

> *"A survey is not synonymous with a particular technique of collecting information: questionnaires are widely used but other techniques such as structured and in-depth interviews, observation, content analysis and so forth are also appropriate. The distinguishing features of surveys are the form of data collection and the method of analysis" (De Vaus, 1996, p3).*

Most survey methods, for example questionnaires have three very general purposes:

description, explanation and exploration. They can therefore provide a "search device" when beginning the inquiry into a particular topic (Babbie 1990). At the early stage of this research, questionnaires were adopted to explore the specific research areas. Then they were used again before testing the product prototypes, to reveal participants' backgrounds. For the user testing, observations through video recording were employed to collect data for further analysis. Finally, short interviews were introduced after user testing to examine participants' attitudes.

De Vaus (1996) recognises questionnaires as the easiest way of structured data matrix and it is believed that they are the most common technique used in survey research. According to Saunders, Lewis and Thornhill (2003), questionnaires can be used for descriptive or explanatory research to test attitudes or opinions and explain the relationships between variables. They also can be linked with other methods in further research. Taking the above benefits into account, two questionnaires, questionnaire A (2006) and questionnaire B (2008) were used in the early stage of this research (Table 9) to explore the research focus and to identify key problems of product instructions.

	Questionnaire A (2006)	**Questionnaire B (2008)**
General purpose:	To examine the general attitudes of users toward product instructions.	To identify key problems of product instructions.
Specific Research questions:	Do users think product instructions are important? Do users think problems widely exist in product instructions? Are users satisfied with the general performance of product instructions? Do differences exist in attitudes toward product instructions among user groups of differing age, gender and educational attainment?	What kind of product instructions do users use most? Are product instructions easily accessed? Are product instructions effective?
Target population:	All users of product instructions.	All users of product instructions.

Table 9: Questionnaire specification – Questionnaire A (2006) and Questionnaire B (2008).

They serve for similar purposes and were designed through a similar process to maximise the validity and reliability of responses:

- Exploratory research
- Planning of questionnaire
- Draft the questions
- Formative the questions
- Pilot testing
- Refine questions
- Collecting data

Then, before testing the performance of instruction prototypes, another questionnaire, Questionnaire C (2009) was designed to explore users' background and to identify participant groups for user testing (Table 10):

	Questionnaire C (2009)
General purpose:	To identify if a participant was a Digital Native, or how many Digital Natives' characteristics a participant had.
Specific Research questions:	Did the participant grow up with digital technology? Does the participant have the characteristics of a Digital Native?
Target population:	Potential participants for testing product instruction prototypes.

Table 10: Questionnaires specification – Questionnaire C (2009)

3.1.2 User testing

Schumacher (2007) studied the use of effective illustrations for pictorial assembly instructions. In his study, instructions were evaluated based on observations from people performing a given task on given instructions. Very similar tests were carried out in this research to test the usefulness of product instruction prototypes. Ideas for testing and data analysis in this study were also borrowed from the usability tests in HCI (human computer interaction). Lindgaard(1994) concluded four dimensions of usability as: effectiveness, learnability, flexibility and attitude. Learnability was about how easy a system could be learned and how much training a user needed to be offered. This was not related to the testing of product instructions as closely as the other dimensions (Table 11). The results of user performance on effectiveness, flexibility and attitude were then analysed to conclude the inclusiveness performance of the instruction prototypes.

Measured dimensions of usability	Definition	How it is normally measured	Methodology for testing in this research
Effectiveness	The level of user performance.	It could be measured in terms of speed, accuracy, the probability of completion of a given task under the usage environments by specified target users.	Observation on speed, accuracy and complication.
Flexibility:	Allow users some specified variation in tasks or environments beyond those first specified.		Observation on alternative solutions.
Attitude:	User acceptability of the system in question.	This is normally measured in interviews or surveys.	Interview after user testing

Table 11: Measured dimensions of usability in this research.

Bowers and Snyder noted that concurrent protocols tend to present procedural information while retrospective protocols are better for finding explanations (Bowers & Snyder, 1990, cited in Haak et al., 2003). Also, a comparative evaluation by Ohnemus and Biers (1993) showed that retrospective protocols give more useable information than concurrent protocols.

In this research, when testing final instruction prototypes, user performance was observed in the laboratory. The tasks and users' actions were complex and the timing was crucial. There was too much importance happening simultaneously for the observer to write down. Thus retrospective protocols were used, this means that data was obtained after the task performance via videotape review. According to Wickens (2003), this is practical and it is easy on the user.

3.1.2.1 Protocol dialogue analysis

When designing the prototypes, two diagnostic tests were taken. Different from the final user testing experiments, the aim for these tests was to identify design problems with instruction prototypes, in order to improve them. Users were asked to think aloud as they performed various tasks. Dialogues were recorded then analysed to reveal how the users

think about the tasks, instructions and where the problems were.

3.1.3 Interview

According to Berger (2000), less structured interviews have lists of questions that people are asked to answer and at the same time interviewers can explore subjects that come up, by chance. This was helpful for getting users' opinions in this research. Thus interviews were applied to debrief prototype tests and to reflect users' attitudes towards instruction prototypes. They were documented by note taking.

3.2 Problems with Product instructions

Sometimes when you buy a new product, which has to be activated or tuned in, the instructions that come with it always seem to be simple to use at first glance but very often they do not make sense. This is a common experience which many people have shared (Ingham, 2002). It illustrates that bad product instructions are common in our daily life and that they have not been studied seriously. However, the ranges of products are wide. Do all kinds of product instructions have problems? Or do problems with instructions only exist in some particular kinds of products? Further, as some modern products are intended to be designed for intuitive use, are product instructions still necessary? Where do the problems really lie? To find out answers for these questions, two questionnaires were sent out at different research stages. They are detailed in this chapter.

3.2.1 Questionnaire A (2006)

3.2.1.1 About the survey

Table 12: About Questionnaire A (2006)

Title:	Do you use product instructions?
Date:	30 January 2006
General purpose:	To examine the general attitudes of users toward product instructions.
Specific Research questions:	• Do users think product instructions are important? • Do users think problems widely exist in product instructions? • Are users satisfied with the general performance of product instructions? • Do differences exist in attitudes toward product instructions among user groups of differing age, gender and educational attainment?
Hypothesis:	Users do not realise the value of product instructions. There are problems with some product instructions.

	They are not satisfied with product instructions.
	There are differences in attitudes toward product instructions among people of differing user groups.
Target population:	All users of product instructions.
Type of survey instrument:	Unstructured interview, self-administered questionnaire

3.2.1.2 Design of survey

3.2.1.2.1 Exploratory research

In the exploratory research, literature was studied; unstructured interviews were made regarding the importance and performance of product instructions. According to secondary research on published materials, it could be recognized that instructions were very important; they influenced the use and sale of products. Then six unstructured interviews were carried out. These aimed at exploring valuable topics and possible questions for the questionnaire. The study illustrated that most interviewees admit the value of product instructions even if they were not satisfied with them. They also pointed out some specific problems of product instructions. For example, there are too many technical terms in instructions; many user guides are difficult to understand and visually poor; instructions are wordy but do not address what the users really need or even do not match the actual product. These problems were repeated by different interviewees and also, one user expressed that some instructions contain bad translations. These findings from the exploratory research were used for the designing of individual questions.

3.2.1.2.2 Planning of questionnaire

Referring to key findings taken from the exploratory research, the aims of Questionnaire A have been put into detailed key questions as below:

Key question A	Do users think product instructions are important?
Key question B	Do users think problems widely exist in product instructions?
Key question C	What side effects can bad product instructions cause?

The content of the questionnaire was made up of a few sections including: title, introductory remarks, instructions for completing items (ticking boxes, etc.), respondent data (age etc.) and questions. The chief design work was focused on the questions; two drafts were drawn

of one after another to achieve proper solutions for high response rates. Most items in this questionnaire were designed as closed questions but open-ended questions were also experimented with in drafts.

3.2.1.2.3 Pilot testing

A pilot test was carried out based on 26 samples. According to the pilot test, the majority of questions provided people's opinion but they could be improved in their semantic structuring and formatting. Therefore questions were redesigned afterwards.

3.2.1.2.4 Final design of questionnaire

3.2.1.2.4.1 Design of questions:

The final questionnaire (Table 13) retains totally 6 items. They were reorganised in a comprehensible order and suitable formats. The design of each question was determined by the exploratory research and refined according to the pilot test. The language was kept simple to make sure that respondents decoded the question in the way the researcher intended them to.

Table 13: Final questions in Questionnaire A (2006).

Question	**Concern**	
1. When you use an unfamiliar product, do you usually refer to the product instructions?	How widely have product instructions been used?	
2. You mostly use product instructions to____	What's the purpose of using product instructions?	
3. Which of the following products do you have the most problems with regarding their instructions?	Which types of products contain the most problems?	
4. Which of the following types of problems exist in the product instructions you have seen?	What is the most common problem in product instructions?	
5. Please indicate how strongly you agree with the following statements.		
The instructions influence the correct use of the products	Do product instructions affect the use of products?	

The instructions influence my overall opinion of the products	Do product instructions affect the users' opinion of the products?	
I expect high quality instructions to accompany the products	What are user's expectations level regarding product instructions?	
I am satisfied with the current product instructions	How satisfied the users are with product instructions?	
6. When your product instruction is not very clear, what do you do?	What side effects can bad product instructions cause?	

Key question A	Do users think product instructions are important?
Key question B	Do users think problems widely exist in product instructions?
Key question C	What side effects can bad product instructions cause?

3.2.1.2.4.2 Forms of Questions:

The final questions delivered the initial aims efficiently. The items were presented in the following three types of closed questions:

- List; where the respondent is offered a list of items, any of which may be selected;
- Scale or rating, in which a rating device is used to record response;
- Grid, where responses to two or more questions can be recorded using the same matrix.

3.2.1.3 Sampling

A sample is a selection of elements (member of units) from a population; it is used to make statements about the whole population. The ideal sample is one that provides a perfect representation of a population, with all the relevant features of the population included in the sample in the same proportions. However, Blaikie (2000) believes that this ideal is seldom achieved. In this survey, the target population refers to all users of product instructions. This population is difficult to identify and locate. According to Blaikie (2000), when it is not possible to estimate population parameters from the data acquired, researchers could use a non-probability sampling method. Similarly, Fink (1995) states that one of the reasons for using non-probability samples is that of "hard to identify groups". Sapsford (2007) suggests that if there is no sampling frame and if the sample cannot be located geographically, haphazard or convenience sampling can be considered. In this research, a convenience sampling method was adopted. Questionnaires were presented to people randomly in the street and on the internet. At the end of this survey, 77 printed

questionnaires were collected and another 48 questionnaires were returned on the Internet. In total, 114 of them were completed. Because sampling was opportunistic and voluntary, participants may be unlike most of the constituents in the target population. Statistical means of estimating errors were not applied to this survey because they are not valid for non-probability sampling. Though the samples do not give accurate estimates of error, a statistical test was still good to be referred to for general purposes.

3.2.1.4 Results

All questions in this questionnaire were about "what" the users' attitudes were. According to Blaikie (2003), "What" questions can usually be answered with univariate descriptive analysis without more complex techniques. This simply isolates the characteristics of some aspects from a social phenomenon, counts and manipulates the resulting number, then offers descriptions. This descriptive analysis was used for interpreting overall results and also for comparing results between different gender and age groups. Some essential results are presented and described below.

3.2.1.4.1 Q1: When you use an unfamiliar product, do you usually refer to the product instructions?

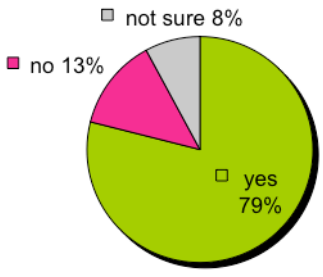


Figure 28: Result for Q1- Questionnaire A (2006)

The result (Figure 28) revealed that 90 out of 114 (79%) participants usually referred to the product instructions (as shown in Figure 28); other 15 people (13%) did not read the instructions. A further 9 participants (8%) were not sure. When looking at the gender difference, the number of female users who read instructions (84%) was slightly higher than that of male users (73%). Many male users (20%) claimed that they do not use instructions at all. Further, 89% of participants over 50 years old used instructions for an unfamiliar product. This

number was slightly higher that that in other age groups.

3.2.1.4.2 Q2: Do you mostly use product instructions to learn how to use a new product, solve problems or are you not using instructions at all?

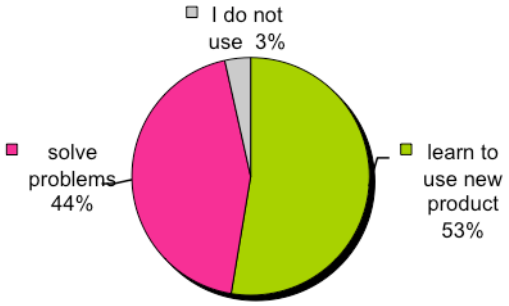
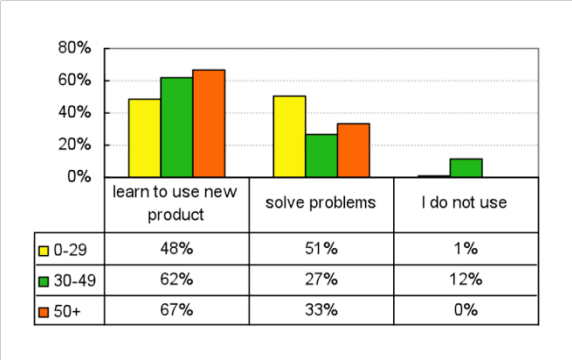


Figure 29: Result for Q2- Questionnaire A (2006).

According to the statistics (Figure 29), among the 114 participants, except four who had never used instructions, the rest 110 (97%) could be approximately separated into two groups. 60 people (53%) mainly used product instructions for discovering the usage of new products, the other 50 people (44%) tended to use instructions as reference for problem solving purposes. Female and male participants did not have much difference on the purpose of using instructions.



	learn to use new product	solve problems	I do not use
0-29	48%	51%	1%
30-49	62%	27%	12%
50+	67%	33%	0%

Figure 30: Result for Q2 from age groups - Questionnaire A (2006).

However, differences could be identified between age groups. In the younger group (0-29 years old), 48% of 79 participants used instructions to learn to operate new products and 51% of them used instructions for troubleshooting. The two numbers were very close. In the other two age groups (Figure 30), more people used instructions for using new products than for solving problems.

3.2.1.4.3 Q3: Which of the following products do you have the most problems with regarding their instructions?

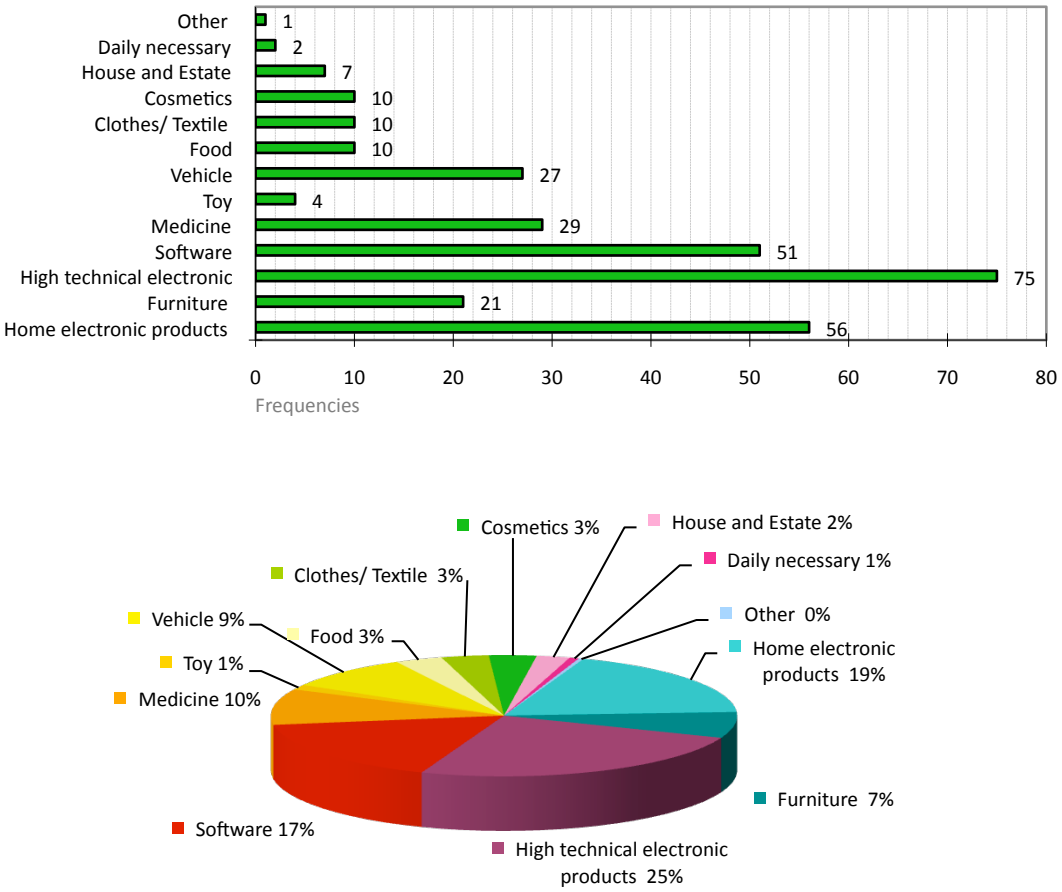


Figure 31: Result for Q3 from all participants - Questionnaire A (2006).

As indicated in figure 31, high technical electrical products, home electrical products and software were the top three types of products, which needed most concern with their instructions. These three types of product instructions together took 61% of the total 303 answers. Medicine, with 29 participants chosen, was 4th on the list. Some of the other types were selected by small numbers of people.

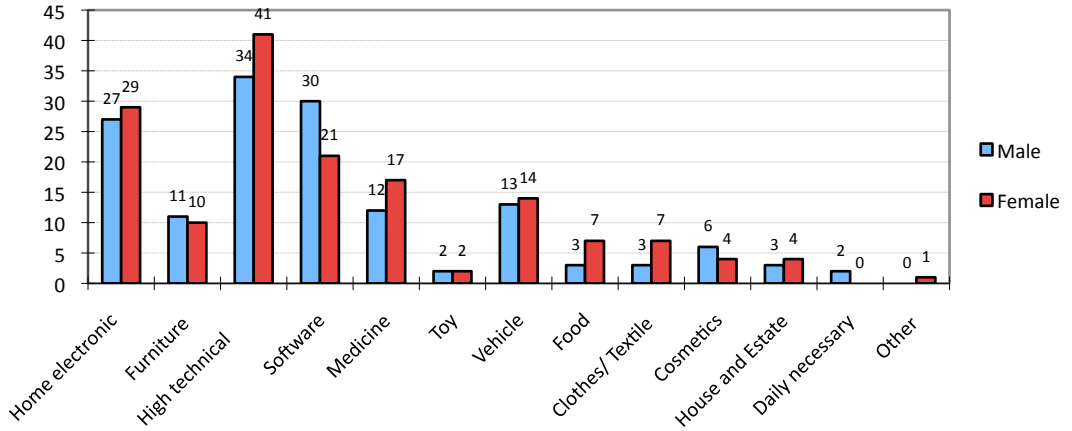


Figure 32: Result for Q3 from gender groups - Questionnaire A (2006).

It could be recognized (Figure 32) that there were minor differences between the male and female categories. Highly technical electronic products (41) and Home electrical products (29) were the largest two types of products which females find most problems with regarding their instructions. Chosen by 21 female participants, Software was the third popular answer. According to males' responses, they found most problems with High technical electronic products. 30 males had problems with Software instructions, which was higher than that of females. Meanwhile, the number of male participants who found problems with Home electrical product instructions was 27, which was similar to the number in the female category.

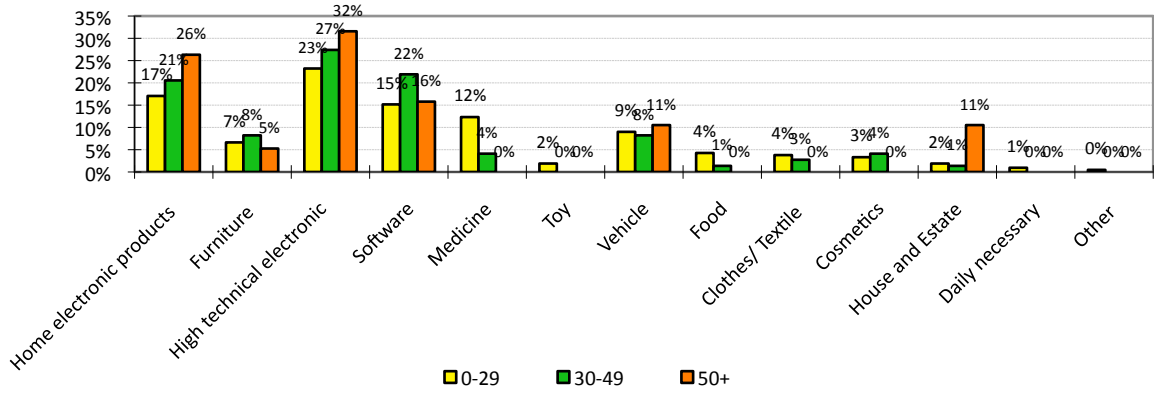


Figure 33: Result for Q3 from age groups - Questionnaire A (2006).

As shown in figure 33, all participants in different age groups recognised that there were many problems with highly technical electronic products instructions. However, their

attitudes towards other types of product instructions differed from each other. For participants under 29 years old, 22% of them had problems with Software instructions. The percentage was higher than that (15%) in the group of people between 30 and 49 years old, and also higher than that (16%) in the group of people above 50. Recognisable differences also existed in other types of product instructions for example Medicine and House and Estates. The numbers in the sample who found problems with Medicine instructions dropped down as their ages increase.

3.2.1.4.4 Q4: Which of the following types of problems exist in the product instructions you have seen?

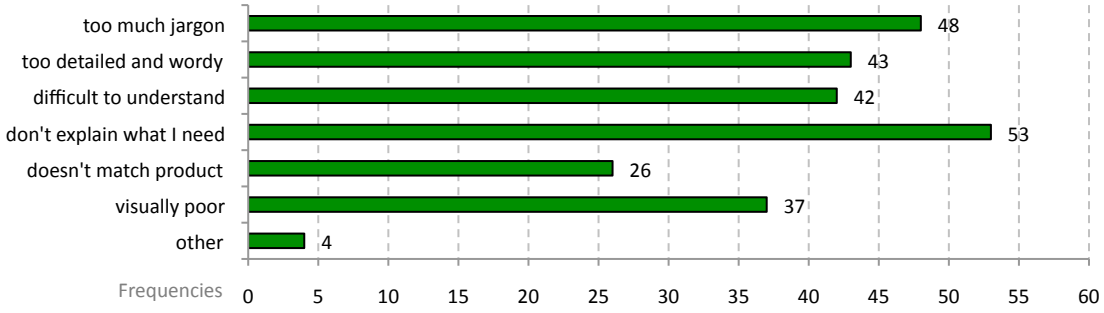


Figure 34: Result for Q4 - Questionnaire A (2006).

The data in figure 34 shows that 114 participants identified 253 problems with the product instructions on this item. It reveals the fact that many problems existed in current product instructions. It is also revealed in this chart that there were 53 participants who found that product instructions don't explain what they need. Participants suggested that bad translations and meaningless words exist in product instructions. Other unlisted problems were lack of trouble shooting and too thick to read. One out of the total 114 samples indicated that the result depends on what product the instructions refer to. Though minor differences exist, the two gender categories observed most of the problems similarly.

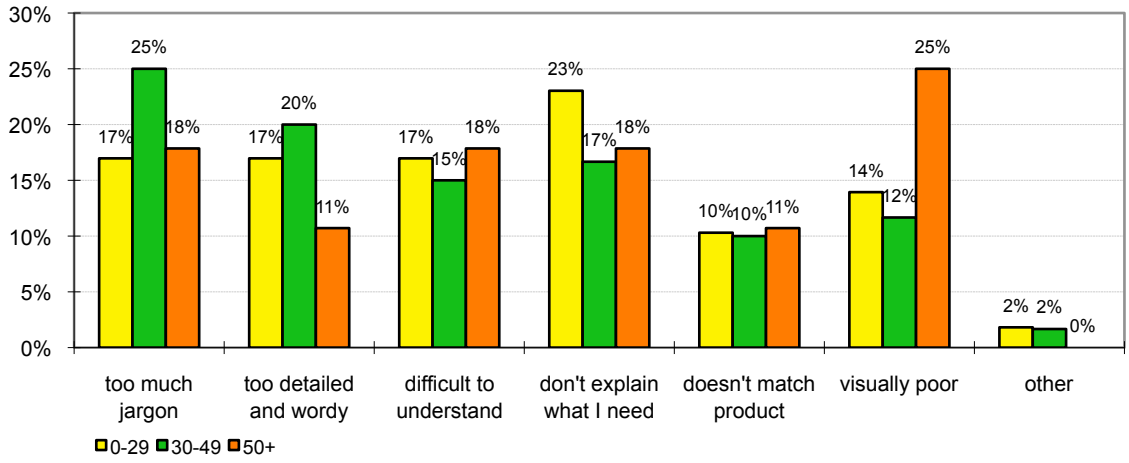


Figure 35: Result for Q4 from age groups - Questionnaire A (2006).

Participants in different age groups (Figure 35) had different foci toward product instructions. Among those under 29 years old, the main complaint was that they could not find what they need in product instructions. For participants who were aged between 30 and 49 years old, the biggest problem was the overuse of professional terms. People above 50 years old tended to care about the visual performance of product instructions. 25% of them in this survey thought that product instructions were visually poor.

3.2.1.4.5 Q5

Question five contains four different statements regarding the effects of the instructions, the expectation of the users and the satisfaction levels. For the four statements, the most important aspect was the proportion of people agreeing and disagreeing with the statements. The results can be made clear by pie charts. The mid-point of these dimensions (uncertain) can be regarded as corresponding to a ‘don’t care’ or a ‘don’t know’ answer.

3.2.1.4.5.1 Q5, Statement 1: The instructions influence the correct use of the products.

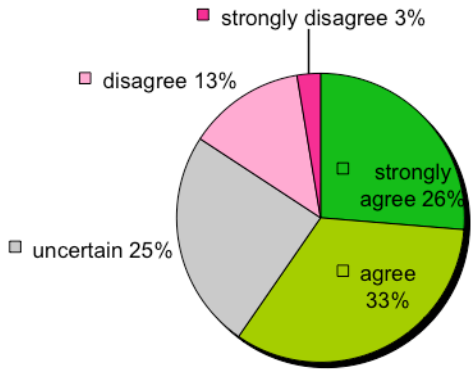


Figure 36: Result for Q5: statement 1 - Questionnaire A (2006).

A pie chart (Figure 36) shows that among all participants, 33% agreed and 26% strongly agreed that the instructions influence the correct use of the products. 13% respond disagreed and 3% replied strongly disagree. The other 25% participants had no strong opinion on this statement. No distinct difference was found between the two genders' opinions. Also, data indicates that young participants had stronger opinions about this statement than those in other age groups.

3.2.1.4.5.2 Q5, Statement 2 : The instructions influence my overall opinion of the products.

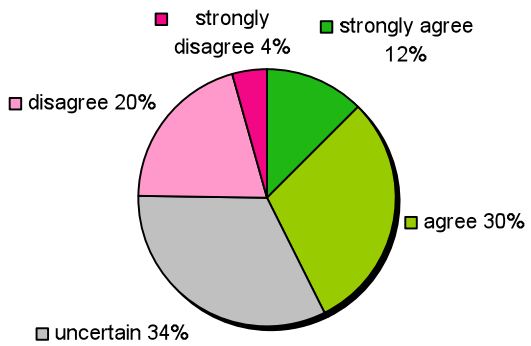


Figure 37: Result for Q5: statement 2 - Questionnaire A (2006).

30% people agreed that instructions influence their overall opinion of the products as well as another 12% who strongly agreed with this opinion (Figure 37). 24% participants disagreed or strongly disagreed with the statement. In addition, 34% people replied "uncertain".

The number of women who responded 'uncertain' (40%) was much higher than that of men (25%), from which it can be understood as women tended to consider products and instructions separately. Also, in age groups, the

number of participants under 29 years old who responded 'uncertain' (35%) was slightly higher than that of participants in other age groups (31% and 22%).

3.2.1.4.5.3 Q5, Statement 3: I expect high quality instructions to accompany the products.

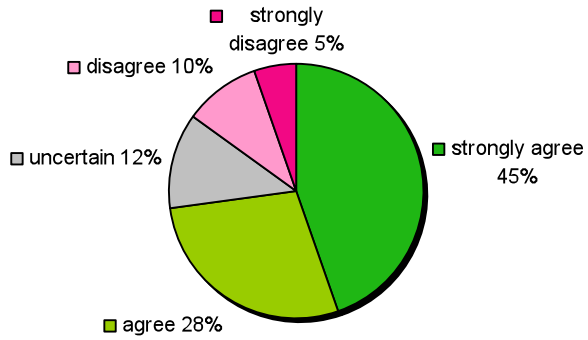


Figure 38: Result for Q5: statement 3 - Questionnaire A (2006).

Among 114 responses, the majority of participants (73%) strongly agreed or agreed that they tend to expect high quality instructions to accompany products (Figure 38).

Similar attitudes were found in both female and male groups. When taking age into consideration, the elder people had higher expectations on good quality instructions.

3.2.1.4.5.4 Q5, Statement 4: I am satisfied with the current product instructions

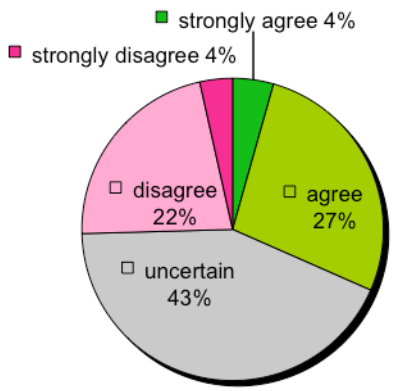


Figure 39: Result for Q5: statement 2 - Questionnaire A (2006).

As the data shows in figure 39, people were at very different satisfaction levels regarding the product instructions. The proportions of people agreeing and disagreeing with the statement were close. 27% of respondents were satisfied with current product instructions and 4% were very satisfied. Another 26% of people gave negative responses, which means these people tended to be

unsatisfied with the instructions. The rest, 43% of people responded 'not sure'. These respondents could be considered as if 'they didn't pay enough attention on the product instructions' or 'they don't care'.

Also, when we look at figures from different age groups, it is shown that 48% of participants under 30 years old were not sure about this statement. The number is higher than that in other age groups. It indicates that younger respondents didn't care about instructions as much as elder people.

3.2.1.4.6 Q6: When your product instruction is not very clear, what do you do?

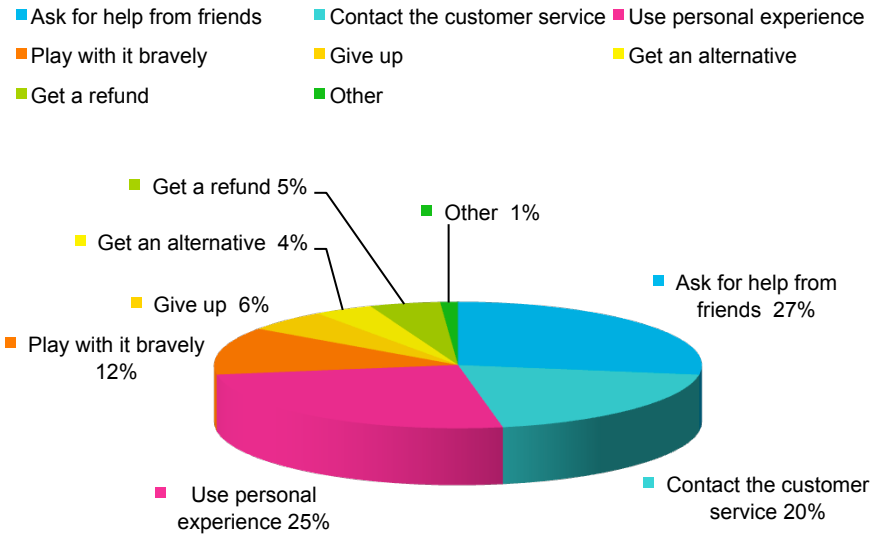


Figure 40: Result of item 6 for all respondents – Questionnaire A.

This question aimed to discover people's substitute activity when facing unclear instructions. Among the total of 225 answers, the first three most popular options were 'ask for help from friends', 'carefully solve the problems with personal experience' and 'contact the customer service for suggestions'. Each of them took 27%, 25% and 20% of the total (Figure 40). There were also many people (12%) who usually play with the products bravely, even when they know that there is a chance of damaging the product. Apart from the 'other' option, the listed optional solutions could be roughly put into three routes:

Route 1: Look for external assistance as an alternative of product instructions

- Ask for help from friends/family
- Contact the customer service

Route 2: Rely on personal practical experiments

- Use personal experience, to carefully discover it
- Play with it bravely, even if it might damage the product

Route 3: Give up the product

- Give up and put the product away
- Get an alternative from another brand
- Get a refund

All options had advantages and disadvantages. 'Contact the customer service' could increase the customer's cost. The option of 'ask for help from untrained people' from route 1 and all options from route 2 could influence the safe and correct use of products and even break the products. Options from route 3 showed that for those customers who gave up on the products, both 'Get an alternative from another brand' (4%) and 'get a refund' (5%) meant that the products are loosing their customers due to the unclear instructions.

There might be some other reasons such as personal interest which drove the respondents to choose options from route 1 and 2. However for those users, who might give up on the products, they simply cannot use the products properly by reading the instructions.

3.2.1.5 Findings

Though a few people do not use instructions at all, the result reveals an unquestionable fact that the majority of the people usually refer to instructions when they use an unfamiliar product. Most of these users use instructions either for learning to operate new products or for troubleshooting. When asked which kind of products had the most problems regarding their instructions, many different responses were given by users. Answers included all types of products from DVD recorders to mobile phones, from washing machines to hair products. The result shows that modern products, especially the ones involving high technologies, have more problems with their instructions than others. Also, people of both genders, of different ages have problems with different types of products. This can be interpreted that the numbers of problems with an instruction is determined by which type of product users use most and also depend on the complexity of the product.

The survey shows that there are many problems with product instructions. People in different age groups have different foci toward product instructions. Users under 29 years old are mainly not satisfied with the content of product instructions. Users between 30 and 49 years old concentrated on the communication problems of instructions. People above 50 years old tend to care about the visual performance of product instructions more than other problems.

Although more users agree that instructions influence the correct use of products than those who disagree, there are still many people who do not believe instructions are important for using products. From the results, it is very difficult to find how much instructions influence users' overall opinion of products because the numbers of people who agree, disagree and do not care are almost equal. People tend to expect high quality instructions to accompany products but not many of them are satisfied with the product instructions they have, especially the elder people. Many users are uncertain about the quality of instructions and the author interprets this as it depends or they do not care.

In this survey, results reveal that when product instructions are not very clear, users take alternative actions. They either look for assistance, rely on personal practical experiments to use products or give up the products completely. There might be some other reasons such as personal interest which drove the respondents to choose options like looking for help or experimenting on their own. However for those users, who might give up on the products, they simply cannot use the products properly by reading the instructions.

Overall, this survey suggests that although people expect high quality product instructions, many users do not appreciate the value of product instructions and they do not care much. Not many users are satisfied with the instructions they have. Problems are with all kinds of product instruction. Users in different gender and age groups hold slightly different opinions toward product instructions, for example people over 50 are more eager to expect high quality instructions. However, the gaps are not large enough to influence all users' overall attitudes.

3.2.2 Questionnaire B (2008)

After reviewing literature and interpreting the first set of questionnaires (2006), it was revealed that product instructions were necessary and important; problems with instructions widely existed with all sorts of products. Then the next key research question was to find out what the main problems were with general instructions. The author assumed that there were problems with the effectiveness and accessibility of instructions and another questionnaire (2008) was designed to understand this better:

3.2.2.1 About the survey

Title:	Product instructions problems
Date:	20 February 2008
General purpose:	To identify key problems of product instructions.
Specific Research questions:	What kind of product instructions do users use most?
	Are product instructions easily accessed?
	Are product instructions effective?
Hypothesis:	Accompanying product instructions through printed media.
	Product instructions are not easily accessible.
	Product instructions are not effective.
Target population:	all users of product instructions
Type of survey instrument:	self-administered questionnaire

Table 14: About Questionnaire B (2008)

3.2.2.2 Design of survey

Based on the results collected from Questionnaire A (2006) and findings from literature, this questionnaire, Questionnaire B (2008) was structured in order to gather more information about key problems of product instructions. The aim of this questionnaire was to ask detailed questions such as identifying the type of product instructions, the effectiveness and accessibility of the instructions. Similar to Questionnaire A (2006), the content of this questionnaire was made up of several sections for example the title, introductory remarks, instructions for completing items, questions, respondent data etc.. The main design work was focused on the question items. Most items were designed as closed questions. A pilot test was carried out based on 3 samples. And questions were redesigned afterwards. The final questionnaire retains total item numbers of seven (Table 15) and the items were

presented in closed questions like lists and scales.

Question	Concern	
1. When you use a product, which type of accompanying instructions do you use most?	What kind of product instruction has most problems?	
2. Do you keep ALL instructions that come with a product?	Are product instructions easy to store?	
3. If your answer is yes, do you some time lose them?	Are product instructions easy to access?	
4. Do you find product instructions are too long?	Are product instructions effective?	
5. Is it easy to locate the information you need in product instructions?	Are product instructions effective?	
6. Do you think product instructions include sufficient information?	Are product instructions effective?	
7. Are product instructions easily understandable?	Are product instructions effective?	

Key question A	What kind of product instruction has most problems?
Key question B	Are product instructions easy to access?
Key question C	Are product instructions effective?

Table 15: Final questions in Questionnaire B (2008).

3.2.2.3 Sampling

Questionnaires in this survey were sent to every student and staff in the School of Design of the University of Leeds. 223 online questionnaires were returned and 216 of them were completed. As suggested by questionnaire A (2006), gender and age difference should not have a huge impact on the general attitude about product instructions; these samples should suggest what the main opinions were.

3.2.2.4 Results

For questionnaire B (2008), univariate descriptive analysis was used and the results for all questions are shown below.

3.2.2.4.1 Q1: When you use a product, which type of accompanying instructions do you use most?

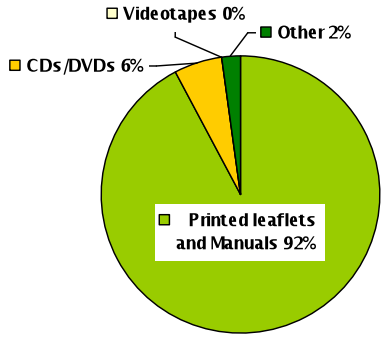


Figure 41: Types of accompanying instructions.

According to the survey, except one response, which indicated that online help documents were mostly used, all other answers showed that commonly used product instructions were in physical forms. And among them, the vast majority (92%) of product instructions were printed (Figure 41). Other forms such as CD/DVDs were also adopted but only used by very small number of users. Product instructions on old media, for example videotape, was apparently dated and no longer in use.

3.2.2.4.2 Q2: Do you keep ALL instructions that come with a product? (for example leaflet,manuals,CDs,DVDs,Videotapes etc.)

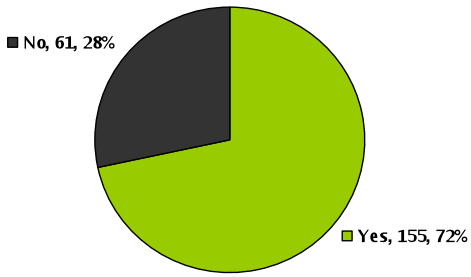


Figure 42: Do users keep instructions?

Figure 42 shows that 73% participants (155) intended to keep all instructions that accompany products. The rest of participants do not do so.

3.2.2.4.3 Q3: If your answer is yes, do you lose them?

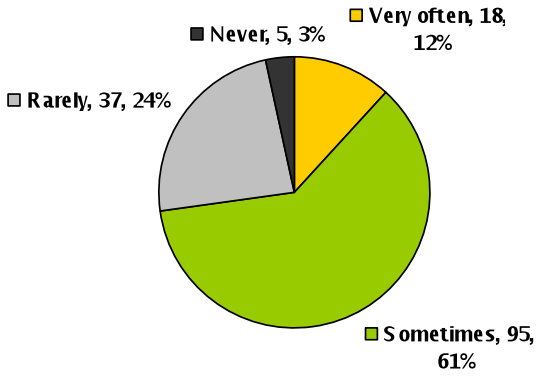


Figure 43: Do users lose instructions?

Among 155 users who claimed they always keep product instructions, only 5 participants (3%) never lose the instructions and another 37 participants (24%) rarely lose them. 12% participants admit that they lose product instructions very often. Majority of users (61%) replied "sometimes" (Figure 43).

3.2.2.4.4 Q4: Do you find product instructions are long?

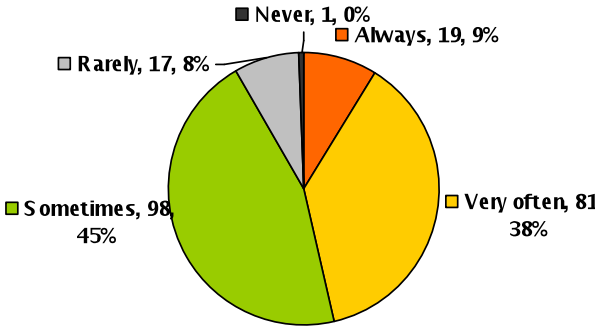


Figure 44: Are product instructions too long?

As shown in figure 44, when asked "Do you find product instructions are too long?", 19 participants (9%) answered "always", 81 participants(38%) said "very often" and 98 participants(45%) replied "sometimes". There were a small number of participants (8%) who never or rarely found instructions too long.

3.2.2.4.5 Q5: Is it easy to locate the information you need in product instructions?

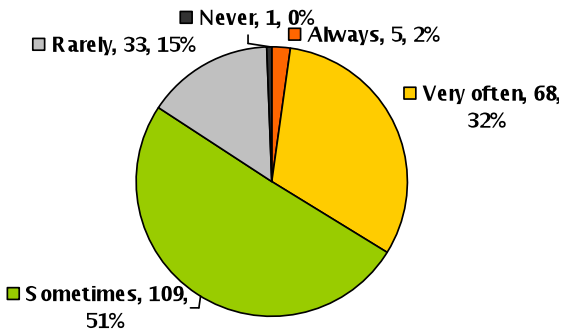


Figure 45: Is it easy to locate certain information in product

Figures in chart 45 represent that only 5 participants (2%) respond that it is always easy to locate certain information in product instructions; another 32% participants can find certain contents very often. Over a half participants (51%) admitted that they "sometimes" find information easily. 15% participants answer that they "rarely" find it easy to

instructions?

get useful information in instructions and 1 participant claimed that it has never been easy to find useful information in product instructions.

3.2.2.4.6 Q6: Do you think product instructions include sufficient information?

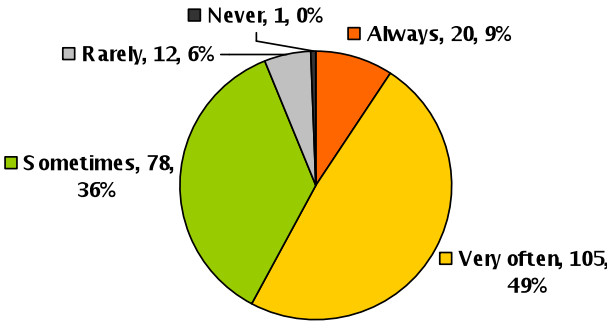


Figure 46: Do product instructions include sufficient information?

Results in figure 46 represent that 9% and another 49% of the participants always or very often agreed that product instructions included sufficient information. The percentage of people who suggested that instructions lack necessary information is very low (6%). There are also a large number of participants (36%) who chose "sometimes" as their answers.

3.2.2.4.7 Q7: Are product instructions easily understandable?

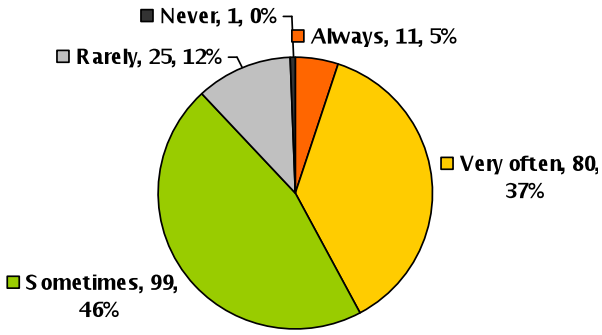


Figure 47: Are product instructions easily understandable?

Though in this item, 5% participants answer "always" and 37% participants reply "very often" (Figure 47), product instructions are not easily understandable to every user. 12% samples in this survey respond that product instructions are very often difficult to be understood. 1 participant claims that product instructions are never easily understandable. 99 participants (46%) mark "sometimes" as their opinion.

3.2.2.5 Findings

According to this survey, the majority of commonly used product instructions are in physical

forms. Printed is currently the most accepted form of product instructions. CD/DVDs are also used but they are less popular. Product instructions on new media, for example online help documents are used by some users but they are not the main stream yet. Product instructions on old media, for example, videotape is apparently dated and no longer in common use. Although many users (73%) intend to keep all product instructions, only a very small number of users (3%) never lose them. These results indicate that instructions which accompany products are not always well stored during the lifetime of the products so that they are not always easily accessed when needed. This survey also suggests that when in use, product instructions are not all effective. Results show that 47% participants tended to think instructions are too long. And only 34% participants in this survey very often or always found it easy to locate useful information. Although 58% of the participants always or very often agreed that product instructions include sufficient information, product instructions were only easily understandable to less than half of the participants (42%). Also, many participants chose "sometimes" as their answers for many items, which implies that they are uncertain about their answers or they do not care.

3.2.3 Summary

To conclude findings from the early literature review and questionnaires, it was discovered that:

3.2.3.1 Product instructions are still necessary, because:

- Instructions Influence safe use of products.
- Most users still need them for learning new products and problem solving;
- Users have high expectations;

3.2.3.2 The problems of product instructions are from three design aspects.

Product instructions are not designed and updated quickly enough to catch up with the changes in emerging products. Users are not very satisfied and problems widely exist in product instructions across different products; With the majority of product instructions, users are mainly suffering from problems in three design aspects: the effectiveness, accessibility and inclusiveness.

3.2.3.2.1 Effectiveness

Users complain about many problems with product instructions such as they do not explain what the users really need; they are either too wordy or difficult to understand, hold unusual technical terms, may contain bad translations and bad visuals. These problems suggest that instructions are not effective enough on their contents, communication and appearance.

3.2.3.2.2 Accessibility

Product instructions are mostly delivered through physical media. They are big, not easily accessed and easy to lose. In recent years, there are more product instructions available online to download. However, they are mostly digital or scanned versions of the traditional instructions, and are still very limited compared to other instructions delivered by physical media.

3.2.3.2.3 Inclusiveness

Product instructions are mostly presented by text, images or a mixture of both. They are not satisfying users with different learning styles and preferences. Product instructions dominated by text certainly enable aural learners to follow easily, however, they are not as straightforward to use for other readers with different strengths. Instructions full of pictures and charts can help visual learners to process information effectively and use products quickly but yet again they might not be the best choice for other users, for example, kinesthetic learners.

Additionally, it is difficult to locate a piece of information among instructions, as they are often very lengthy. Users have to scan all information and evaluate them to select the part they need. This works well when the assimilating learning style is favoured. However, when an accommodating learning style is preferred, users will be annoyed, often because they are forced to go through lots of instructions, instead of getting hands on experience quickly.

Chapter 4. Current and Possible Solutions

The last chapter concluded that the main problems of product instructions are with their effectiveness, accessibility and inclusiveness. In this chapter, the author is going to focus on the solutions for corresponding solutions and point out design challenges.

4.1 Current solutions

Although evidence for problems with product instructions is everywhere, neither consumers, nor manufacturers or researchers have paid enough attention to these problems. Many consumers do not care about product instructions. They have a tendency to ignore the unintelligible product instructions and discover alternative ways of learning how to use products. Many users are not aware that instructions are parts of their products and they should be always available and comprehensible. On the other hand, the majority of manufacturers have not paid enough attention to the instructions either. They happily spend money on their production and promotion, but are not so serious about making customers know how to use them through instructions. However, there are exceptions amongst particular industries like computers and software. In the case of some major manufacturers, such as British Aerospace, instruction publications are a vitally important part of what they provide for customers and they send writers for training before they produce the documents. The result is that they provide much better instructions.

A similar situation also exists in the academic world. Generally, related research is not common and hardly any colleges run specific training courses in product instruction design. Nevertheless, a number of researchers have carried out some studies in recent years. For example, the Helen Hamlyn research centre (2000) worked on a project to explore the relationship between mandatory and marketing information on packs. They aimed to devise a strategy to make packs easier to use for older consumers who require information about ingredients, product use, dosage etc. A research on refining medicine instructions was carried out in Australia to find out how information design can make a social change (Sless &

Tyers, 2006). Schumacher (2007) from Australia researched on Pictorial Assembly Instructions (PAIs) in flat pack products, his research focused on practice guidelines for the design of illustrations in assembly instructions. However, projects like these are uncommon examples and they are very specific research studies focused on particular problems with certain types of product instructions.

4.1.1 Solutions for effectiveness problems

In terms of improving the effectiveness of product instructions, standards for preparing product instructions can be referred to (Chapter 2.1.7). These guides provide many suggestions for designers or anyone who is involved in the process of developing instruction materials.

4.1.2 Solutions for accessibility problems

Currently, there is currently no sign of well-proved solutions for making product instructions more accessible. It is mainly the users' responsibility to reserve all accompanying instructional materials. Once they are lost, some companies charge for replacement and others do not even provide them. There are also some websites providing online downloads of scanned manuals for some products from a limited number of brands and a charge is usually applied. Plus, given information normally will not be available after an updating of devices. Therefore they are only accessible for a certain period of time.

4.1.3 Solutions for inclusiveness problems

Again, the standards do not suggest solutions for inclusive problems of product instructions. Many manufacturers publish separate instructions for technical professionals and general users. Some manuals are available in different languages which then become very long. To shorten lengthy instructions, quick start guides are sometimes available for new and complex products.

The majority of product instructions are presented by either text, images or a mixture of both. They help visual learners to learn to use products quickly but they might not be the best choice for other users, for example, kinesthetic learners.

4.1.4 Summary

In chapter 3.2, the author studied the current solutions for key problems in product

instructions. Facing all these problems with product instructions, some actions have been taken to alleviate the frustrations. To make product instructions more comprehensible and effective, a number of standards for formulating instructions are available and textual materials on how to write instructions are provided. For example, ISO 3864 can be referred to when designing warning notices; ISO 7001 can be used when defining public information symbols. Among all relevant standards, the author found ISO/IEC GUIDE 37 and the BS EN 62079:2001/ IEC 62079 contributed most to the formulation and design of product instructions. They make suggestions on a wide range of problems, for example, the principles, contents, writing and design during the whole process of preparing product instructions. By following these two standards, many problems of product instructions regarding their effectiveness can be avoided. However, they are abstract and limited. It is difficult to use them in the practical design situation. Further, they are dated and do not fit all requirements of the fast moving market of products.

Meanwhile, info-graphics have been studied by some designers and academic researchers so that graphics can be used to aid the presentation of information. They are mostly focused on how to visualise information and present step by step assembly instructions. Research on the general design process of product instructions or on the accessibility and inclusive design of product instructions is relatively rare; suggestions particularly for digital instructions are still not sufficient although they should be vital. Problems of product instructions are not completely and successfully solved and users are continuing to suffer from annoyance caused by poor product instructions. It is necessary to carry out a systematic and up to date study to improve the performance of product instructions, especially in this digital age.

4.2 Possible Solutions and Design Challenges

4.2.1 Possible solutions

By solving the main problems with current product instructions, a good product instruction should be:

- Effective communicate and present right and understandable contents, in order to ensure the safe use of products;
- Accessible up to date; always available,
- Inclusive usable by all target product users

They should be easily accessed, understood, stored and updated for all; meanwhile fulfilling the requirements of being cheap to produce and environmentally friendly.

The people who are producing product instructions should all be trained to write and produce effective user guides. They should understand standards for formulating instructions and be able to apply them while doing their jobs. The standards and guidance for producing instructions should be simplified and provided in a way that can be easily used by designers.

To make product instructions easily accessible, stored and updated effectively, they could be created and distributed by digital means, through networks, for example Internet or 3G networks. This could provide product instructions at anytime, from anywhere around the world and could be translated into multiple languages with a very low budget for maintenance demands. There were 1,966,514,816 Internet users around the world in June 2010. The number has grown by 444.8 % between 2000 and 2010, and it is still growing (Miniwatts Marketing Group, 2010). On the other hand, based on Nielsen's estimate (Nielsen, 2010,cited in Entner, 2010), 50% of US mobile subscribers (142.8 million) will be smartphone users by 2011, which means they could get access to a 3G network very easily on their phones. Similar trends are actually happening everywhere across the world.

To fulfil requirements from users with different intelligence levels and learning styles, instructions could involve multiple media for example, sound, music, animation etc., as well

as the traditional media of text and images. Product instructions might also be interactive so that they could be read in almost any order. Once instructions are designed to be interactive rather than linear, they can be read by choice. This should enable the users to reread instructions and to repeat the tasks when an error is discovered. This will also minimise the amount of time spent on reading instructions, especially for those inexperienced users who have little prior knowledge. Also, a combination of minimalist and systematically complete instructions might be able to offer the most productive learning experience.

4.2.2 Design Challenges

Theoretically, multimedia instructions should help people with different learning styles and strengths to operate products easier, quicker and safer. However, it was not proved to work for all types of instructions and for all users yet. For example, earlier studies evidenced that older users had higher expectations on instructions. In fact many of them were not necessarily good with digital devices because of picking up the skills gradually after grown up. It would be a question that if multimedia instructions could be accepted by those users. Also, Tapscott (2009) suggested that Digital Natives (those who have grown up with digital devices) and Digital Immigrants (those who learnt to use digital devices as an adult) learn things differently and have different opinions on digital products and interactive works. Therefore the key challenges for this study were:

- to discover if multimedia instructions are going to perform better in terms of their effectiveness and inclusiveness, compare to traditional instructions;
- to determine if multimedia instructions can be better solutions for all users, including Digital Natives and Digital Immigrants.

Chapter 5. Prototyping Product Instructions

To find the answers to the design challenges, instructions for a particular product, a flat pack photo table were chosen and rewritten according to the standards and regulations for planning product instructions. Two versions of product instructions were then produced: a printed version combining text and images; a multimedia version of the product instructions, which used the same text and imagery information but involved extra sound, animation and was designed as interactive. Participants were separated into two groups: Digital Natives and Digital Immigrants to test their performances.

5.1 Selection of the product instructions

When selecting a particular set of product instructions for testing, results from an earlier survey (2006) were referred to. Generally, high technical electrical products, home electrical products and software were the top three types of products which generated most concern with their instructions. Medicine was the 4th on the list and followed by vehicle and flat pack furniture. It was also concluded that user responses to instructions vary. This could be affected by the complexity of the product and users' previous experiences. When using a complicated product, in particular, previous knowledge has a huge impact on the user perception of the instructions. It normally takes novice users a longer time to follow them. Experienced users with more knowledge can have quicker reactions to a product and might skip instructions while using it.

In this investigation, the tests focused on the usefulness of the product instructions rather than the performance of the product itself. The selected type of product could not be too complicated so that general users of different age and gender could all follow the instructions then use the product. Their previous knowledge or experience should not have affected how they understood and used the product instructions too much. The chosen product instructions should also have contained essential information that could not be skipped or ignored. Further, the whole process of user testing had to be monitored in a laboratory. Thus there should be little limitation on when and where to use the product to

enable the recording. All in all, the selected product and its instructions were required to meet the following specifications:

- Universal the product and its instructions can be used by general users.
- Simple no specific knowledge is required to use the product.
- Compulsory the instructions cannot be skipped or ignored.
- Recordable the process of using the product instructions can be recorded.

According to these criteria, the top six products which need most concern with their instructions were reviewed (Table 16):

Product type	Requirement	Yes(○) or No (X)	Comment
High technical electrical products	Universal Simple Compulsory Recordable	○ X X ○	Previous experience and knowledge can affect heavily on how users use the products and instructions. Experienced users can skip parts of the instructions.
Home electrical products	Universal Simple Compulsory Recordable	○ X X ○	Previous experience and knowledge can affect heavily on how users use the products and instructions. Experienced users can skip parts of the instructions.
Software	Universal Simple Compulsory Recordable	○ X X ○	Previous experience and knowledge can affect heavily on how users use the products and instructions. Experienced users can skip parts of the instructions.
Medicine	Universal Simple Compulsory Recordable	X ○ ○ X	Products cannot be applied to all users. It is difficult to record the process of applying the products.
Vehicle	Universal Simple Compulsory Recordable	○ X X ○	Previous experience and knowledge can affect how users use the products and instructions. Experienced users can skip parts of the instructions.
Flat pack furniture	Universal Simple Compulsory Recordable	○ ○ ○ ○	Previous experience and knowledge can affect how users use the products and instructions but instructions cannot be skipped for installation.
○ = Yes X = No			

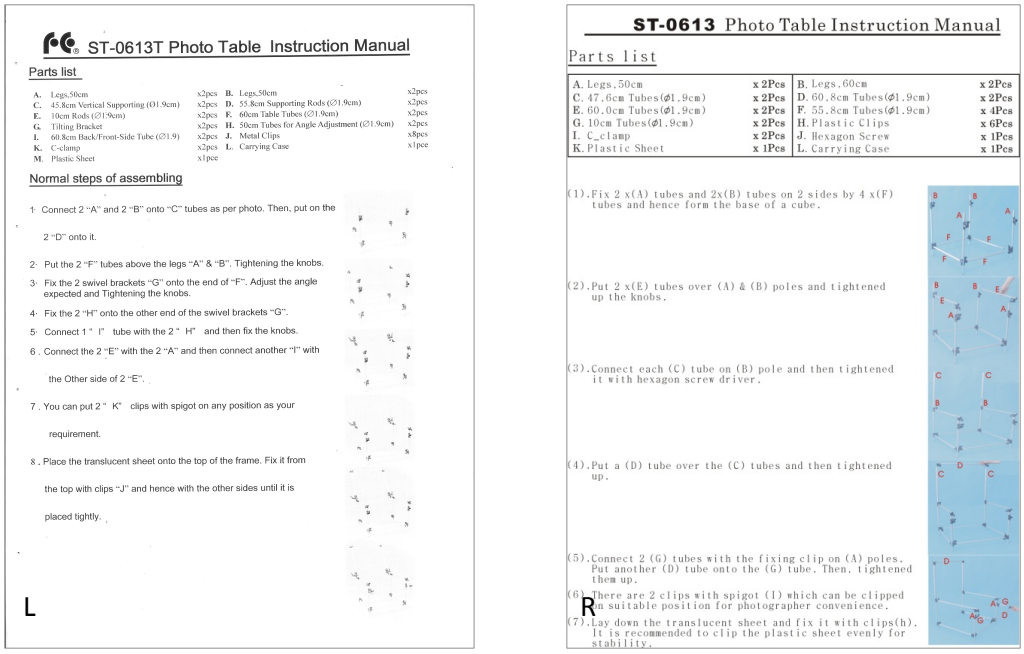
Table 16: Review of different types of products and their instructions.

High technical electrical products, home electrical products, software and vehicles were not appropriate for this test although they had more problems. For those products, users needed to perform complicated tasks and their experience and knowledge could affect how users use the products and instructions. Medicines were not a good choice for this investigation either. They should only be tested by specific user groups and not by general participants. The last type of product, however, Flat pack furniture, met all the requirements. It was designed for average adult users and no specific knowledge or experience was required. Assembly instructions had to be followed in terms of using the type of product and users' actions could be easily recorded due to the scale of chosen product.

Figure 48: A photo of the selected product.

Then, a particular flat pack product, an ST-o613T Photo table (Figure 48) was selected for this investigation. This product did not require any previous experience to use. It was not a common product that average people would have used; General users should not have a mental model therefore they had to follow the instructions to set the product up. It was light in weight; could be assembled and operated by one person, either male or female without any extra tools. Different tasks on its assembling and operating were available for testing. It was also of a good size for video recording.

5.2 Evaluation of the original product instructions



ST-0613T Photo Table Instruction Manual

Parts list

A.	Legs,50cm	x2pcs	B.	Legs,50cm	x2pcs
C.	45.8cm Vertical Supporting (Ø1.9cm)	x2pcs	D.	55.8cm Supporting Rods (Ø1.9cm)	x2pcs
E.	10cm Rods (Ø1.9cm)	x2pcs	F.	60cm Table Tubes (Ø1.9cm)	x2pcs
G.	Tilting Bracket	x2pcs	H.	50cm Tubes for Angle Adjustment (Ø1.9cm)	x2pcs
I.	60.8cm Back/Front-Side Tube (Ø1.9)	x2pcs	J.	Metal Clips	x8pcs
K.	C-clamp	x2pcs	L.	Carrying Case	x1pce
M.	Plastic Sheet	x1pce			

Normal steps of assembling

1· Connect 2 "A" and 2 "B" onto "C" tubes as per photo. Then, put on the 2 "D" onto it.

2· Put the 2 "F" tubes above the legs "A" & "B". Tightening the knobs.

3· Fix the 2 swivel brackets "G" onto the end of "F". Adjust the angle expected and Tightening the knobs.

4· Fix the 2 "H" onto the other end of the swivel brackets "G".

5· Connect 1 " I" tube with the 2 " H" and then fix the knobs.

6 . Connect the 2 "E" with the 2 "A" and then connect another "I" with the Other side of 2 "E".

7 . You can put 2 " K" clips with spigot on any position as your requirement.

8 . Place the translucent sheet onto the top of the frame. Fix it from the top with clips "J" and hence with the other sides until it is placed tightly.

L

ST-0613 Photo Table Instruction Manual

Parts list

A. Legs,50cm	x 2Pcs	B. Legs,60cm	x 2Pcs
C. 47.6cm Tubes(ϕ1.9cm)	x 2Pcs	D. 60.8cm Tubes(ϕ1.9cm)	x 2Pcs
E. 60.0cm Tubes(ϕ1.9cm)	x 2Pcs	F. 55.8cm Tubes(ϕ1.9cm)	x 4Pcs
G. 10cm Tubes(ϕ1.9cm)	x 2Pcs	H. Plastic Clips	x 6Pcs
I. C_clamp	x 2Pcs	J. Hexagon Screw	x 1Pcs
K. Plastic Sheet	x 1Pcs	L. Carrying Case	x 1Pcs

(1).Fix 2 x(A) tubes and 2x(B) tubes on 2 sides by 4 x(F) tubes and hence form the base of a cube.

(2).Put 2 x(E) tubes over (A) & (B) poles and tightened up the knobs.

(3).Connect each (C) tube on (B) pole and then tightened it with hexagon screw driver.

(4).Put a (D) tube over the (C) tubes and then tightened up.

(5).Connect 2 (G) tubes with the fixing clip on (A) poles. Put another (D) tube onto the (G) tube. Then, tightened them up.

(6).There are 2 clips with spigot (I) which can be clipped on suitable position for photographer convenience.

(7).Lay down the translucent sheet and fix it with clips(h). It is recommended to clip the plastic sheet evenly for stability.

R

Figure 49: The unclear original product instructions.

The selected product was accompanied by two different instructions (Figure 49). Each of them was printed on A5 white paper. They both included basic product information like a parts list and also gave the assembling directions. One of them (Figure 49, L) describes the correct product however the illustrations are not clear. The other instruction list (Figure 49, R) contains better quality images but it does not match the product model. The author contacted the manufacturer and questioned the importance of both product instructions. They replied that the product instructions for a different model, ST-0613 photo table (Figure 49, R) were added as an extra, to backup the proper product instructions. Therefore it was obvious that the manufacturer was aware of the poor quality of the instructions but had not taken action to improve them.

Product instructions for the correct model, ST-o613T Photo table (Figure 49, L) were evaluated in this experiment. For the evaluation, ISO/IEC GUIDE 37 (1995) and BS EN 62079/ IEC 62079 (2001) were referred to. They both provided checklists for assessing product instructions. The contents in their checklists were almost the same, except that there were some minor differences in their wordings and also BS EN 62079/ IEC 62079 (2001) contained evaluation criteria for multimedia instructions. A combination of both guides was followed in this study. ISO/IEC GUIDE 37 (1995) was used when both standards deliver the same

meaning, as it was an international guide. Additional criteria from BS EN 62079/ IEC 62079 (2001) were included when they were not provided by ISO/IEC GUIDE 37 (1995). The quality of the product instructions was examined against these criteria (Appendix A & Appendix B).

Overall, the product instructions for the ST-o613T Photo table had problems with contents, communication and visual presentation. They did not contain all the necessary information for example information of the manufacturer or instructions for operation. The assembly instructions were far too textual. The description was obscure and confusing. The illustrations were of poor quality and did not clarify any problems. They were very difficult to follow and were ineffective.

These instructions were used for diagnostic tests, two participants were asked to recognise all product parts, assemble the product and adjust it to use. However, both users found it not possible to use instructions for completing any of these tasks. The author believed that no further analysis was needed until the instructions were refined to fulfil all requirements from the standards.

5.3 Planning essential elements of new instructions

Instructions were re-planned for testing in this research. To find out the impact of different media on instructions, the printed and multimedia instructions had to use exactly the same contents, text and illustrations, in different formats. The shared information was vital to the effectiveness of instructions. To ensure its quality, the product was examined first, then the user profile was reviewed and tasks were analysed. Contents were then decided and rewritten according to the recommended communication rules, followed by the redesign of visuals.

5.3.1 Preparing for the design of instructions

5.3.1.1 Examination of the product

Figure 50: Examination of the product

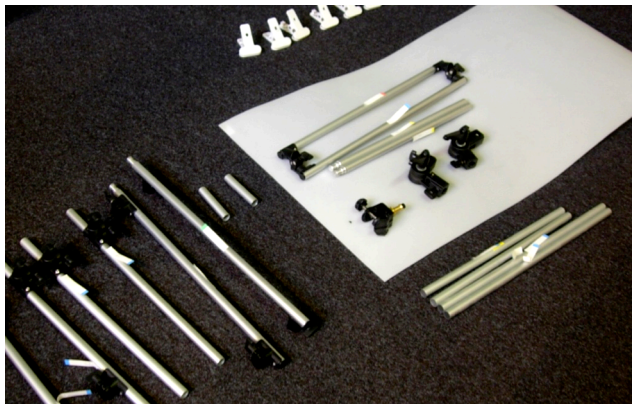


Figure 51: Labels were added onto product parts.

In the examination, all parts of the product were inspected and measured (Figure 50). It was discovered that the sizes of some parts were not accurate in the given product description. They had to be corrected during the revision. Also, there was no label on any part of the product. It was difficult to differentiate similar parts and use the instructions, particularly when following the assembly guides. Although this research focused on the instructions which accompany the product, labels had to be added in term of using the accompanying guides properly (Figure 51). Further, experiments on using the product, for example installing and operating were performed (Figure 52). The process was observed and recorded by a camera.

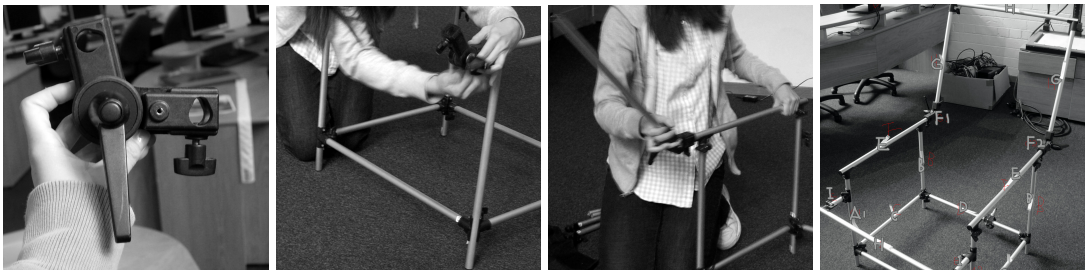


Figure 52: Examine the installing and operating procedures.

It was observed that some parts of the product needed to be relabelled with a different number, from “A” to “K”, according to the assembly procedure. Children should not be allowed to play with the product because some parts were small. Also, the shape of the product itself was very similar to a common chair. A potential problem could be that people could misuse the product as a chair and expose themselves to danger. Warning messages

should be included to avoid these foreseen dangers.

5.3.1.2 User profile

After the examination of the product, its user profile was created. This process ensured that all redesigned instructions would satisfy the product's appropriate user groups and meet their special requirements if there was any. The chosen product was designed for photography practitioners, including both experts and novices. Photography experts might have more chances to expose themselves to similar products before but it was a simple product therefore separate instructions for experienced and new users were not necessary. The redesigned instructions should require the minimum knowledge from users and be able to be used by people from all experience levels. It was important that users should be physically capable of carrying out the required actions because the product needed an installation and adjustments for use (Table 17):

Product name: Photo table	**Model**: ST-0613T			
User knowledge and experience:				
Reading level:	low	medium	high	✔all levels
Product experience:	experienced	novice	✔both	
User of similar products:	many some	little or none	✔all	
Physical characteristics:	not mobility impaired			

Table 17: User profile of photo table ST-0613T.

5.3.1.3 Possible tasks

Users mainly need instructions either for learning to use a product, for troubleshooting or for both. In this experiment, the main purpose of the instructions should be providing sufficient information so that users could set the photo table up to use safely. The main tasks users could be involved in include:

- Finding general information, e.g. product dimensions, it's capacity, what should not be done...
- Preparing the product for assembly (unpacking and checking all parts),
- Assembling the product,
- Adjusting the product for photo shooting.

To use the product, for example assembly, several sub tasks were needed: to make the frame base, to finish the frame, to fix the top sheet then attach the accessory. Consequential actions were required to fulfil each task. These tasks, sub tasks, actions and their ideal

solutions, acceptable/ alternative solutions even possible errors were analysed (Table 18). This detailed task analysis was a foundation for planning contents of instructions.

Table 18: Possible tasks for using the photo table ST-0613T and the required actions.

	Ideal solution	**Acceptable solution**	**Possible errors**
Finding general information			
Locating information	Locate information quickly	Locate information slowly	Cannot locate information
Reading information	Read information correctly		Read information incorrectly
Preparing the product for assembly			
Unpacking	Unpack all parts		Miss parts
Matching every part to instructions	Check all parts	Check parts during assembling	Mismatch parts
Assembling the product			
➔Making the frame base ◆Preparing A(L)", "A(R)", "B"× 2; -finding A(L) -positioning A(L) -finding A(R) -positioning A(R) -finding "B" × 2 -positioning "B" × 2	**Making the frame base in designed order** ◆Right parts face correct directions;	**Making the base in any order**	◆Use wrong parts; Right parts face wrong directions;
◆Connecting "C"× 2 to "A"legs and "B"legs; -finding "C" × 2 -positioning "C" × 2 -connecting first "C" and A(L) -tighten the knobs -connecting first "C" and "B" -tighten the knobs -connecting second "C" and A(R) -tighten the knobs -connecting second "C" and "B" -tighten the knobs	◆Right parts are fixed in the right joints; Parts are safely fitted into each other; Knobs are tightened;		◆Connect wrong legs; Connect right legs in wrong joints; Parts do not sit into a secure position; Knobs are not tightened properly;
◆Connecting "D" legs to A"legs and "B"legs; -finding "D" × 2 -connecting one "D" and A(L) -tighten the knobs	◆Right parts are fixed in the right joints; Parts are safely		◆Connect wrong legs; Connect right legs in wrong joints;

-connecting one “D” and A(R) -tighten the knobs -connecting “B” and “B” -tighten the knobs	fitted into each other; Knobs are tightened;		Parts do not sit into a secure position; Knobs are not tightened properly;
➔Finishing the frame			
◆Fixing “E” tubes to “A” legs and “B” legs; -finding “E(L)” -finding “E(R)” -fixing “E(L)” above A(L) and B -tighten the knobs -fixing “E(R)”above A(R) and B -tighten the knobs	◆Knobs on “E” face the backside; Parts are fixed safely; Knobs are tightened;		◆Knobs on “E” face the front side;
◆Fixing “F” × 2 onto “E” × 2; -finding “F(L)” -finding “F(R)” -positioning “F(L)” -positioning “F(R)” -fixing “F(L)” onto the end of“E(L)” -tighten the knobs -fixing “F(R)” onto the end of“E(R)” -tighten the knobs	◆Right parts are fixed safely; Handles on “F” × 2 face out; Both shorter sides of “F” × 2 are connected to “E” × 2; Knobs are tightened;	◆ Swap “F(L)”&“F(R)”; handles on “F” × 2 face out; both longer sides of “F” × 2 are connected to “E” × 2;	◆Swap “F(L)”&“F(R)”; One longer side and one shorter side of “F” × 2 are connected to “E” × 2;
◆Fixing “G” × 2 onto “F” × 2; -finding “G”× 2 -fixing one“G” onto the end of“F(L)” -tighten the knobs -fixing one “G” onto the end of“F(R)” -tighten the knobs	◆Right parts are fixed safely; Knobs are tightened;		◆Use wrong parts; Parts do not sit into a secure position; Knobs are not tightened properly;
◆Fixing one “H” onto end of “G” × 2; -finding one “H” -using “H” to connect “G” × 2 -tighten the knobs	◆Right parts are fixed safely; Knobs on “H” face the backside; Knobs are tightened;		◆Use wrong parts; Parts do not sit into a secure position; Knobs are not tightened properly;
◆Fixing “I” × 2 onto the front side of “A” × 2; -finding “I”× 2	◆Right parts are fixed safely; Knobs		◆Use wrong parts; Parts do not sit into

-fixing one“I” onto “A(L)” -tighten the knobs -fixing another “I” onto “A(R)” -tighten the knobs ◆Using another “H” to connect “I” × 2. -finding “H” -using “H” to connect “I” × 2 -tighten the knobs	are tightened. ◆Right parts are fixed safely; Knobs are tightened.		a secure position; Knobs are not tightened properly. ◆Same as above
➔ Fixing the top sheet ◆Placing plastic “J” onto the top of the finished frame; -finding “J” -identifying the upper side of “J” -putting the rough side up -placing “J” onto the top of the finished frame ◆Using “K” × 8 to hold “J”. -finding “K”× 8 -positioning “K” clips -attaching “K” clips to hold “J”	 ◆Rough side of “J” faces up;		 ◆Smooth side of “J” faces up;
➔ Attaching the accessory ◆Attaching “L” to any position on the frame. -finding “L” -positioning “L” - tighten “L”	 ◆Attach “L” to any position on the frame. “L” is fitted tightly.		 ◆ “L” is loose.
Adjusting the product for photo shooting			
➔ Adjust the angle of the top panel; -loosening “F(L)” -loosening “F(R)” -resetting the angle of the top panel -tighten “F(L)” -tighten “F(R)”	The top panel is adjusted to a new angel; Two sides of the top are on the same horizontal level; The panel is fixed tight.		Two sides of the top panel are not balanced; The panel is not fixed tight.
➔ Repositioning “L”. -loosening “L” -repositioning “L” -tighten “L”	“L” is fitted tightly.		“L” is loose.

5.3.2 Designing the contents

Having the users needs in mind, the contents of the instructions were redesigned. The compliance checklist from the standards was used as a reference (Appendix C). The contents applicable for the chosen contents were organised to cover five key elements: product identification, product specification, preparing the product, operating instructions and health and safety information. The details are as below (Table 19).

Product identification	Brand and type No. of model Date of publication of the handbook Producer/supplier, distributer Address, etc. of producer/ service agency	Falcon Eyes ST-0613T Photo Table ST-0613T The product instructions were redesigned on August 2009 Manufacturer: Falcon Eyes Limited BENEL BV; Nabliudatelnyje Pribory Ltd. Contact details of both manufacturer and distributers
Product specification	Dimensions	130x60cm (back height is 60cm) (words combined with illustrations/animations)
Preparing the product	unpacking Installation and assembly	Parts list (in both words and illustration) Assembly Instructions (words combined with illustrations/animations)
Operating the instructions	Complete for correct intended use	Operation Instructions (words combined with illustrations/animations)
Safety and health information	Warnings	Not suitable for children It is not a chair Keep the instructions for future reference

Table 19: Contents of the revised product instruction.

5.3.3 Planning the communication of written instructions

To communicate successfully, the revised product instructions were written in a clear style and active voice. The instructions were in short sentences and the commands were direct. The written instructions followed the communication process and offered users a continuously improved understanding. Terms, information and communication styles were consistent in all parts of the product information (Figure 53).

- Prepare leg “A(L)”, “A(R)”, “B”x2;
- Use “C” to connect “A”x2 and “Bx2”,; Tighten the knobs.
- Use one “D” to connect A(L)and A(R), another “D” to connect B and “B”.
- Fix ”E” tubes above “A” and “B”.
- Fix two tilting brackets “F” onto the end of “E”; Tighten the knobs.
- Fix two “G” onto the other end of tilting brackets “F”.
- Fix one “H” tube onto the “G”s.
- Fix “I” tubes onto the side of “A” legs.
- Use another “H” to connect the “I” tubes.
- Place the translucent plastic “J” onto the top of the frame.
- Use “K” clips to hold “J” tightly.
- Attach “L” clips to any required position.

A. 50cm Legs	B. 50cm Legs	C. Supporting Rods
D. 55.8 Supporting Rods	E. 60cm Tubes	F. Tilting Brackets
G. 50cm Tubes	H. 60.8cm Back/Front-Side Tube	
I. 10cm Rods	J. Plastic Sheet 170cm x 60cm	
K. Clips	L. C - clamp	

Figure 53: An example of written information.

5.3.4 Producing the visuals

As illustrations are very often more successful than written words in making sense, especially in assembly instructions. Szlichcinski (1984) found factors that affect the comprehension of pictographic instructions. Heiser et al. (2003) suggested some cognitive design principles for visualizations. Also, a research focused on effective step-by-step assembly instructions was carried out (Agrawala et al., 2003). Schumacher (2007) reviewed the other studies and did more up to date research on pictorial assembly instructions. Together, these studies suggested that illustrations in assembly instructions should:

- have clear and explicit order;
- Indicate added parts and the mode of attachment for each step;
- use elevated perspective or isometric projection methods;
- present objects from the depict viewing angles;
- avoid arbitrary change of the viewing angle;
- show parts in gravitationally stable orientations, how it would appear ‘on the bench’ in front of the user;
- show as many important features of the parts as possible;
- show entire object for each step if possible to provide contextual information;

- use line drawings rather than photographs;
- use various line weights for depth perception and 3-dimensional understanding of images ;
- show right amount of details for the best interpretation.

5.3.4.1 3D modelling and rendering

The author used these findings, created a huge amount of illustrations to describe the product, demonstrate the product parts and help to explain the assembling and operating process. To ensure the accuracy of details in illustrations, 3D models of the product were created in Autodesk Maya using the exact proportions (Figure 54).

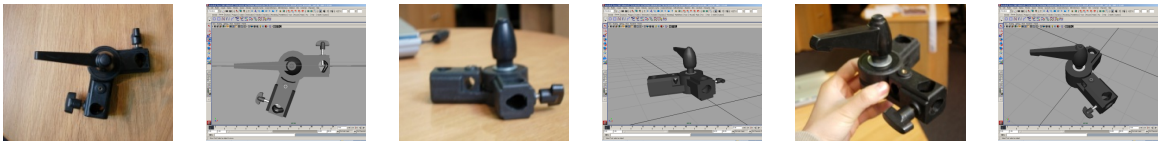


Figure 54: 3D models reflected the real product.

In the 3D model, metal pipes and plastic joints plus clips were assigned with different materials to reflect their real textures and colours. All models were kept simple and basic. The details of product parts were controlled to the minimum level for easy recognition therefore the files were kept small enough to be quickly exported to both still images and animations. In relatively realistic pictures like bitmap images, too many details such as shades and textures would reduce the effectiveness of visual recognition. The 3D models were then rendered as vector images (Figure 55).

Figure 55: Rendered image examples of the product.

The structures and outlines of the product were clearly presented mainly by lines. Main parts could be identified in a very small scale. Also, the product was presented in a consistent viewing angle, just as how it would appear in front of users.

5.3.4.2 Colours and text size

The majority of information was designed in greyscale. Orange colour was used to highlight numbers and some icons (Figure 56). All information was guaranteed to be recognisable when printed out in black and white. Text was designed in black on a white ground to ensure a high colour contrast on both print and digital media. Font sizes varied between titles and body text and they were legible.

Figure 56: Colours used in prototypes.

5.3.4.3 Numbering and highlights

The parts, tasks and steps were organised by numbers and their appearances were designed to be coherent. All essential information was either enlarged or emphasized by colours. For example, the warning message was highlighted with a yellow colour to raise attention (Figure 57).

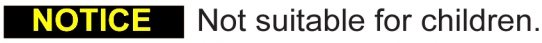


Figure 57: An example of highlighted warning message.

5.4 Redesign of the printed product instruction

The printed instructions followed the tradition of using text and images to make sense. It was printed on double sides of durable paper and the smallest font in the instructions was 10 point, which should be legible for average users.

5.4.1 Producing the instruction

5.4.1.1 Combining illustrations and text

Illustrations and text were combined together to display information and address problems. For example, an illustration of the product was given on the first page of the instructions, to demonstrate the appearance, structure, and organization of the product. General information for the product, for example product name, item number and the manufacturer information were provided next to the illustration. Together, they provided users with an overview of the product (Figure 58).

Figure 58: Combining illustrations and text to display general information.

For the chosen product, all parts were named by letters. It was difficult to describe and differentiate them in written language. When redesigning the parts list, illustrations were adopted to indicate the shapes of different components. Detailed information like length was given in text, underneath the illustrations (Figure 59).

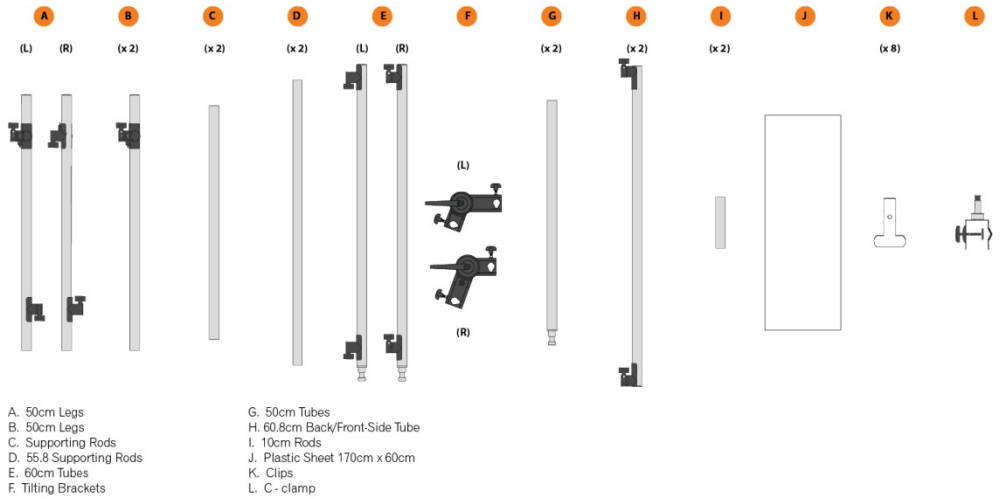


Figure 59: Combining illustrations and text to explain terms.

For the assembling instructions, illustrations were arranged to accompany the re-written instructions and specified assembling procedures (Figure 60).

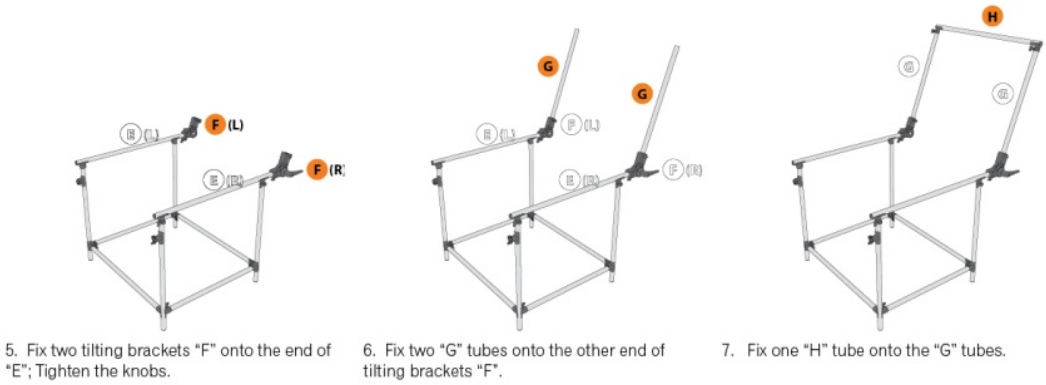


Figure 60: Combining illustrations and text to explain procedures.

The illustrations followed a clear order; the entire object was shown for each step and added parts were indicated, the viewing angle was consistent; features of the parts were shown; 3-dimensional depth of the products was displayed, details were enlarged when necessary.

5.4.1.2 Layout

The instructions were minimised and arranged on an A3 double side print. This was a good size for reading and handling and it also minimised the cost for printing (Figure 61). Main sections were clearly marked to enable users to locate information quickly and read instructions in their own order.

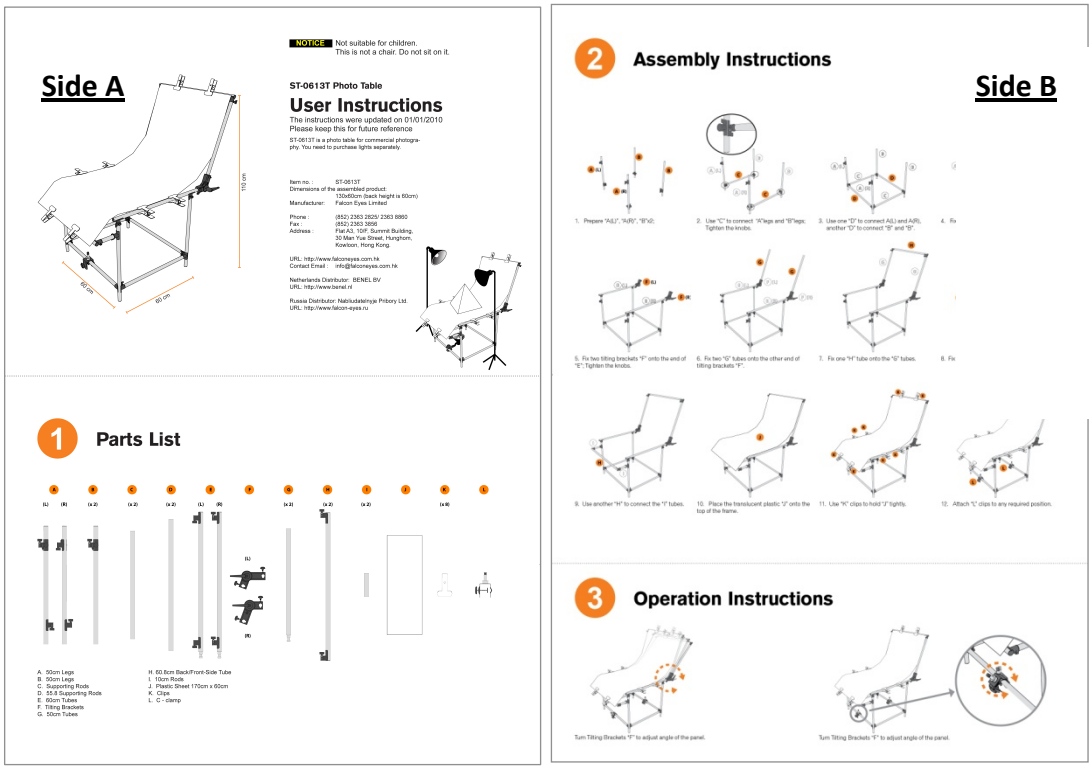


Figure 61: Layout for the redesigned product instruction.

5.4.2 Evaluation based on standards

For the evaluation, the international standard, ISO/IEC GUIDE 37 (1995) was referred to. The same assessment guide used previously for evaluation was followed (Table 20 below). It satisfied all required applicable requirements.

Table 20: Evaluative checklist for the re-designed printed instructions.

Very good	Good	Average, just acceptable	Poor	Very poor	Not applicable/not necessary
++	+	#	-	--	0

Items to be checked	**Evaluation (++/+/#/-/--/0)**	**Comments**
Legibility		
➔On-product information		
◆Type size depending on reading distance	+	All parts are labelled to enable easy
◆Brightness contrast (needs to be more than 70%)	+	assembling. Although this is not part
◆Instructions incorporated in material of product	+	of this investigation.
➔Handbooks, manuals, leaflets		
◆paper quality	+	
◆type size	+	Black type on white high quality

◆line spacing ◆use of different typeface, type size etc. ◆captions easy to read ◆brightness contrast (needs to be more than 70%) ◆use of colours ◆general impression of the page is balanced and uncluttered	+ ++ ++ + + +	paper, legible. Different font size for headings. Clear. Orange for highlights. Yellow for warning messages. Page layout is considered
Electronic media (audio, video, multimedia) ➔Technical equipment ◆minimum configuration ◆"best result" configuration ➔User-friendly system access and easy operation ◆"How to use these instructions" clause ◆linear structure in menu guidance and operating buttons ◆navigation system eases finding answers to user's questions ◆print utility ◆bookmark option ➔User-friendly design ◆general consistency in titling, high-lighting, fonts, text positioning ◆text(spoken and written) corresponds to video animation ◆duration of sequence and information quantity per unit does not stress the user's perception ◆screen design enables the user to pick up necessary information ◆optimal topic length (at most two screens, paragraphs maximum 20 lines long) ◆complex information broken down into smaller categories with secondary windows to subordinate information ◆helpful emphasis by font, font size, highlighting, colour, contrast and graphics ◆language appropriate to target group ◆graphics, animation and video sequences contribute to the understanding ◆the use of colours is consistent and not system dependant	0	
Indications ◆Quality and clarity of information provided to user ◆Explanation of signals	0	
Text and terms ➔Text/use of words ◆simple/meaningful	+ +	 Simple

◆short	+	Short
◆one sentence/ one command	+	One sentence
◆active voice	+	Active voice
◆action verbs	+	Active verbs
➔Term used		
◆abbreviations explained at first occurrence	0	Terms (part number) explained and
◆technical terms defined at first occurrence	+	repeated consistently
◆well explained, understandable for ordinary readers	++	
◆consistent use of terms	++	
➔Structure of text		
◆consistently structured	+	Well structured
◆structure follows communication principles	+	Follows communication principles
◆structure from basic to sophisticated operations/ functions	++	From basic to complicated
◆meaningful separation between basic product and optional modules	++	Separate sections
◆informative headings	++	Clear headings
◆nonsense avoided	+	Avid nonsense
➔Communication principles		
◆encouraging quick reactions (e.g. simple and easy instructions for an emergency)	++	Assembly in steps Makes sense and answer the
◆setting out learning process for complex functions	++	questions
◆answering the questions Where?Who?What?When?How?Why?	+	
Language		
➔Information given in appropriate language(s)	+	Yes, there is only one language
➔Clear differentiation of languages	++	Obvious connections
➔Clear connection between text and illustrations	++	Captions are given
➔Clear pronunciation (audio)	0	
➔Absence of linguistic errors	+	No linguistic error observed
Illustrations		
➔General quality	+	Clear
➔Sufficient number of illustrations for each one to provide clear and specific information	++	Clear illustrations for the whole product, all parts and all steps
➔Illustrations supported by clear and helpful captions	++	Captions are given
Graphic symbols ◆internationally standardized where possible ◆clearly understandable or explained	0	
Figures	0	

◆sized according to purpose ◆clear (i.e. same information –same structure) ◆text within figures clearly arranged and consistently used ◆figures and text that belong together shall appear close to each other		
Tables ◆approximately located ◆clearly set out and informative ◆repeated where necessary	0	
Flow-charts ◆provided where appropriate ◆supported with clear and helpful captions/ text ◆adjacent to the text to which they belong	0	
Use of colours ◆functional ◆clear ◆consistent	 + + ++	The consistent use of black, grey and orange colour is functional and clear
Table of contents/ index ◆appropriate to length and complexity of text ◆headings identical to those in the text ◆clear, consistent and helpful ◆list of keywords if helpful ◆numbered pages	0	The instruction manual is less than four pages long and does not need a index
Trouble- shooting advice ➔Checklist of possible faults with repair instructions(paying due regard to safety) ➔Clear indication whether or not users can attempt repairs themselves	0	It is a simple product and there is no need for trouble shooting
Durability ➔Adequate provision against loss and deterioration in expected (normal) use	 +	 Instructions are printed on durable paper.
Target users ➔Target group is mentioned ➔Representation of contents is suitable for target group	 0 +	 General users Designed to suitable all users
General performance		
◆clearly identify the product;	++	General information is presented. E.g. model no., size…
◆recognise the type of user and his/her capabilities;	++	Designed after users' profile

◆provide all necessary information for correct and safe use of the product;	++	Contents meet pre-analysed possible tasks
◆present warnings about hazards or restrictions effectively;	+	Low danger warning messages presented.
◆provide special handling information, warning notices for particular groups when necessary;	0	
◆give information on the year of manufacture and/or of expiry and warning for products with a limited safe or effective life;	0	
◆be readily available at the point of sale if they are necessary to make a reasoned purchasing decision among products;	0	
◆be consistent with all other material about the same product such as advertising or packaging.	0	

5.4.3 Diagnostic testing

The revised product instructions were tested to identify any problem in use. The participant for this test was male, not in the profession of photography and had not used the product before therefore the participant did not have a mental model for this particular product. During the test, the participant was required to “think aloud”, speak out his thoughts. Two video cameras were used to record the whole process in different positions by catching the participants’ action and voice. The participant was asked to use given instructions to check all parts, assembly the product and adjust the product. The full list of tasks for this round is attached as Appendix D.

5.4.3.1 Dialogue analysis

The recorded dialogue contents were typed down following the time sequence (Table 21). They were categorised depending on which kind of thinking activity they represented. The participant was sometimes quiet, either reading instructions or concentrating on actions. These silences between dialogues were also marked and analysed as physical activities.

Start time	Duration (second)	Thinking activity	Physical activity	Contents
0.00	12	Statement of intention	Reading instructions	If I start off by simply taking the “A” parts, and find those first.
0.12	8		Action	Err…
0.20	5	Considering		B…There suppose to be two "B"s
0.25	4	Solution found		Ah…look, that's B..
0.29	3	Considering		Ahh…Let's see…
0.32	4		Action	Silence
0.36	4	Solution found		That's a "B".
0.40	9		Action	B…Ems……
0.49	1	Solution found		That's a "B".
0.50	7	Statement of intention		Two of those. And there should be two "C"s.
0.57	5	Considering		Which… No . That's doesn't fit these.
1.02	5	Solution found		Err…m. Those are "E"s
1.07	3		Action	And "C"s…
1.10	6	Decision made		In fact, obviously, if they have marked. I can…

Table 21: A data example for the diagnostic testing of printed instructions.

The categories for the dialogue contents included confusion, statement of problems, decision made, solution found, statements of intention, considering, statements of feeling, comments on the product and activities like reading instructions and action. They were marked using different colour codes (Table 22). Physical activities like reading instructions and doing things were marked by blue colours in different tones. Negative thinking processes that involved difficulties and problems were represented by warm oranges. Positive judgments towards some decisions and solutions were drawn in greens and pinks demonstrated the rests. The full coloured data sheet is in Appendix E.

Thinking activities	Time (s)	Physical activities	Time (s)
Confusion	137	Reading instructions	129
Statement of problems	60	Action	876
Decision made	168		
Solution found	207		
Statements of intention	200		
Considering	377		
Statement of feelings	68		
Comments on the product	30		

Table 22: Categories for the recorded dialogue contents.

In general, all tasks were accomplished in 37 minutes and 32seconds (2252 seconds), and all activities were timed individually. Information is presented in figure 62 to indicate time spent on each activity.

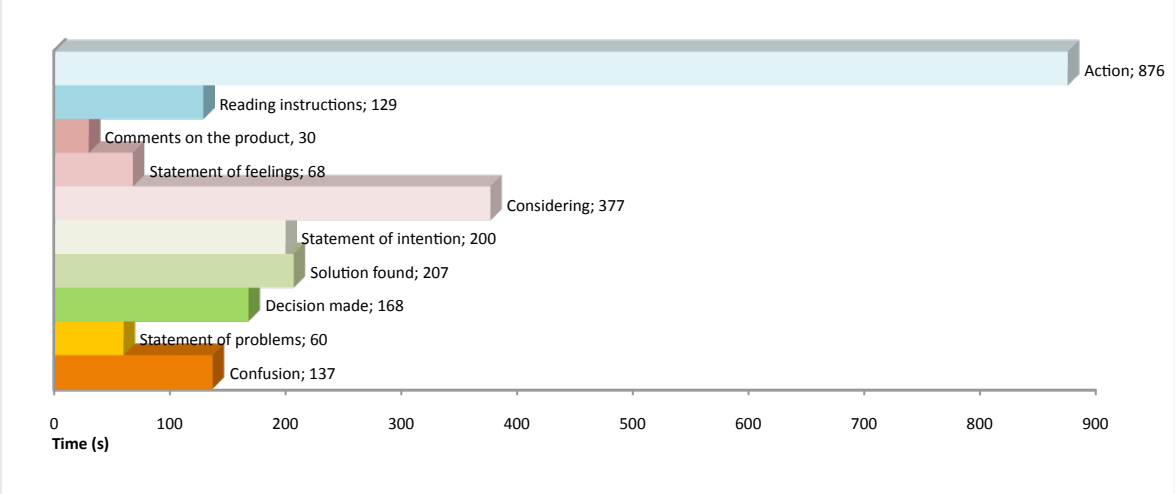


Figure 62: Time has been spent on different thinking and physical activities.

Overall the tasks performed well; a huge amount of time has been taken by the physical actions; a reasonable amount of time was used for considering and making decisions. However, the participant also met several problems. He expressed his confusions for 137 seconds and spent 60 seconds describing the nuisance.

The majority of time has been spent on the assembly process and most struggles have also happened in this stage (Figure 63). By looking at the time span for each task, it was identifiable that task 2.1.2, task 2.2.2 and task 2.3.1 have taken much longer than the other tasks. To identify when did the struggles happened, the expressed confusions and problems were indicated by orange colours. Confusions, represented by a brown orange ■, occurred in the middle of task1, task 2.1.2, task 2.2.2, task 2.2.5, task 2.3.1 and task 2.4.1. Stated problems, presented by bright orange colour ■, occurred during task1, task 2.1.2, task 2.2.4, task 2.3.1 and task 3. The participant did not express any problem for the other tasks (Table 23).

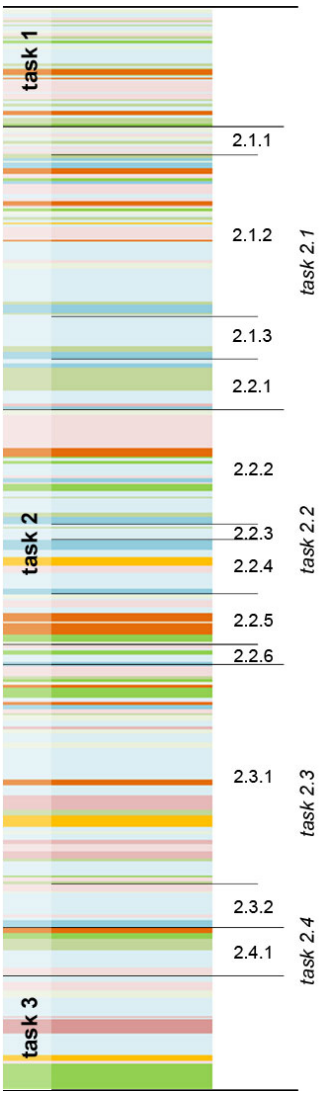


Figure 63: Different activities in all tasks presented by colours.

Task			Confusion	Stated problems	No reported problem
1			■	■	
2	2.1	2.1.1			✓
		2.1.2	■	■	
		2.1.3			✓
	2.2	2.2.1			✓
		2.2.2	■		
		2.2.3			✓
		2.2.4		■	
		2.2.5	■		
		2.2.6			✓
	2.3	2.3.1	■	■	
		2.3.2			✓
	2.4	2.4.1	■		
3				■	✓

Table 23: The distribution of confusion and stated problems.

The confusions and stated problems were listed and analysed to find out the reasons. Some problems could be solved by enhancing the product instructions while some others could not (Table 24).

Task No.	Thinking activity	Duration (s)	Contents	Analysis	Can problems be solved by altering instruction?	Solutions
Task 1	Statement of problems	1	So, I have no "F"s.	The participant could not find the part "F". It was found in 5 seconds.	Has been solved	
Task 1	Confusion	11	And…that's…and .. That's... Is this it? It's… en… is it a "F"? Em?	The participant could not identify the part. It was solved shortly by looking at the on product labels.	Has been solved	
Task 1	Confusion	3	Those are for whatever. I don't know what those are.	The participant could not identify the part. It was solved shortly by using instructions.	Has been solved	
Task 1	Confusion	9	Em. That is says here. According to this, there is only one L, but I've got two.	The instructions did not match the real product.	Yes	Refine the instructions to match the product.
2.1.2	Confusion	12	This is interesting because I am not quite certain whether be like that or…or like that…	The participant could not decide the direction of "A" pipes because the knobs on the pipe look similar. However, this should have been indicated and prepared in the last step.	Yes	Enhance the instructions by enlarging the joints part in the previous illustration.
2.1.2	Confusion	8	Oh,Gosh…oh….em…	The participant could not decide the direction of B pipes.	Yes	
2.1.2	Statement of problems	4	Oh… The wrong way.	The participant fixed A pipes and B pipes in the wrong way.	Yes	
2.1.2	Confusion	2	Oh, god. Err…	The participant was trying to figure out the correct direction of using A pipes and B pipes.	Yes	
2.2.2	Confusion	17	A little bit confused here. Simply because according to this, this part should be out, and therefore…	The participant was confused about which side of bracket "F" should be facing outside. Solutions was found by using instructions.	Yes	Enhance the instructions by adding some aid lines to help users making their judgements.
2.2.4	Statement of problems	19	So… It doesn't specify whether these are… But according to the map,accroding to the plan, it should be another way.	The participant intended to fix the "H" pipe in the wrong direction. The problem was identified by using instructions and the incorrect use of this part was avoid.	Has been solved	
2.2.5	Confusion	19	Now that screw is down and that screw is up. Is that going to cause a problem?	The participant was not sure if there was any potential mistake. This was not a mistake. The product was designed like that. A clear illustration was put in the product instruction. However it could not compensated the product design problem.	Has been solved	
2.2.5	Confusion	24	And if I get a problem, I just wonder why one is up and one is down. If I haven't made a mistake, then, that seems strange why they do and design it in that way.	The participant was confused about whether it was a operation problem or a design problem.	Has been solved	
2.3.1	Confusion	5	Now, which side?	The participant could not decide which side of the plastic "J" should be placed as the up side.	Yes	Add an illustration and text to indicate which side of plastic "J" should face up.
2.3.1	Confusion	5	Ah, hang on… How can I ?	The plastic could not stay on the frame. This was because that the participant has placed the wrong side of the plastic "J" up.	Yes	
2.3.1	Confusion	11	Arh,god. It's a……	The plastic could not stay on the frame.	Yes	
2.3.1	Statement of problems	24	Which way was up? I thought was the…I thought it might be this smooth bit that was to go up, but I was wrong. And think about it logically, I should have noticed this sort of counter that have been… I am not…	The participant could not decide which side of the plastic "J" should be placed as the up side.	Yes	
2.4.1	Confusion	11	What are they for?	The participant did not know the function of the component.	Yes	A brief description of the product can be supplied and a illustration demonstrating the use if the product can be added.
Task 3	Statement of problems	7	I am not going to be able to… look after and clamp it, I am not be able connect it at the bottom.	The plastic was short. It could not reach the top of the frame when the back panel was adjusted to the maximum angle. This was caused by the design deficiencies of the product and can not be compensated by the product instructions.	No	This was a problem caused by the design deficiencies of the product and cannot be compensated by the product instructions.
Task 3	Statement of problems	5	So I've done something wrong and I don't know what it is.	It was a design deficiency of the product but the participant assumed that his operation was incorrect.	No	The task should be removed.

Table 24: Confusions and problems during diagnose testing of the printed instruction.

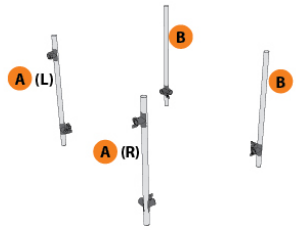
5.4.3.2 Observed errors

Many problems the participant felt and expressed involved subjective judgements of the user. For example, for task 1, task 2.2.4, task 2.2.5 and task 3, the participant described some problems but actually no error has been observed. To study real problems of the product instruction more objectively, the user testing results were analysed again by observing errors during the test.

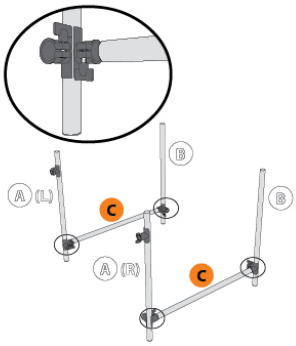
This revealed that majority of the tasks were solved smoothly however two major errors occurred during assembling: C pipes were not connected to the right side of "A" and "B" legs; used the wrong side of plastic sheet "J" to face up. These involved three tasks (Table 25):

Table 25: Observed errors in the diagnostic testing of the printed instruction.

Task	Ideal solution	Acceptable solution	Errors
2.1.1 Preparing A(L)", "A(R)", "B"× 2; 2.1.1.1 -finding A(L) ***2.1.1.2 -positioning A(L)*** 2.1.1.3 -finding A(R) ***2.1.1.4 -positioning A(R)*** 2.1.1.5 -finding "B" × 2 ***2.1.1.6 -positioning "B" × 2***	Right parts face correct directions;		**◆Right parts face wrong directions;**
2.1.2 Connecting "C"× 2 to "A"legs and "B"legs; 2.1.2.1 -finding "C" × 2 2.1.2.2 -positioning "C" × 2 ***2.1.2.3 -connecting first "C" and A(L)*** 2.1.2.4 -tighten the knobs ***2.1.2.5 -connecting first "C" and "B"*** 2.1.2.6 -tighten the knobs ***2.1.2.7 -connecting second "C" and A(R)*** 2.1.2.8 -tighten the knobs ***2.1.2.9 -connecting second "C" and "B"*** 2.1.2.10 -tighten the knobs	◆Right parts are fixed in the right joints; ◆Parts are safely fitted into each other; ◆Knobs are tightened;		**◆Connecting right legs in wrong joints;**
2.3.1 Placing plastic "J" onto the top of the finished frame; 2.3.1.1 -finding "J" ***2.3.1.2 -identifying the upper side of "J"*** 2.3.1.3 -putting the rough side up 2.3.1.4 -placing "J" onto the top of the finished frame	◆Rough side of "J" faces up;		**◆Smooth side of "J" faces up;**



1. Prepare "A(L)", "A(R)", "B"x2;



2. Use "C" to connect "A"legs and "B"legs; Tighten the knobs.

Figure 64: Instructions used for task 2.1.1 and 2.1.2.

When using the instructions (Figure 64), the user was stuck on the operation of task 2.1.1 and 2.1.2. He could not discover which way 'A' legs and 'B' legs should face. More than 5 minutes were spent on experimenting with connecting "C" pipes to the wrong sides of other legs. This error should be avoided by having a clearer indication in the details of the illustrations.

10. Place the translucent plastic "J" onto the top of the frame.

On step 10 of the assembly instructions (Figure 65), it was not clear which side of the plastic sheet should face up. This led the participant to the error on task 2.3.1. Consequently, the rest of the tasks were delayed because the plastic sheet "J" did not stay on top of the frame, as it should have.

Figure 65: Instructions used for task 2.3.1.

5.4.4 Improvements

By combining findings from the dialog analysis and error observations, five major improvements on the redesigned instructions were made:

1. Briefly explain what the product does in the instructions.
   How: A short description of the product was supplied at the beginning of the instructions and an illustration was added to demonstrate how the product should look like when it was in use.
2. Refine the instructions to match the product better.
   How: Altered the number of part “L” in the part list.
3. Clarify direction of ‘A’ legs and ‘B’ legs.
   How: Details for the joints were enlarged in the first illustration of the assembly instructions.
4. Show more hints on the position of brackets “F”s.
   How: Added aid lines to the fifth illustration in the assembly instructions. This should help users making their judgements on the orientation of brackets “F”s.
5. Indicate which side of plastic "J" should face up.
   How: Added illustrations and text in the fifth step of the assembly instructions.

These changes were on the essential part of information, thus they were also applied to the multimedia instruction. After making these changes, the redesigned instructions still would not fix all discovered problems. This was because of design deficiencies in the product itself. Instructions could not and should not compensate for those product insufficiencies. Due to the aim of this investigation being focused on the usability of instructions; the minor confusions caused by the design deficiencies for example the one with task 2.2.5 was ignored.

However, in the operation process (Task 3), the participant discovered bigger product faults like the plastic “J” was short. It could not reach the top of the frame when the back panel was adjusted to the maximum angle. This problem could not be explained by using the instructions and there was not any alternative solution. Therefore, this task should be removed in the final tests of instruction prototypes.

5.5 Creation of multimedia product instructions

Interactive multimedia production instructions were created based on the revised instruction contents, same as that was used in the final printed instructions.

Instead of a linear presentation, information was delivered by re-structured contents. They were re-categorised and designed to be interactive so that users should be able to search and locate information easily.

While dealing with new information, individuals perform better through some senses rather than others, from kinaesthetic practice, visuals or audio, it depends on their intelligence preferences and learning styles. Therefore a combination of different media was selected to encourage the universal usage of instructions.

Main visual elements, for example, the written instructions and illustrations remained the same as they were in the printed instructions. They benefited visual learners who have strong visuo-spatial ability and those who would like to learn through reading. Other media like sound and animations also have been integrated together with images and text to provide more effective guidance for users. Sound was used to help audio learners to receive information quickly or to aid visually impaired users. Animations were added to stimulate the action sequence for the assembly and operation process to enhance users' understanding.

5.5.1 Producing the instruction

5.5.1.1 Information structure

Information in the multimedia instructions was categorised by its function and level of usefulness. Some information for example product ID and warning messages were situated prior to the others (coloured in purple in Figure 66). It was automatically played to raise attention and was repeated later on. The product was previewed in animation so that users could know what should be expected, then a message showed users how to use the instructions.

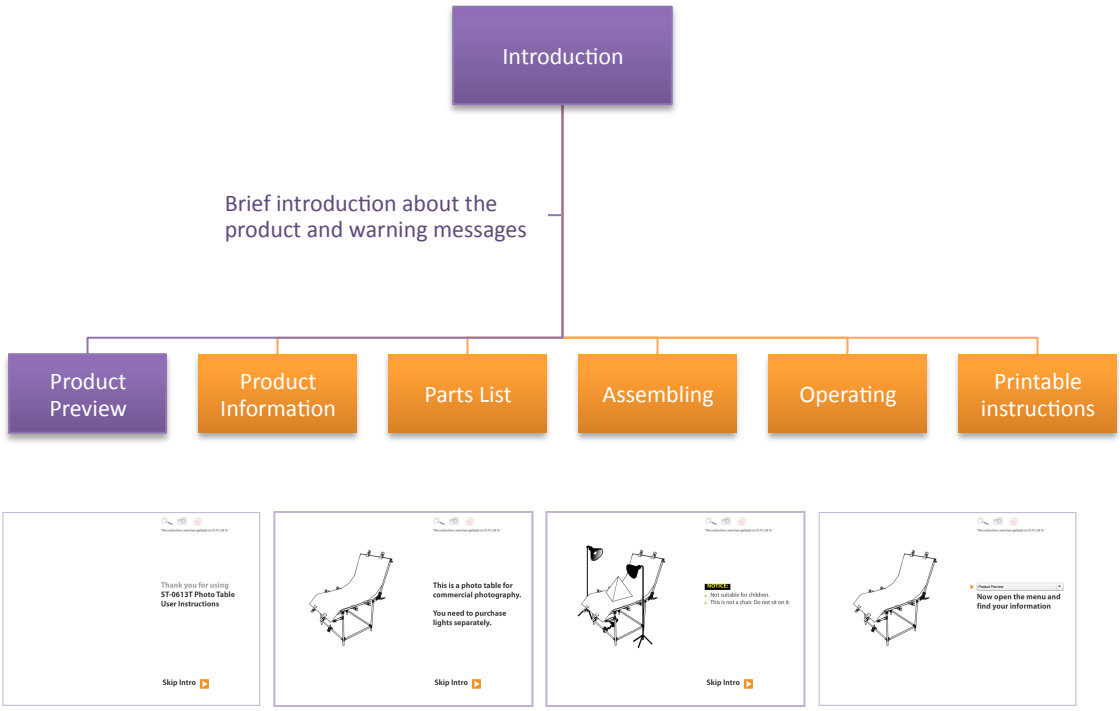


Figure 66: Information structure of the multimedia product instruction.

Figure 67: Choices from the drop down menu.

Other sections such as product information, parts list, assembling, operating and printable instructions were equality important and they were shown as orange in figure 66. There were optional choices on the main page and these could be selected from a drop down menu (Figure 67). Ideally, users should be able to locate any key word through a searching engine. Also users should be able to choose between different languages. The icons for the searching option, audio control and language choices were available permanently and consistently in the top right corner of every page. However, the searching and language functions were not active in the test prototype because the instructions were not long and only tested with one language.

5.5.1.2 Reading order

While going through different sections, users could interact with the contents and customise their own reading order. They could either follow a designed learning process or only pick the information they wanted to know. The assembling section was a typical example for

doing this (Figure 68). In this section, an animation for the overall assembly process was displayed by default; this gave users an overview of what to do. They could also choose to watch the step-by-step animated demonstration in any preferred order at any time.

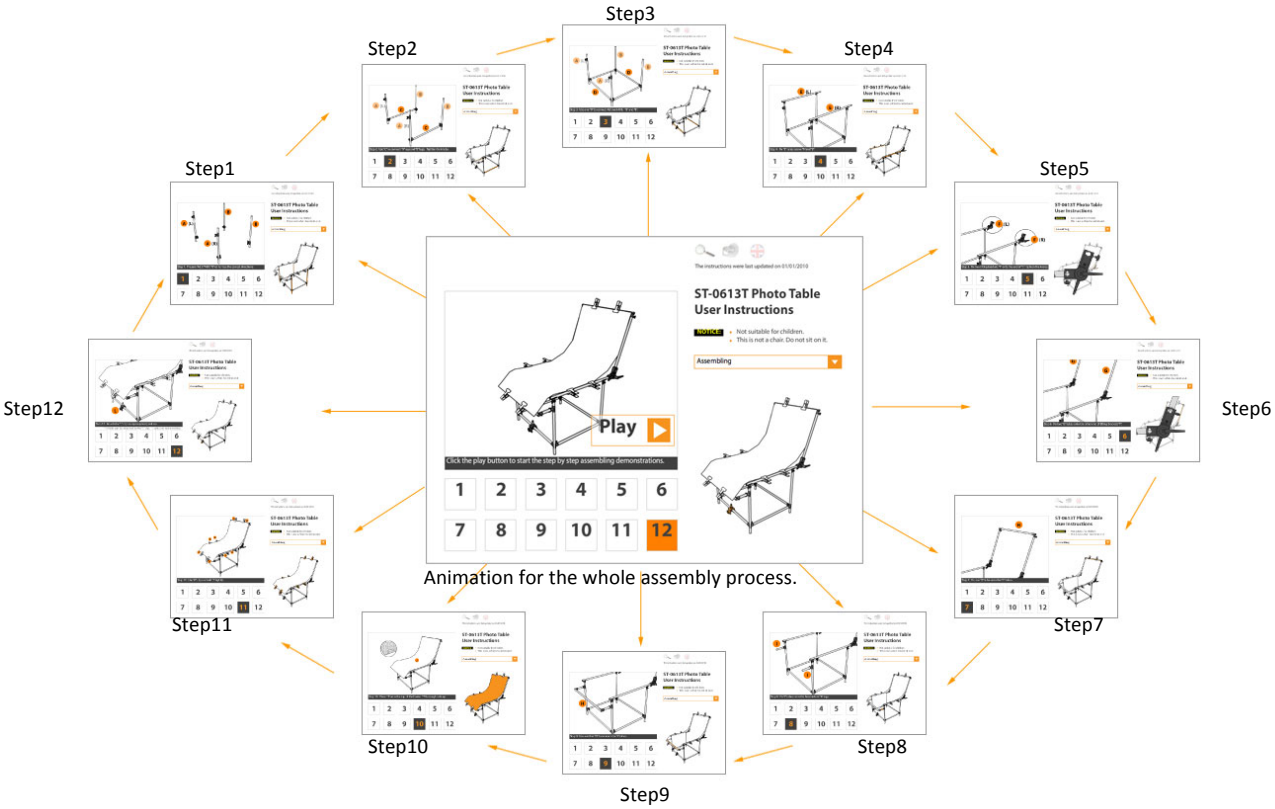


Figure 68: Customise reading order in the Assembling section.

5.5.1.3 Appearance of menus and buttons

As described earlier, the main navigation was designed in the format of a consistent drop down menu. It was in an obvious position, highlighted by an orange outline and an animated arrow. All other buttons for navigation were in either orange colour or big sizes. They responded to mouse actions and were for intuitive use.

5.5.1.4 Audio script

Audio scripts and sound control were added to the instructions. First of all, the majority of the written contents in the product instruction were read out. For example, in the Product Information section, information like item numbers, set up dimensions were explained through both visual and audio means. The sound could be switched off at any time through the sound control buttons. In addition to these written contents, new verbal instructions

were added to guide users interacting with the multimedia instructions (Figure 69). There were short and clear captions, mainly explaining how to use the instructions.

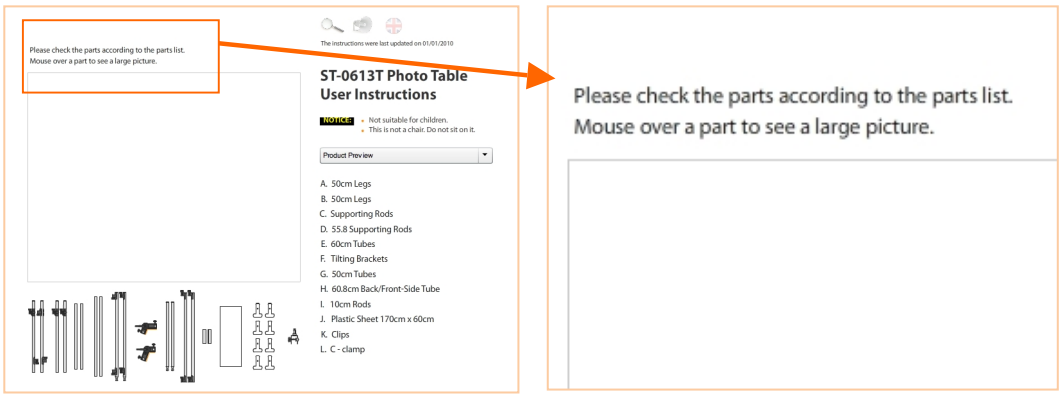


Figure 69: An example of audio aid in the multimedia instruction

5.5.1.5 Animation

Animations were added to 1) give a preview of how the finial product should look like and 2) stimulate assembly and operation processes (Figure 70). The 3D model for the product was animated and rendered from the same perspective view, with the same appearance as was used in the printed product instructions. This was to ensure that the quality of visual elements between the printed product instructions and multimedia instructions was similar.

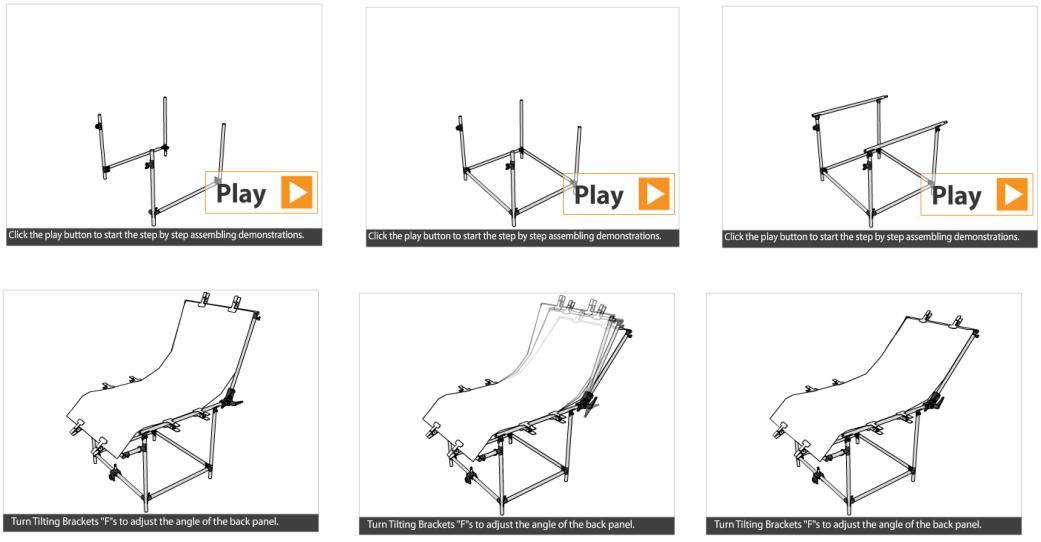


Figure 70: Examples of animations in the multimedia instruction

5.5.2 Evaluation based on standards

Again, the multimedia instructions were evaluated by the assessment guides. Many parts

were kept as they were in the printed instructions (marked as grey in table 26) and the different bits are in black (Table 28). It was easy to use the guides to check the quality of contents, text and illustrations.

Table 26: Evaluative checklist for the multimedia instructions.

Very good	Good	Average, just acceptable	Poor	Very poor	Not applicable/not necessary
++	+	#	-	--	0

Items to be checked	Evaluation (++/+/#/-/--/0)	Comments
Legibility		
➔On-product information		
◆Type size depending on reading distance	+	All parts are labelled to enable easy
◆Brightness contrast (needs to be more than 70%)	+	assembling. Although this is not part
◆Instructions incorporated in material of product	+	of this investigation.
➔Handbooks, manuals, leaflets		
◆paper quality	+	
◆type size	+	Black type on white background,
◆line spacing	+	legible. Different font size for
◆use of different typeface, type size etc.	++	headings.
◆captions easy to read	++	Clear. Orange for highlights. Yellow
◆brightness contrast (needs to be more than 70%)	+	for warning messages. Amount of
◆use of colours	+	information on each screen is
◆general impression of the page is balanced and uncluttered	+	designed. Page layout is considered
Electronic media (audio, video, multimedia)		
➔Technical equipment	0	
◆minimum configuration		
◆"best result" configuration		
➔User-friendly system access and easy operation		
◆"How to use these instructions" clause	+	Included
◆linear structure in menu guidance and operating buttons	+	Included
◆navigation system eases finding answers to user's questions	+	Simple navigation
◆print utility	+	Included
◆bookmark option	-	Not included as it is a stand alone
➔User-friendly design		prototype file
◆general consistency in titling, high-lighting, fonts, text positioning	++	Consistent
◆text(spoken and written) corresponds to video animation	++	Included

◆duration of sequence and information quantity per unit does not stress the user's perception	+	Minimum information in each section
◆screen design enables the user to pick up necessary information	+	Navigation and highlights are used Audio is added
◆optimal topic length (at most two screens, paragraphs maximum 20 lines long)	++	All text was short and kept minimum.
◆complex information broken down into smaller categories with secondary windows to subordinate information	+	Considered
◆helpful emphasis by font, font size, highlighting, colour, contrast and graphics	++	Included
◆language appropriate to target group	+	Only language, English is used for the prototype
◆graphics, animation and video sequences contribute to the understanding	+	Understandable
◆the use of colours is consistent and not system dependant	+	Consistent
Indications	0	
Text and terms		
➔Text/use of words		
◆simple/meaningful	+	Simple
◆short	+	Short
◆one sentence/ one command	+	One sentence
◆active voice	+	Active voice
◆action verbs	+	Active verbs
➔Term used		
◆abbreviations explained at first occurrence	0	Terms (part number) explained and
◆technical terms defined at first occurrence	+	repeated consistently
◆well explained, understandable for ordinary readers	++	
◆consistent use of terms	++	
➔Structure of text		
◆consistently structured	+	Well structured
◆structure follows communication principles	+	Follows communication principles
◆structure from basic to sophisticated operations/ functions	++	From basic to complicated when read in linear order and can be read in customised order
◆meaningful separation between basic product and optional modules	++	Separate sections
◆informative headings	++	Clear headings
◆nonsense avoided	+	Avid nonsense

➔Communication principles ◆encouraging quick reactions (e.g. simple and easy instructions for an emergency)	++	Interactive, flexible reading order
◆setting out learning process for complex functions	++	Assemble process is shown in steps, can also be used in any order
◆answering the questions Where?Who?What?When?How?Why?	+	Answer the questions
Language ➔Information given in appropriate language(s)	+	There is only one language available in the prototype and language options could be provided
➔Clear differentiation of languages	++	Clear connections
➔Clear connection between text and illustrations	++	Captions are given
➔Clear pronunciation (audio)	++	Clear
➔Absence of linguistic errors	+	No linguistic error observed
Illustrations ➔General quality	+	Clear
➔Sufficient number of illustrations for each one to provide clear and specific information	++	Clear illustrations for the whole product, all parts and all steps
➔Illustrations supported by clear and helpful captions	++	Both audio and written captions are given
Graphic symbols	0	
Figures	0	
Tables	0	
Flow-charts	0	
Use of colours ◆functional	+	The consistent use of black, grey and orange colour is functional and clear
◆clear	+	
◆consistent	++	
Table of contents/ index ◆appropriate to length and complexity of text	+	There is no content or index page. A consistent drop down manual with a section list is available. It is not possible to number interactive (none linear) pages but section names are give.
◆headings identical to those in the text	+	
◆clear, consistent and helpful	+	
◆list of keywords if helpful	+	
◆numbered pages	0	
Trouble- shooting advice ➔Checklist of possible faults with repair instructions(paying due regard to safety)	0	It is a simple product and there is no need for trouble shooting

➔Clear indication whether or not users can attempt repairs themselves		
Durability ➔Adequate provision against loss and deterioration in expected (normal) use	++	Instructions are digital
Target users ➔Target group is mentioned ➔Representation of contents is suitable for target group	 0 +	 General users Designed to suitable all users
General performance		
◆clearly identify the product;	++	General information is presented. E.g. model no., size…
◆recognise the type of user and his/her capabilities;	++	Designed after users' profile
◆provide all necessary information for correct and safe use of the product;	++	Contents meet pre-analysed possible tasks
◆present warnings about hazards or restrictions effectively;	+	Low danger warning messages presented.
◆provide special handling information, warning notices for particular groups when necessary;	0	
◆give information on the year of manufacture and/or of expiry and warning for products with a limited safe or effective life;	0	
◆be readily available at the point of sale if they are necessary to make a reasoned purchasing decision among products;	0	
◆be consistent with all other material about the same product such as advertising or packaging.	0	

5.5.3 Diagnostic testing

In this diagnostic test, all components of the product were given to the participant and the multimedia product instructions were provided on a laptop computer. The computer and mouse were cordless and portable so that the participant could reposition the devices for more convenient use.

In the diagnostic test with the revised printed instructions, it was concluded that one of the test tasks involved a problem that caused by the product design deficiencies. It was replaced by a new task to identify design problems with instructions. The main goal for the participant was to refer to the given instructions and assemble the lighting table. To achieve this, the participant was asked to use given instructions to find some product information, check all

parts and assemble the product. The full list of tasks for this round is attached as Appendix F.

5.5.3.1 Dialogue analysis

After the participant had used the multimedia instructions, dialogue contents in the recorded videos were typed down following the time sequence (Appendix G). Consequently, by analysing the dialogues, thinking activities and physical actives were identified and classified into different catalogues. The time for each activity was calculated and presented in seconds (Figure 71).

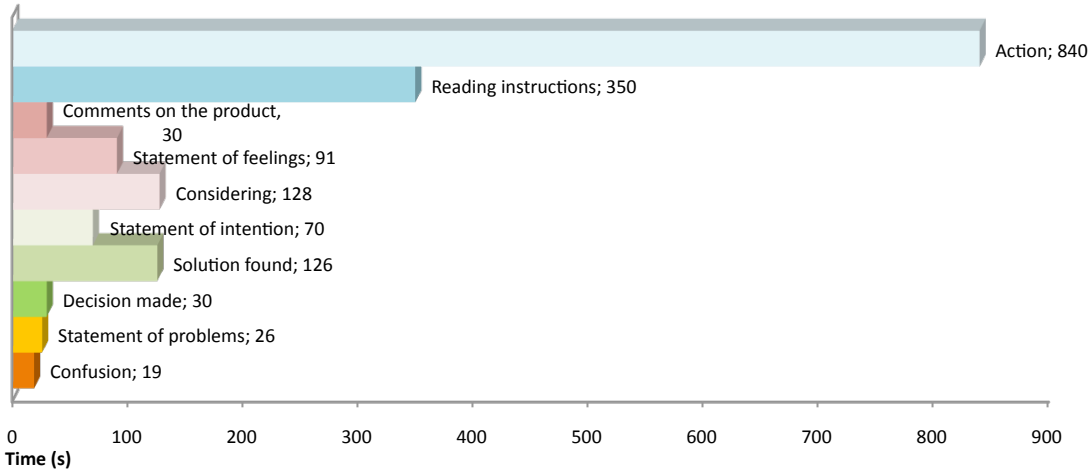


Figure 71: Time has been spent on different thinking and physical activities (multimedia instructions).

The total time used for completing all tasks was 28 minutes and 30 seconds (equals to 1710 seconds) by using multimedia instructions. Nearly half of the entire period (840 seconds) was spent on physical actions. There were still confusions for the tasks but the timing for these negative responses was relatively low (Table 27 below).

Thinking activities	**Time (s)**	**Physical activities**	**Time (s)**
Confusion	19	Reading instructions	350
Statement of problems	26	Action	840
Decision made	30		
Solution found	126		
Statements of intention	70		
Considering	128		

Statement of feelings	91		
Comments on the product	30		

Table 27: Comparison of timing for each activity category when testing using multimedia instructions.

Physical activities were presented by blue colours, positive judgements towards decisions and solutions were presented in greens and negative thinking processes which involve difficulties and confusions were presented by warm colours, yellow or orange (Figure 72). The majority of time had been spent on task 3, assembling the product and this was also the stage where most problems occurred. For example, the time spans for task 3.2.1, task 3.2.2 and task 3.3.2 were much longer than the others and there were negative responses involved in these steps. To clarify details of where the problems were, coloured square icons were used in the following table (Table 28) to indicate confusions and stated problems:

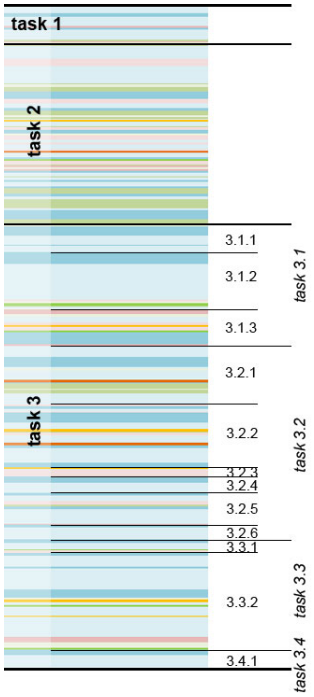


Figure 72: Different activities in all tasks presented by colours.

Task No.			Confusion	Stated problems	No reported problem
1					✓
2			■	■	
3	3.1	3.1.1			✓
		3.1.2			✓
		3.1.3		■	
	3.2	3.2.1	■		
		3.2.2	■	■	
		3.2.3		■	
		3.2.4			✓
		3.2.5			✓
		3.2.6			✓
	3.3	3.3.1			✓
		3.3.2		■	

Table 28: The distribution of confusion and stated problems.

The negative expressions from the participant like the confusions and problems were listed and analysed (Table 29). These subjective expressions from the participant explained what problems he had been feeling. By using instructions, some of them (Task 2 and 3.1.3) were discovered to be misunderstandings and some of the real problems in Task 3.2.2 were solved.

Tasks No.	Thinking activity	Time (s)	Contents	Analysis	Can problems be solved by altering instruction?	Solutions
Task 2	Statement of problems	4	There should be another one… like that.	The participant could not find the part "A(R)". It was found in 4 seconds.	Has been solved	
Task 2	Confusion	5	So, why was that? Have I miss something in it?	The participant could not find one of the part "B". It was found in 5 seconds.	Has been solved	
Task 3.1.3	Statement of problems	4	Obviously I have made a mistake.	The participant assumed that “A” pipes were fitted in incorrect positions. However, he proved them to be right after checking instructions.	Has been solved	
Task 3.2.1	Confusion	6	Ah! Why wouldn't I be able to…Where was those two?	The participant was trying to figure out the correct direction of using A pipes and B pipes.	Yes	The illustrations for pipe ends should be further enlarged for easy checking.
Task 3.2.2	Statement of problems	6	Ah, this is left right.	The participant fixed the "F(L)" part in the position for "F(R)" part. The problem was identified by using instructions and on product labels.	Has been solved	
Task 3.2.2	Confusion	8	Em… I would expect that to be...	The participant intended to fix the two brackets "F" in the wrong direction. The problem was identified and solved by using instructions.	Has been solved	
Task 3.2.3	Statement of problems	4	The biggest problem I got was - have to move backwards and forwards.	The participant had to move backwards and forwards to read instructions on screen and take some actions. The instructions were displayed on a portable laptop computer. Therefore this could be avoid by taking the computer and place it closer to the product parts.	No	The tested participant was not familiar with the digital device. The situation varies depend on how much each user is accustomed to different devices. Also, this problem would not occur if the product instructions were displayed on smaller and more portable devices for example smart phones.
Task 3.3.2	Statement of problems	6	These are bit... It doesn't seem to say any particularly. So …	The participant was trying to find out which side of clip “K” should face up.	Yes	This can be solved by slightly enlarge the illustrations for this part. However, this does not influence the use of the product. Either side of a “K” clip could face up.
Task 3.3.2	Statement of problems	2	It's a bit awkward.	The plastic “J” was left too long at the bottom of the frame at cannot be clipped on. This was partly caused by the design deficiencies of the product however can be solved by clarify the assembling order in the product instructions.	Yes	The instructions could show that the “K” clips on top should be fixed first. Then the plastic “J” should be adjusted to catch the bottom of the frame. Although this cannot fully cover the design deficiencies of the product, it should improve the results.

Table 29: The analysis of confusions and problems in the diagnose test for the multimedia instructions.

5.5.3.2 Observed errors

The dialogue analysis showed that participant was confused at some stages, for example when he was trying to complete Task 3.2.2 and Task 3.3.2, problems and confusions were pointed out. To study real problems of the product instruction more objectively, the user test results were analysed again by reviewing the video, checking times for each task and observing errors during the test (Table 30).

Task	Ideal solution	Acceptable solution	Error
3.2.2 Fixing "F" × 2 onto "E" × 2; 3.2.2.1 -finding "F(L)" 3.2.2.2 -finding "F(R)" 3.2.2.3 -positioning "F(L)" *3.2.2.4 -positioning "F(R)"* 3.2.2.5 -fixing "F(L)" onto the end of"E(L)" 3.2.2.6 -tighten the knobs *3.2.2.7 -fixing "F(R)" onto the end of"E(R)"* 3.2.2.8 -tighten the knobs	◆Right parts are fixed safely; ◆Handles on "F" × 2 face out; ◆Both shorter sides of "F" × 2 are connected to "E" × 2; ◆Knobs are tightened;	◆Handles on "F" × 2 face out; ◆Both longer sides of "F" × 2 are connected to "E" × 2;	◆ One longer side and one shorter side of "F" × 2 are connected to "E" × 2; **(Corrected by the user)**

Table 30: An example of observed errors in the diagnostic testing of the multimedia instruction.

Though the observation, one error was found out while the participant was carrying out Task 3.2.2, when an "F" bracket was fixed onto the opposite side at the beginning. The error was identified and corrected by the user himself after checking against the instructions. This showed that the product instructions explained the operation process but they could be clearer and more effective in terms of preventing misuse of the product.

For some other tasks, for example Task 3.3.2, where the participant pointed out a few problems, the time span was observably longer than others. However, no error was discovered in the process of finishing it.

Overall, the multimedia product instructions performed well and no major mistake was discovered. This meant that firstly, the rearrangement of tasks had avoided showing deficiencies in the design of the product. Secondly, the improvements of contents based on findings from the diagnostic test on printed instructions had effectively prevented some foreseen misuse of the product. Still, improvements could be carried out to reduce users

confusions therefore shorten the time for some tasks, for example task 3.2.2 and task 3.2.2.

5.5.4 Improvements

By combining findings from both the dialogue analysis and error analysis, three improvements on the multimedia instructions were made:

1. Clarify direction of 'A' legs and 'B' legs.
   How: For 'step 1' in the 'assembly' section, pipe ends in the illustrations were enlarged for easy viewing on mouse over.
2. Show more hints on the position of brackets "F".
   How: On 'step 5' in the 'assembly' section, enlarged illustrations of two "F" brackets were shown on mouse over; aid lines were added to help users making their judgements on the position of brackets "F".
3. Show the order for attaching "K" clips.
   How: On 'step 11' in the 'assembly' section, edited the animation to show that the "K" clips on top should be fixed first, then the bottom ones. "K" clips for the sides were fixed at the end.
4. Indicate which side of clip "K" should face up.
   How: Enlarged illustrations slightly to show the sides. This did not influence the usage of the product therefore the adjustment was minor.

After improvements, both prototypes of printed instructions and multimedia instructions were ready for user testing.

Chapter 6. Testing Prototypes

Both printed and multimedia instructions were tested on the same tasks through the same procedure. The tested tasks were carefully planned and analysed using Hierarchical task analysis (HTA) method then the testing procedure was planned and samples were carefully selected. Each test started by introducing the project plus the testing procedures briefly to a participant. This was followed by a background questionnaire, which was aimed at investigating the participant's profile. After a detailed explanation of what the tasks were and what a participant should do, the main part, the performance test on product instructions was carried out. Finally, each test finished with a brief interview to gather individual thoughts.

6.1 Task analysis

In this stage of the investigation, a practical framework for this task analysis, Hierarchical task analysis (HTA) was employed. It engaged activities including: "appraising the problem, collecting information, organising information and representing the task, modelling behaviour, suggesting solutions " (Wilson & Corleet, 2005, p136). By using HTA, the main goal was expressed as three sub-goals (Figure 73), which were also described as tasks to the participants. Tasks were then broken down to detail actions for further analysis. Ideal solutions and acceptable alternative solutions were given (Appendix H).

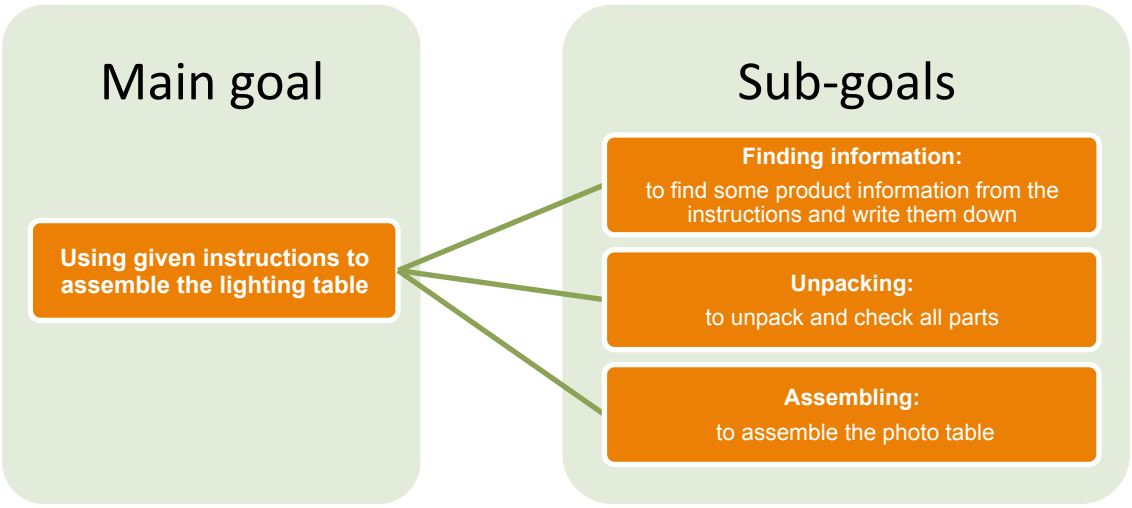


Figure 73: The main goal and sub-goals of user testing.

6.2 Participant profile

For the testing, participants were carefully selected and put into two groups: Digital Natives and Digital Immigrants. Initially, there were 26 participants involved; 14 of them were over 32 years old and 12 were under 32 years old. The younger participants were potential Digital Natives. However, this evidence was not strong enough to suggest group categories. As discussed in earlier chapters (2.5), the age of the oldest Digital Natives could vary between different countries and areas depending on the development of digital technologies in that area; age was not necessarily the only and best criteria to judge if a person is a Digital Native or a Digital Immigrant. Thus Questionnaire (C) was used to discover more participant information and characteristics. A scoring system was involved and the results were used to decide the allocation of participant groups.

6.2.1 Designing the background questionnaire

A questionnaire 'Are you a digital native?' was designed to gather basic information about the participants. The information was useful to identify if the participant was a Digital Native, or how many Digital Native characteristics the participant had, depending on findings from literature (Table 31).

Table 31: Designing questions in Questionnaire (C).

1. Did the participant grow up with digital technology?		
Age?		Q15
When was your first time to use a computer?		Q5
Have you ever played any video game/online game when you were little?		Q6
2. How many Digital Native characteristics did the participant have?		
freedom	Do you prefer to watching TV programmes on TV or online?	Q7
	Do you check product features and prices online very often/ regularly?	Q4
customization	Do you personalise your ringtone?	Q3
collaboration	Do you use online networks for example FaceBook?	Q1
Entertainment	Do you play video games/online games?	Q2
speed	When expecting a quick reply from a friend, what do you prefer to use?	Q9
innovation	Do you always wish to use the latest product or innovation?	Q8

Learning habits	Reading order When you read, do you always start from the beginning and follow the right order? Visual experts Which element do you read first? Title or image or text in the first line? Multi-tasking Do you chat, browse web pages and listen to music at the same time? Switching attentions When using a computer, how many windows/programmes would you have open at the same time?	 Q11 Q10 Q13 Q12
Capability	Does the participant feel comfortable with digital devices?	Q14

Participants were asked to answer the questionnaire with assistance before testing the product instructions therefore introductions for example, who the author was, her name, course etc. were introduced verbally. The assurance of confidentiality was included at the beginning of the questionnaire and a short closing statement was included. Thank you information and an illustration was added to the end. All questions were shuffled to ensure that the first few questions were very easy to answer and difficult questions were located in the middle. The final questionnaire involved 14 single-choice question items plus two open questions. Each question echoed one aspect of a key factor (Table 32).

1. Did the participant grow up with digital technology?		
Q5	10%	
Q6	10%	
2. How many Digital Native characteristics did the participant have?		
Collaboration	Q1	10%
Entertainment	Q2	10%
Customisation	Q3	10%
Freedom	Q4, Q7	10%
Innovation	Q8	10%
Speed	Q9	10%
Learning habits	Q10, Q11, Q12, Q13	10%
Attitude	Q14	10%

Table 32: Two key questions in Questionnaire (C).

The first key question was to find out if a participant had been exposed to digital technology during an early age, which should indicate if a participant was a Digital Native. It was the

essential and main consideration to make the judgement for allocating groups, weighted 20% of the whole 100% score. A participant who scored 20 for this key question was categorised as a Digital Native with no doubt. One who achieved 0 for this part was considered as a very typical Digital Immigrant. Those who achieved 10 were Digital Immigrants with some digital influences. Then the second key question was used to investigate how many of "Digital Native Characteristics" a participant had, according to suggestions from literature. This was used to achieve a clearer view of the background and behaviour of participants. It consisted of another 12 questions, which accounted for 80% out of the total score of 100.

6.2.2 Did the participant grow up with digital technology?

Two main criteria were used on this key question: question 5 and question 6. Each of them weighted 10% of total 100 scores (Table 33).

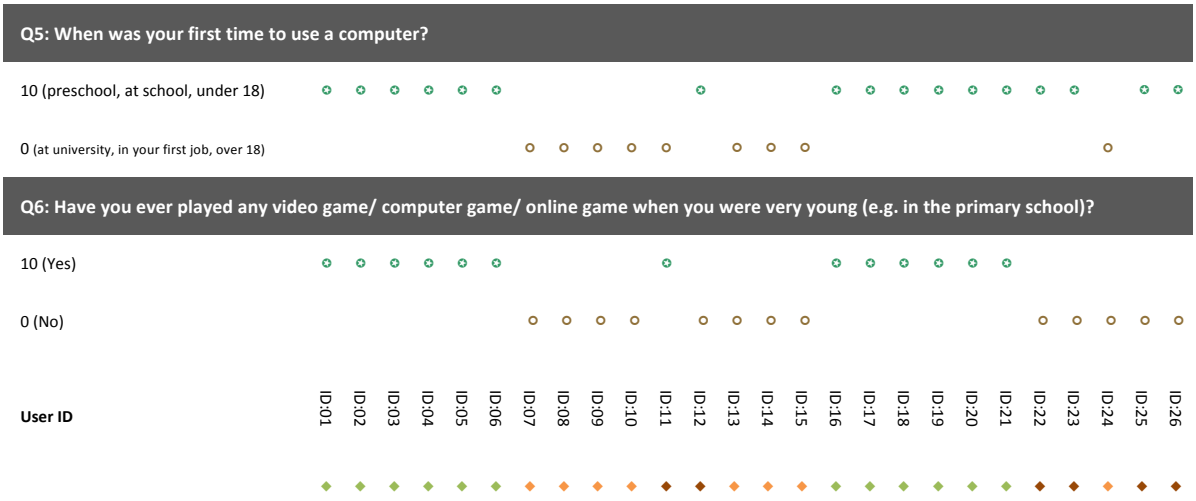


Table 33: Results for Q5 and Q6 from Questionnaire (C).

The result showed that all young participants between age 22 and 27 had been exposed to digital or interactive technologies at a very young age and achieved 20% scores (Figure 74). They reflected findings from the literature review and were classified as Digital Natives (◆).

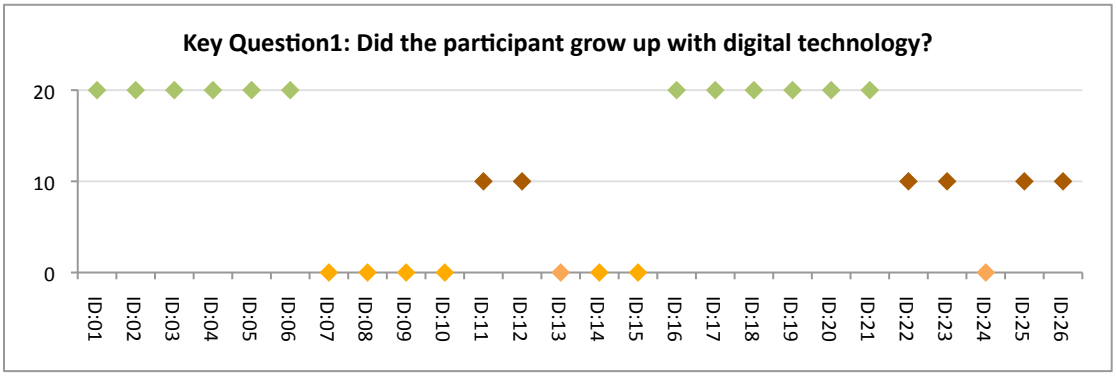


Figure 74: Did the participant grow up with technology?

Among other people aged between 36 and 60, 8 of them were typical Digital Immigrants (◆) by scoring 0. The rest 5 participants (◆) achieved 10 points by learning computers at school but none of them were exposed to other interactive digital media/devices for example video games when they were very young. Together, they were all categorised as Digital Immigrants.

6.2.3 How many Digital Native characteristics did the participant have?

The Digital Native's characteristics consisted, according to literature, of eight aspects: Collaboration, Entertainment, Customisation, Freedom, Innovation, Speed, Learning habits, Attitude and each of them were represented by a few questions.

6.2.3.1 Collaboration Q1 10%

6.2.3.1.1 Q1: Do you have an account with online social networks (e.g. FaceBook) that you maintain regularly?

Answer: □ Yes (10) □ No (0)

Figure 75: Collaboration - Q1.

All Digital Natives had a regular maintained social network account and less than half of Digital Immigrant participants did so.

6.2.3.2 Entertainment Q2 10%

6.2.3.2.1 Q2: Do you play video games/computer games/online games/games on mobile phones more than once a month?

Answer: □ Yes (10) □ No (0)

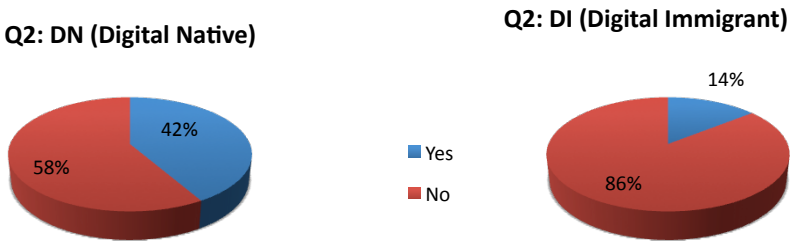


Figure 76: Entertainment – Q2.

For this question, Digital Natives (42%) were obviously more into interactive games than the digital immigrants (14%). But still, the percentage was relatively low, in comparison to what was expected from the literature.

6.2.3.3 Customisation Q3 10%

6.2.3.3.1 Q3: Do you personalise your ringtone (e.g. download or make your own)?

Answer: □ Yes (10) □ No (0)

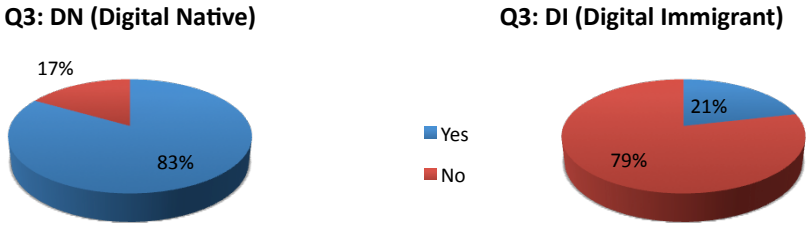


Figure 77: Customisation – Q3.

The majority of Digital Natives liked to customise their own ringtones, while the Digital Immigrants did not. The characteristics of the two groups of participants were clearly distinctive for this question.

6.2.3.4 Freedom Q4, Q7 10%

6.2.3.4.1 Q4: If you are planning to buy a new product, do you check product features and prices online before you buy?

Answer: □ Yes (3) □ No (0) □ Sometime (2)

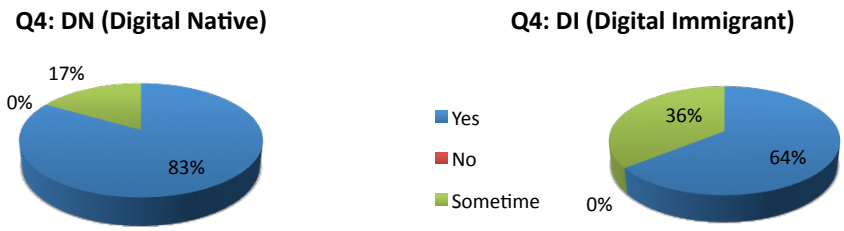


Figure 78: Freedom – Q4.

Participants in both groups tended to check online before buying a product, which indicated that the internet had played an important role in the purchasing process, not only for Digital Natives, but also Digital Immigrants and online product information certainly could be reached by majority users.

6.2.3.4.2 Q7 : Which do you prefer? Watch programmes on TV or Watch TV programmes online?

Answer: □ Watch programmes on TV (0) □ Watch TV programmes online (5)

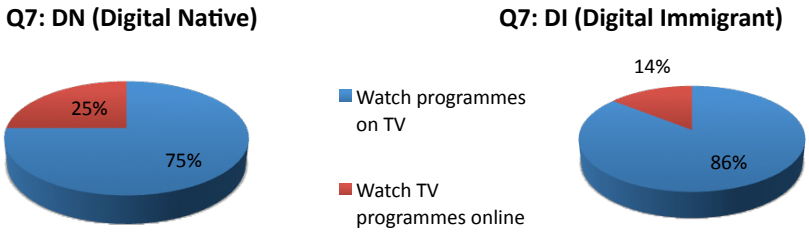


Figure 79: Freedom – Q7.

Although it offered more freedom for users to watch TV programms online rather than on TV sets, the numbers of people who prefer this method was low in both groups and the difference between the two groups was little.

6.2.3.5 Innovation Q8 10%

Q8: Do you always wish to use the latest product or innovation (Game console, software, digital reader etc.)?

Answer: □ Yes (10) □ No (0)

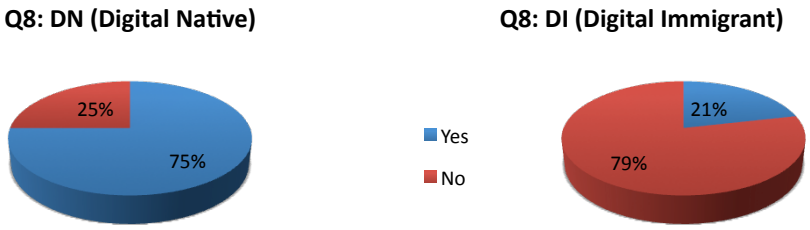


Figure 80: Innovation – Q8.

Digital Natives (75%) had strong wishes to try new products or inventions while the Digital Immigrants were not so keen. However, to be curious and peruse the newest trend is part of nature when people are young therefore it was not necessarily determined by their digital training when they were little.

6.2.3.6 Speed Q9 10%

Q9: When expecting a quick reply from a friend, what do you prefer to use?

Answer: □ Email (0) □ Instant Message (10)

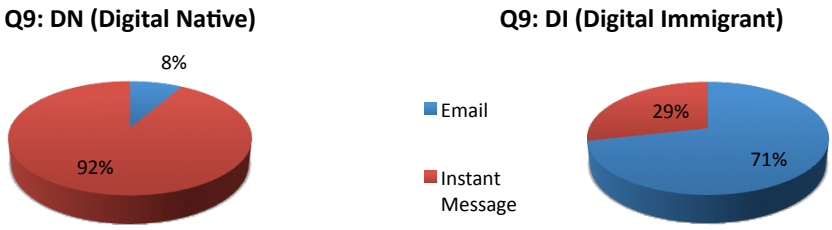


Figure 81: Speed – Q9.

Digital Natives liked to get response quickly and speed was essential for them. This characteristic was strongly represented by the answers to question 9. They prefered contact with others instanty and they rarely bother to wait for replies from emails (Figure 81). The majority (71%) of Digital Immigrants were completely on the opposite. They would prefer to use slower methods, which was by sending emails.

6.2.3.7 Learning habits Q10, Q11, Q12, Q13 10%

6.2.3.7.1 Visual experts

Q10: Which element do you read first?

Answer: □ Title(0) □ Text in the first line (0) □ Image (2)

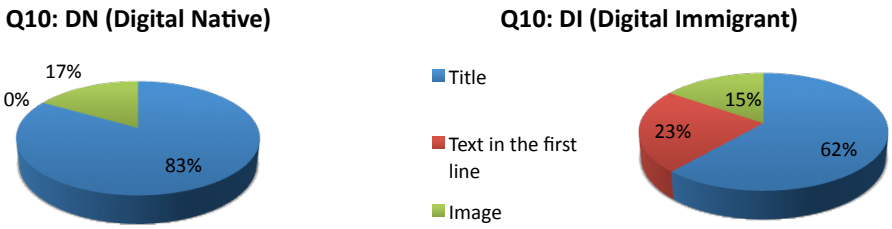


Figure 82: Learning habits – Q10.

The result showed that Digital Natives had more agreement on this question than the Digital Immigrants. Although in the literature, it was suggested that most Digital Natives were visual learners, there were only 17% of participants chose "image" as their answer and the vast majority of them picked "title". The author believed that by altering the size and position of images and the title, the number of answers for these two options could be different. Still, regardless of sizes and position of images and title, 23% of digital immigrants, read text in the first line before any other visual elements.

6.2.3.7.2 Reading order

Q11: When you read a news article, do you always start from the beginning and follow the right order?

Answer: □ Always(0) □ Normally (1) □ No (2)

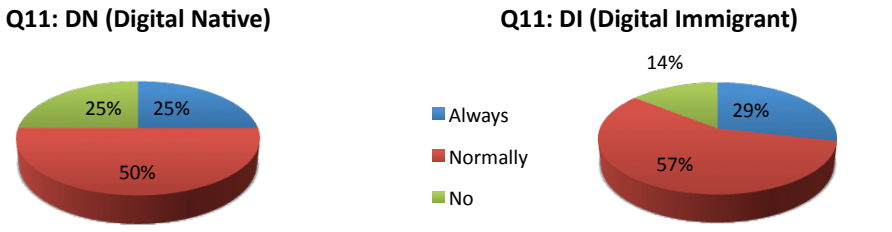


Figure 83: Learning habits – Q11.

Most participants tended to read articles following the present reading order. More Digital

Natives (25%) tended to break the order than Digital Immigrants (14%). The difference was visible but not great enough to make suggestions.

6.2.3.7.3 Switching attention

Q12: When using a computer, how many windows/programmes would you normally have open at the same time?

Answer: □ <5(0) □ 5-10(1) □ >10 (2)

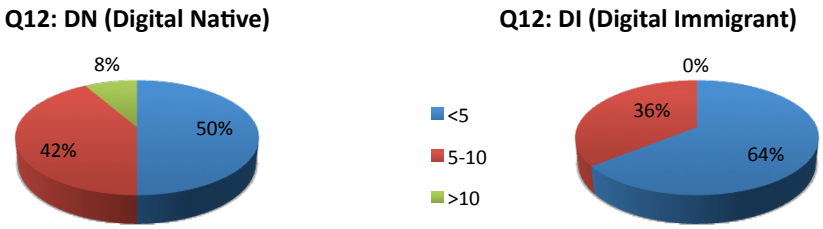


Figure 84: Learning habits – Q12.

The answers for this question depended on the individual's ability and habits but as a group, Digital Natives tended to have more windows/programmes open and switch attention between them.

6.2.3.7.4 Multitasking

Q13: Do you chat, browse web pages and listen to music at the same time?

Answer: □ Yes (2) □ No (0)

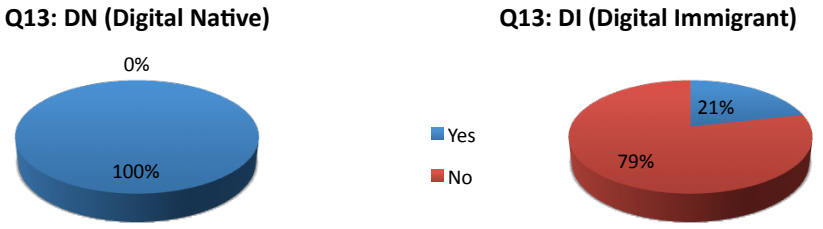


Figure 85: Learning habits – Q13.

Digital Natives were good at multi- tasking. 100% of them (Figure 85) mixed different activities together and only 21% of Digital Immigrants did the same.

6.2.3.8 Attitude Q14 10%

6.2.3.8.1 Q14: With which of the following statements do you agree?

Answer: □ I am comfortable with computers. I don't have to try hard to learn new features on computers. (10)
□ I am nervous when using computers. I need to try hard to learn to use them. (0)

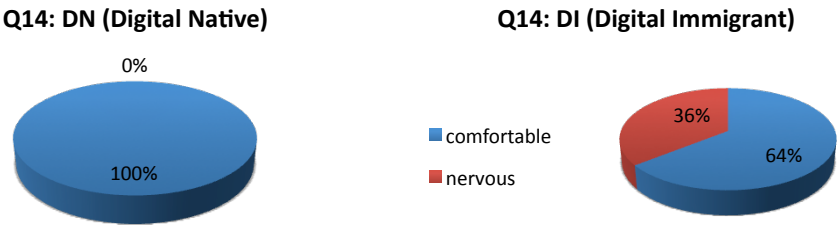


Figure 86: Attitude – Q14.

Digital Natives were born with interactive and digital devices; therefore they were all very comfortable using computers. 36% Digital Immigrants expressed that they were nervous with computers and had tried hard to learn.

6.2.3.9 Summary

Generally, a participant who had more Digital Native characteristics achieved a higher score. Digital Natives had an average score of 77, which was very high in comparison with the average of what Digital Immigrants achieved, 29 (Table 34).

	Mean value	Standard Deviation	Range (score)	Number of samples out of the range
Digital Native	≈77	≈12	65-89	1
Digital Immigrant	≈29	≈15	14- 44	4

Table 34: Scores of Digital Natives and Digital Immigrants.

By looking at scores of both Digital Natives and Digital Immigrants (Figure 87), apart from one sample (ID:09), the vast majority of Digital Natives scored similarly, between 65 and 89, and the standard deviation was lower than that of the Digital Immigrants. This proved that Digital Natives shared very similar characteristics while Digital Immigrants were more individual. Some of the Digital Immigrants (for example ID: 16 and ID:19) had little Digital

Native characteristics, while others (for example participant ID:20), had received high levels of digital influence and shared many characteristics with Digital Natives.

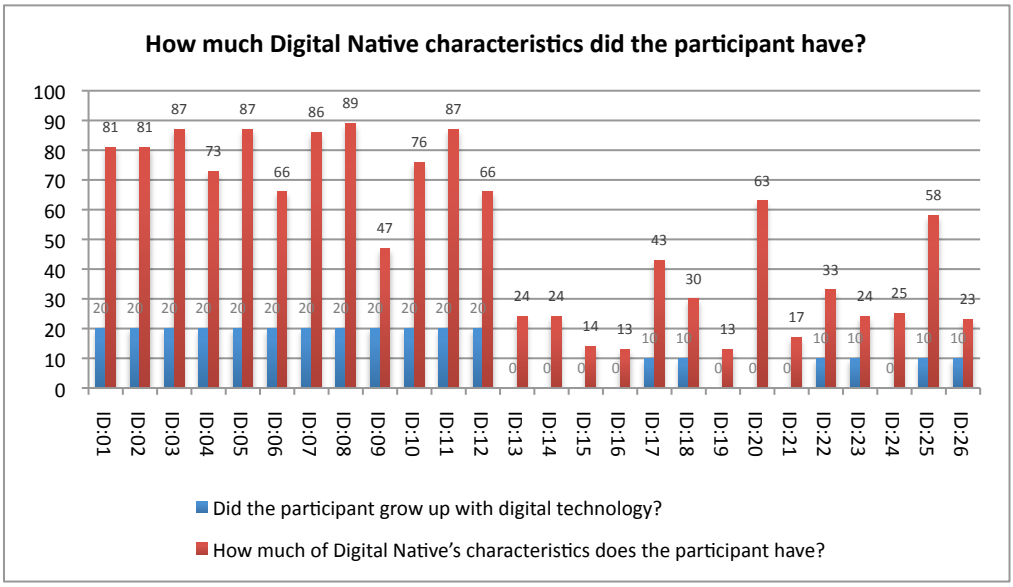


Figure 87: How many Digital Native characteristics did the participant have?

Most of the Digital Native characteristics were proved to be typical and common. However, in terms of learning habits, Digital Natives were not necessarily all visual experts and they did not always demand a customised reading order. The author understood this as that each person had a unique learning preference and the learning habit was decided mainly by each individual's learning style and intelligence.

Over all, the questionnaire (C) facilitated the group allocation and proved that the difference between Digital Natives and Digital Immigrants were visible and should be able to provide different results for user testing.

6.2.4 Choices of participants

The choice of the participants had to be carefully planned in order to ensure that their human performance characteristics were checked prior to the beginning of the tests.

They were required to be new to the chosen product and had never used the product or seen any similar kinds before. This ensured that they did not have mental models for the product and its operations.

They also had to be physically capable of carrying out the tests. This was tested using a

method traditionally used by work-study officers to establish what a hundred percent effort or rating looks like. A full pack of cards was dealt into four hands in a period of 52 seconds. It was ensured that the participants could all carry out this task in periods between 50 and 56 seconds. Thus their human performance characteristics could all be considered similar.

One of the participants (ID:09) had difficulties with visual perceptions and could not read images or operate in a 3D environment. Another participant (ID: 25) showed similar problems and also had strong attitudes with performing assembling tasks. They both claimed that they had never assembled anything before and had no intention to carry out any similar tasks in their future life. Therefore these two unusual examples were not the potential users for this particular product and were taken out to make sure that the data from examples reflected more common situations.

Finally, 24 participants were used, and the numbers of female and male participants were equal. There were 6 Digital Natives and Digital Immigrants to test both printed and multimedia instructions (Figure 88). As Neilsen & Landauer (1993) suggested, 5 users should be able to identify 80% of the design problems. The sample size of 6 in each group is enough for the experiments.

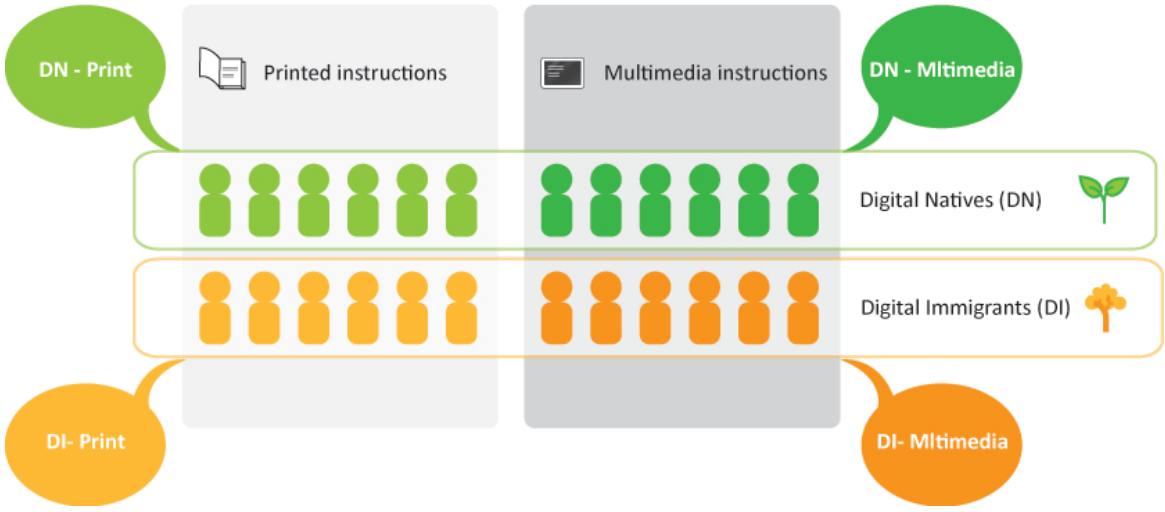


Figure 88: Final participants for user testing.

6.3 Testing procedure

6.3.1 Greeting and introduction

In this section, each participant was greeted and informed that all information was

confidential. This was to ensure that each user was relaxed and not worrying about other people judging her/his performance while taking part. A concise introduction was also given on how long the testing was going to take and what jobs were involved.

6.3.2 Background questionnaire – Questionnaire C

In this investigation, the questionnaires were given to the participants before the testing of instruction prototypes. They were used to collect the participants' information and to put them into different groups.

6.3.3 Orientation

During this section, the aim and process of the user test were briefly explained. Basic information of the product for example 'what the product is' and 'what it does' was introduced very shortly.

Product instructions for testing and a task list (Figure 89) were given to the participants during the orientation.

Tasks list:

Thank you for taking part in this research. Please use the given product instructions and complete the following tasks:

1. Find the following information from the instructions and write them down:

Manufacturer's name: _____

Contact email: _____

Dimensions of the assembled product: _____

2. Unpack and check all parts of the product.

3. Use the instructions to assemble the photo table.

Figure 89: Task list for the participants.

6.3.4 Usability test

In order to test the usability of the product instruction prototypes, participants were asked to perform a set of tasks in the task list during this section. The participants' actions, success or failure, plus time and errors, were observed and recorded by video. A total time of one hour was given for all tasks. When exceeding this limitation, the tasks were recognised as unaccomplished or failure. This time limitation was determined according to the previous

diagnostic tests and it should be sufficient for participants to complete the tasks.

6.3.5 Participant debriefing (Interview)

After all the tasks were completed or the time expired, participants' feedbacks were collected in the form of open questions and discussions, which allowed participants to fully express their own feelings or frustrations.

The debriefing included:

- Participant's perceptions about usability of the product instructions.
- Participant's overall attitudes towards the performance and experience.
- Participant's particular problems or difficulties during the test.

In this section, the following questions were asked to lead the discussion:

- What do you think of the product instructions?
- Do you think they were easy to use?
- Did you have any problem or difficulties when you did the tasks?
- Please mark the instructions:
  very easy to use easy to use average difficult to use very difficult to use

6.4 Re-test

Four sets of re-test were applied (Appendix K) one year after the first tests. This was to ensure that the participants' memory about the product has faded before the re-test of a different set of instructions. The re-tested participant included a Digital Native who used printed instructions first, a Digital Native who used multimedia instructions earlier, a Digital Immigrant who initially used printed instructions plus a Digital Immigrant who used multimedia instructions previously. These re-tested users were asked to redo all tasks using another set of instructions.

Chapter 7. Results, Interpretation and Analysis

Data was gathered from the experiments and analysed to clarify the communication effects of the instructions, mainly from four aspects of task performance: efficiency, accuracy, flexibility and attitudes. The details for data interpretation and analysis are addressed in this chapter. They are then used to prove and conclude the effectiveness and inclusiveness performance of both instruction prototypes in chapter 8.

7.1 Efficiency

To examine efficiency of different types of instructions, the following indices were used:

(1) Time for all tasks, (from the beginning to the end).
(2) Time for task sections.

Task 1 (finding information) and 2 (unpacking and preparation) were simple tasks with uncomplicated aims and each was evaluated as one section. Task 3(assembly) was relatively complicated and task sections 3.1(making the frame), 3.2(finishing the frame), 3.3(fixing the top sheet) and 3.4(attaching the accessory) were examined separately. Figure 90 illustrates the complexity of these sections. Each big circle represents a task section. The medium ones represent sub-tasks and little gray ones are of actions. For 3.1,3.2,3.3 and 3.4, there were too many actions to be shown in the illustration. A full list for timing information from all tests is attached as Appendix I.

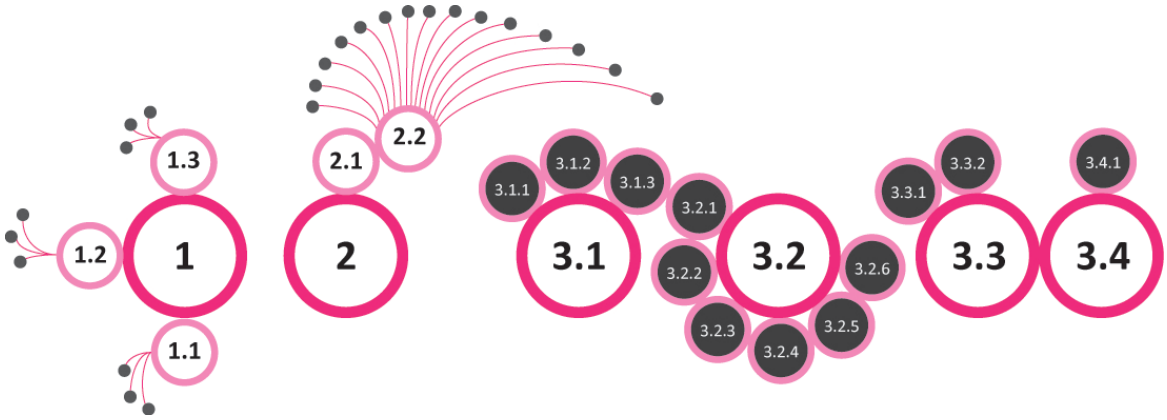


Figure 90: Examined task sections.

7.1.1 Time for all tasks

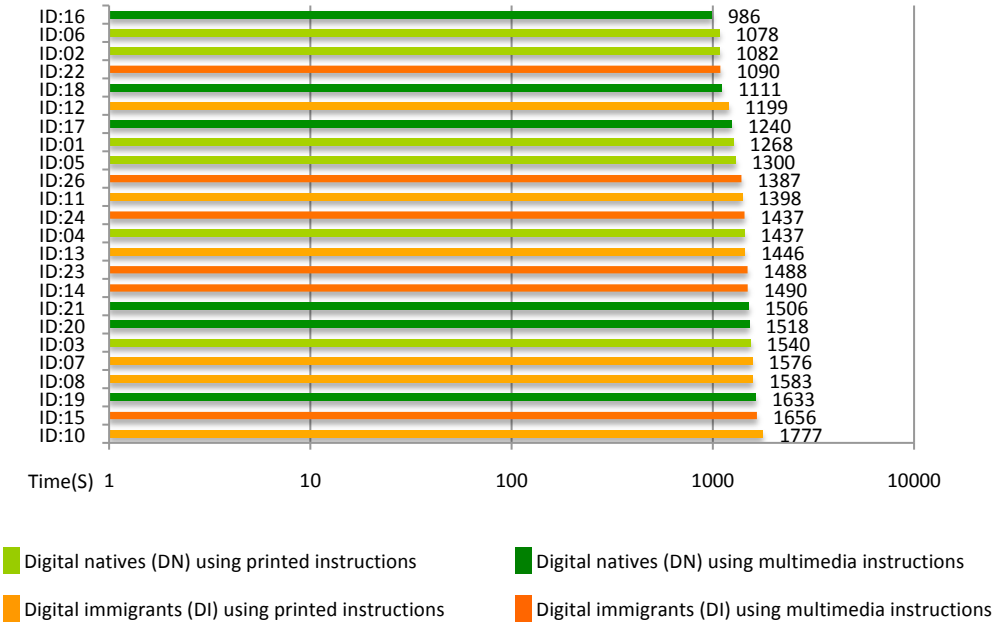


Figure 91: Total time for all tasks.

In the tests, the total time people spent on all tasks varied (Figure91), ranging from the quickest, 986 seconds (16 minutes 26 seconds) to 1777 seconds (29 minutes 37 seconds), which was the slowest. Average time all participants have spent on the test was about 1384 seconds (23 minutes and 4 seconds). The author was very keen to find out how much impact different media could have on instructions in term of efficiency, also to discover if Digital Natives and Digital Immigrants respond to both version of instructions differently. Data from each group (Table 35) was separated for further analysis.

		Digital Natives (DN)	Digital Immigrants (DI)
		Average Duration (s)	Average Duration (s)
Printed product instructions	Average duration (s): ≈1390	Printed (DN) ≈1284	Printed (DI) ≈1497
Multimedia product instructions	Average duration (s): ≈1379	Multimedia (DN) ≈1332	Multimedia (DI) ≈1425
		All DN Average(s) ≈1308	All DI Average(s) ≈1461

Table 35: Average time for all tasks.

7.1.1.1 Printed instructions VS Multimedia instructions

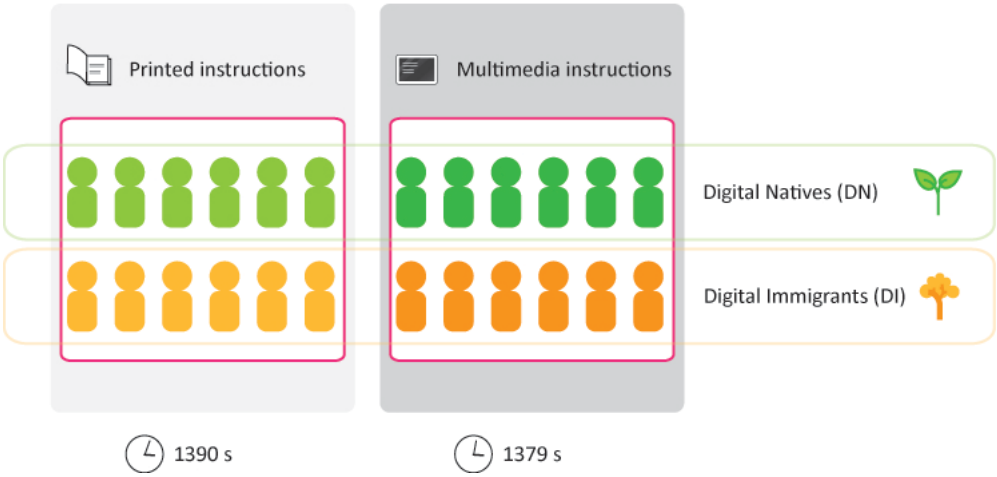


Figure 92: Time for all tasks- printed instructions VS multimedia instructions.

Overall, all participants, who used multimedia instructions, spent averagely about 1379 seconds (22minutes 59 seconds), with a standard deviation of 220 seconds, which seemed to be slightly shorter to those of printed instruction users, who spent 1390 seconds (23 minutes 10 seconds), with a standard deviation of 213 seconds (Figure 92). The author assumed that there was no statistically significant difference between the groups thus a t-test was carried out to find out the confidence level of this hypothesis.

Hypotheses 1:

- Null hypothesis: $T_1 = T_2$

  There is no significant difference between the average total time of users using either printed or multimedia instructions.
- Alternative hypothesis: $T_1 \neq T_2$

There is a significant difference between the average total time of users using either printed or multimedia instructions.

The 2-tailed t- test returned a P-value of 0.89. Since it was greater than the significance level (0.05), the null hypothesis was accepted. This indicated that there was no significant difference between the efficiency of the two versions of product instructions.

7.1.1.2 Digital Natives VS Digital Immigrants

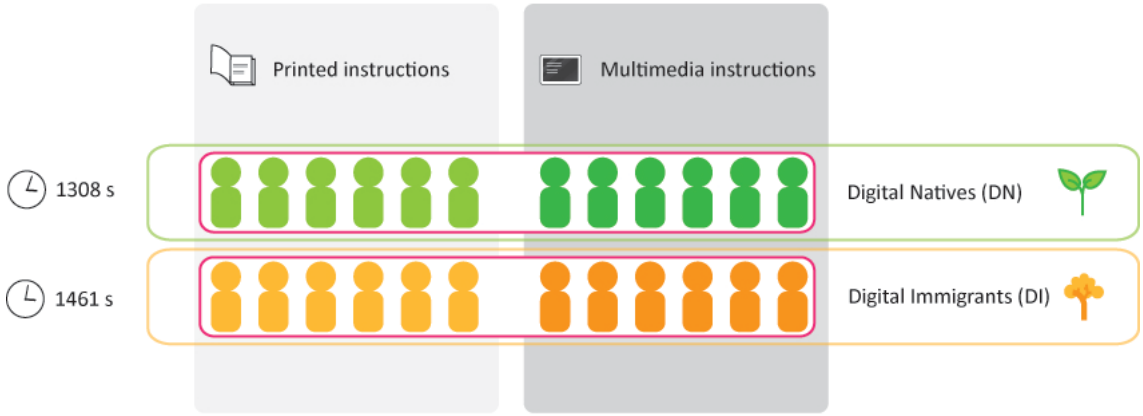


Figure 93: Time for all tasks - DN. VS DI.

Data (Figure 93) showed that Digital Natives spent less (153 seconds) average time than Digital Immigrants. This potentially suggested that the Digital Natives performed quicker. Again, 2-tailed t- tests were carried out to find out the confidence level of the significant differences between Digital Natives and Digital Immigrants on their total time consumptions.

Hypotheses 2:

- Null hypothesis:
  There is no significant difference between the mean time consumption of all Digital Native participants and all Digital Immigrant participants.
- Alternative hypothesis:
  There is a significant difference between the mean time consumption of all Digital Native participants and all Digital Immigrant participants.

The P-value (0.08) was greater than 0.05, thus there was no significant difference between their time consumptions for all tasks. Although the total time Digital Immigrant participants spent on all tasks in this experiment appeared to be slightly longer than those of Digital Natives, the overall performance in a larger population could be similar.

7.1.1.3 Media impact on Digital Natives (DN) when using instructions

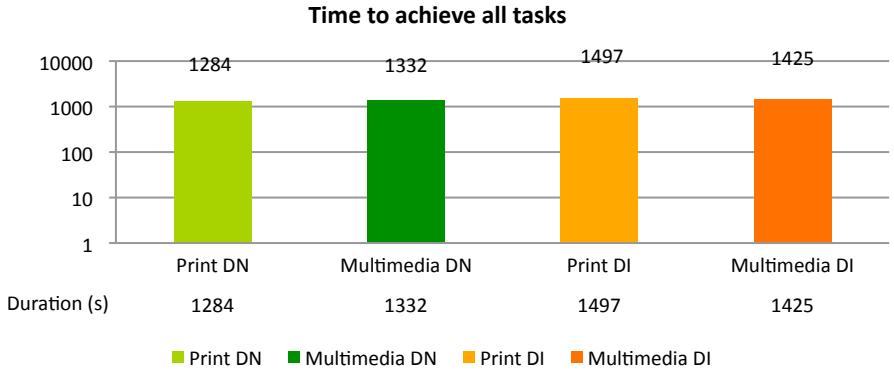


Figure 94: Time to achieve all tasks in each user group using different instructions.

When looking at the Digital Native group and Digital Immigrant group separately, data showed that Digital Natives spent slightly longer but still similar amounts of time on the tasks by using multimedia instructions (Figure 94). This suggested that this media of product instructions might have little impact on the efficiency of instructions for Digital Natives. A 2 tailed t- test was carried out to find out if the data was strong enough to suggest any difference.

Hypotheses 3:

- Null hypothesis:

  There is no significant difference between the mean time consumption of the Digital Native group using the printed instructions and the Digital Native group using the multimedia instructions.
- Alternative hypothesis:

  There is a significant difference between the mean time consumption of the Digital Native group using the printed instructions and the Digital Native group using the multimedia instructions.

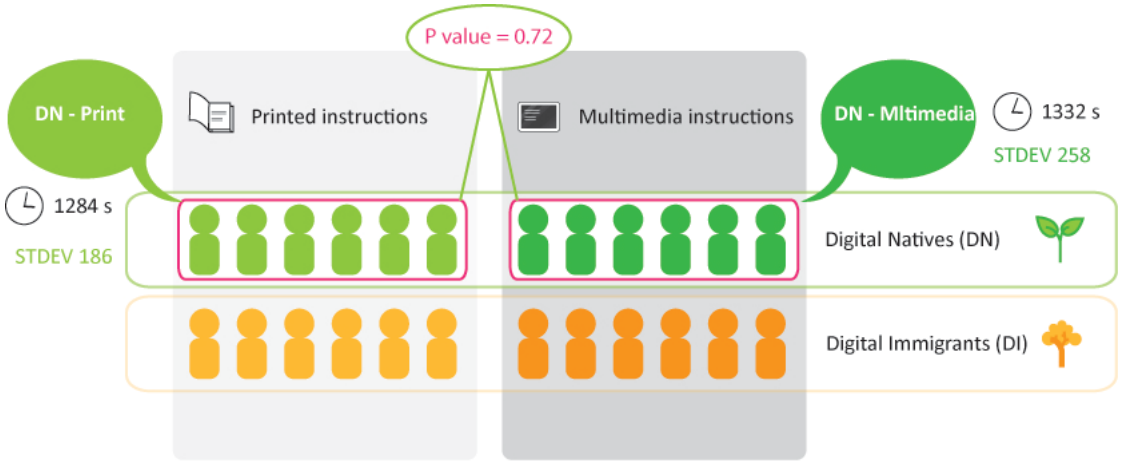


Figure 95: Time for all tasks - DN -print VS DN - multimedia.

The result (Figure 95) showed that there was no significant difference between Digital Natives using different types of instructions. Similar amount of time has been spent to complete all tasks.

7.1.1.4 Media impact on Digital Immigrants (DI) when using instructions

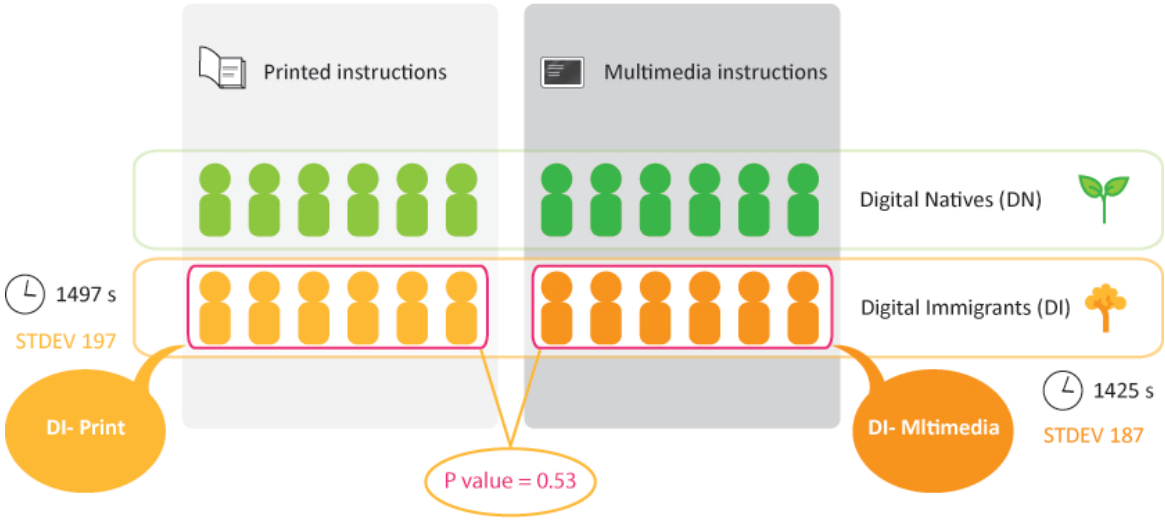


Figure 96: Time for all tasks - DI -print VS DI - multimedia.

For the Digital Immigrants, time difference for all tasks was more identifiable when different media instructions were involved. People averagely used 72 seconds of extra time when adopting printed instructions (Figure 96). Again, the number difference was not large and a t-test was used to prove this.

Hypotheses 4:

- Null hypothesis:
  There is no significant difference between the mean time consumption of the Digital Immigrant group using the printed instructions and the Digital Immigrant group using the multimedia instructions.
- Alternative hypothesis:
  There is a significant difference between the mean time consumption of the Digital Immigrant group using the printed instructions and the Digital Immigrant group using the multimedia instructions.

The P-value (0.53) was once again greater than 0.05, thus there was no significant difference between two groups of Digital Immigrants using different types of instructions.

Although the time consumption between different groups of users seemed to be different at the first glance, four sets of 2-tailed t-tests supported that the difference was not significant. Printed and multimedia instructions were similarly efficient. Both Digital Natives and Digital Immigrants used similar amounts of time to complete all the tasks.

7.1.2 Time for each task section

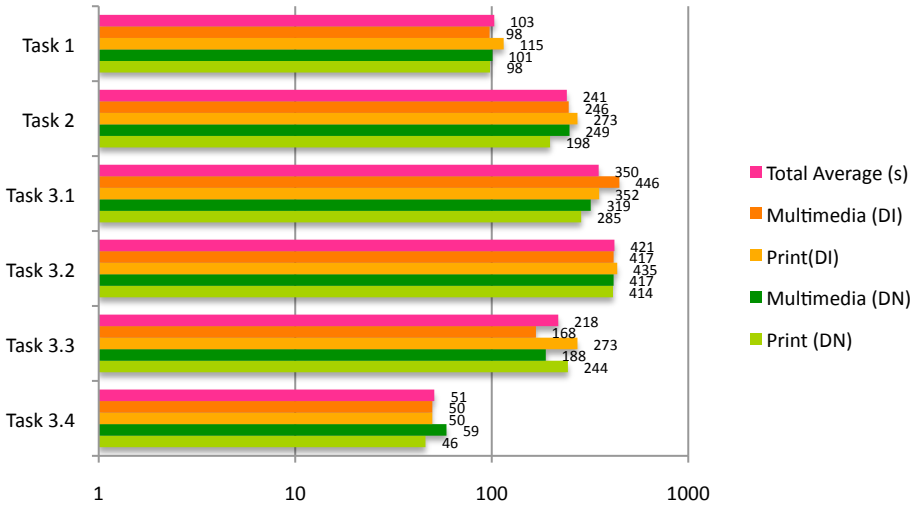


Figure 97: Average time(s) to achieve each task section.

By looking at the time consumption for each task section (Figure 97), it was discovered that multimedia product instructions generally had a positive influence on Digital Immigrants in terms of their efficiency. Yet, this did not apply to all types of tasks. For Digital Natives, different types of instructions did not seem to have significant impacts on their time consumption.

7.1.2.1 Printed instructions VS Multimedia instructions

Task	Users with printed instructions				Users with multimedia instructions				P value
	Average time (s)	STDEV	Range		Average time (s)	STDEV	Range		
1	106	54	52	160	99	11	88	110	0.66
2	235	80	156	315	248	63	185	310	0.68
3.1	318	60	258	378	383	128	255	510	0.13
3.2	424	150	274	575	417	127	289	544	0.90
3.3	258	49	210	307	178	71	107	249	**0.00**
3.4	48	17	31	65	54	37	18	91	0.58

Table 36: Time for task sections – printed instructions VS. multimedia instructions.

For most of tasks, especially task 1 (finding information) and task 2 (unpacking and preparation), the simple tasks required mainly automatic actions with little thinking and decision making, the change of instructions did not make a huge difference on how quickly users work. However, in task 3.3 (fixing the top sheet), the difference was highly significant

(Table 36). A 1 tailed t-test suggested that the difference mainly existed in the sub-task 3.3.2. This was to use "K" clips to hold a plastic sheet in position. Users had to understand the situation, make judgements on where to put the clips, how to make the plastic sheet fit the frame, then decide what actions to take. People who used multimedia instructions found them significantly more efficient for this task. According to participant feedback, this was because the animation gave an overview of the assembly process and showed the best order for putting on the K clips, which helped users to understand the situation then make decisions.

7.1.2.2 Digital Natives VS Digital Immigrants

Task	All Digital Natives				All Digital Immigrants				P value
	Average time (s)	STDEV	Range		Average time (s)	STDEV	Range		
1	99	15	85	114	106	53	53	159	0.68
2	223	65	158	288	260	74	186	334	0.21
3.1	302	69	233	371	399	111	288	510	0.02
3.2	415	140	275	556	426	138	288	564	0.86
3.3	216	76	141	292	220	72	148	292	0.90
3.4	52	36	16	89	50	18	31	68	0.83

Table 37: Average time of all users for task sections.

Previously, it was proved that Digital Natives and Digital immigrants needed similar amounts of time to complete all tasks. However, when the time for each task section was examined, data (Table 37) revealed that the time difference between Digital natives and Digital immigrants on task 3.1 was highly significant.

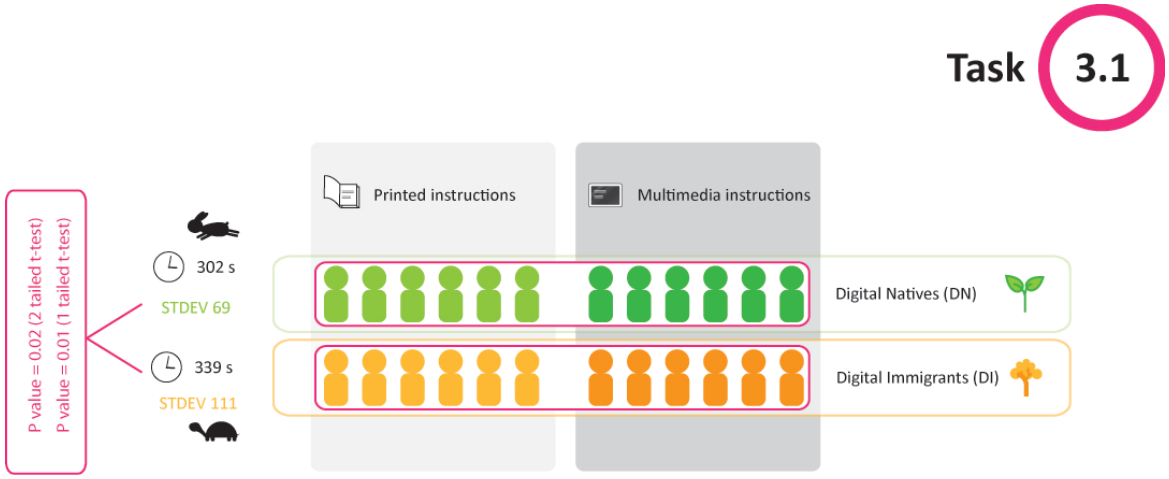


Figure 98: Time for task 3.1 – DN VS. DI.

A one tailed t-test supported that Digital immigrants needed a longer time to complete task 3.1 than Digital Natives (Figure 98). This was particularly obvious when printed instructions were given (Figure 99). When using multimedia instructions, their time consumptions were similar. This suggested that multimedia instructions were more efficient than printed ones for Digital Immigrants to carry out this specific task.

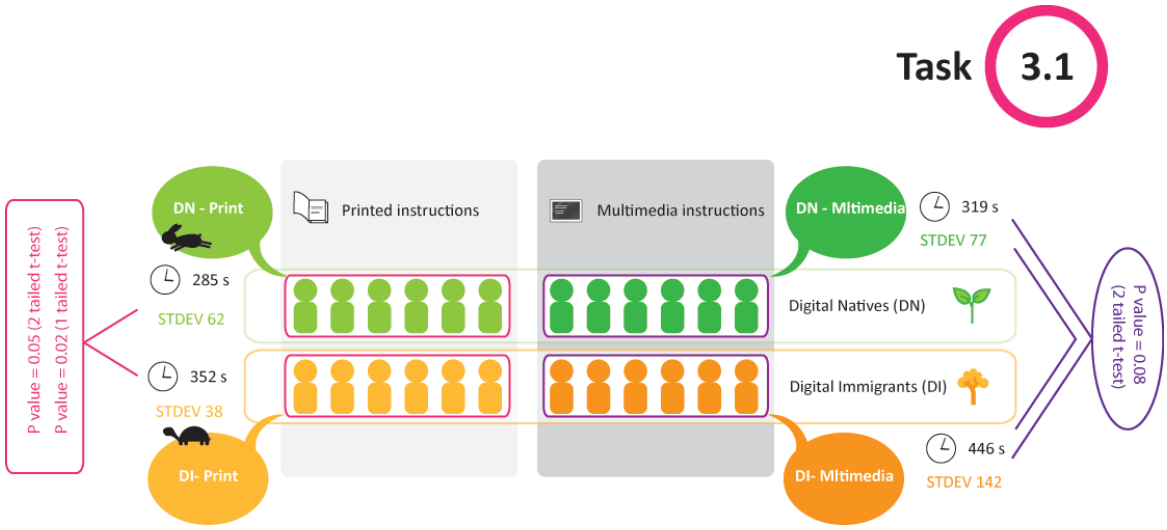


Figure 99: Time for task 3.1 – DN - print VS. DI - print; DN - multimedia VS. DI - multimedia.

This task (3.1) included three sub-tasks and consequential actions. It was a very complicated task which involved recognition processes like finding a product part; transferable processes like connecting different parts and also visuo-spatial judgements such as deciding which side of a pipe should face up The nature of this task suggested that multimedia might improve the efficiency of instructions for complicated tasks.

7.1.2.3 Media impact on Digital Natives (DN) when using instructions

Task	Digital Natives with printed instructions				Digital Natives with multimedia instructions				P value
	Average time (s)	STDEV	Range		Average time (s)	STDEV	Range		
1	98	19	79	117	101	12	89	113	0.76
2	198	59	138	257	249	64	184	313	0.18
3.1	285	62	223	346	319	77	242	396	0.41
3.2	414	145	269	559	417	150	267	567	0.97
3.3	244	39	206	283	188	96	92	284	0.21
3.4	46	22	24	68	59	48	11	107	0.56

Table 38: Time for task sections- DN-printed VS. DN-multimedia.

t-tests showed that the speed differences between DN printed instructions users and DN multimedia instructions users were not significant. This applied to all task sections (Table 38). Thus the use of different media did not affect the efficiency of instructions for them.

7.1.2.4 Media impact on Digital Immigrants(DI) when using instructions

Task	Digital Immigrants with printed instructions				Digital Immigrants with multimedia instructions				P value
	Average time (s)	STDEV	Range		Average time (s)	STDEV	Range		
1	115	77	38	191	98	11	86	109	0.60
2	273	84	189	357	246	67	179	313	0.55
3.1	352	38	313	390	446	142	304	589	0.15
3.2	435	169	266	603	417	115	302	532	0.83
3.3	273	57	216	329	168	39	129	207	0.00
3.4	50	12	38	62	50	24	25	74	1.00

Table 39: Time for task sections- DI-printed VS. DI-multimedia.

There were highly significant differences between Digital Immigrants (Table 39) who used printed instructions and multimedia instructions in task 3.3 (fixing the top sheet). The main difference was within task 3.3.2 (Using “K” × 8 to hold “J”). Again, This task section was relatively complicated and involved recognition processes, transferable processes and also visuo-spatial judgements. Multimedia instructions helped to speed up the performance of Digital immigrants during this task section. This backed up that multimedia instructions for complicated tasks should be more efficient for Digital immigrants.

7.1.3 Summary

The study showed that different media of instructions did not have highly significant impact on the overall efficiency performance of product instructions, especially for the Digital Natives. When the time spent for each task section was studied, it was discovered that people use similar amounts of time to finish simple jobs, which need less thinking. However, surprisingly, Digital immigrants work distinctly faster on complicated tasks when multiple media were involved.

7.2 Accuracy

To examine the accuracy of different types of instructions, the following indices were used:

(1) Types of errors

(2) Errors in each task section

(3) Errors in thinking/processing progress

A full list for error information from all tests is attached as Appendix J.

7.2.1 Types of errors

	Print - DN	Print - DI	Print - All	Multimedia - DN	Multimedia - DI	Multimedia - All
Slip	2 (by 2 persons)	1	3 (by 3 persons)	1	2 (by 1 person)	3 (by 2 persons)
Lapse	0	1	1	0	0	0
Mistake	4 (by 4 persons)	2 (by 2 persons)	6 (by 6 persons)	1	0	1

Table 40: Number of uncorrected errors for all tasks.

By referring to given instructions, users observed and corrected their own errors in the performing progress. When errors were not detected or corrected by the participants, they were evaluated and sorted into different types (Table 40). In this experiment, Digital Natives and Digital Immigrants have both made errors. The numbers of slips and lapses were similar in the two user groups. They were caused by each individual's failures of action or failures of memory. Unfortunately, theses errors were not perfectly solved by changing product instructions. When looking at the overall number of mistakes made by the participants, data revealed that 6 participants made 6 mistakes in the end while using printed instructions. In comparison, only one user still made 1 mistake after using multimedia instructions. The differences in mistakes proved that multimedia instructions performed better in the avoidance of mistakes, for both Digital Natives and Digital Immigrants compared to the traditional printed instructions.

7.2.2 Errors in each task section

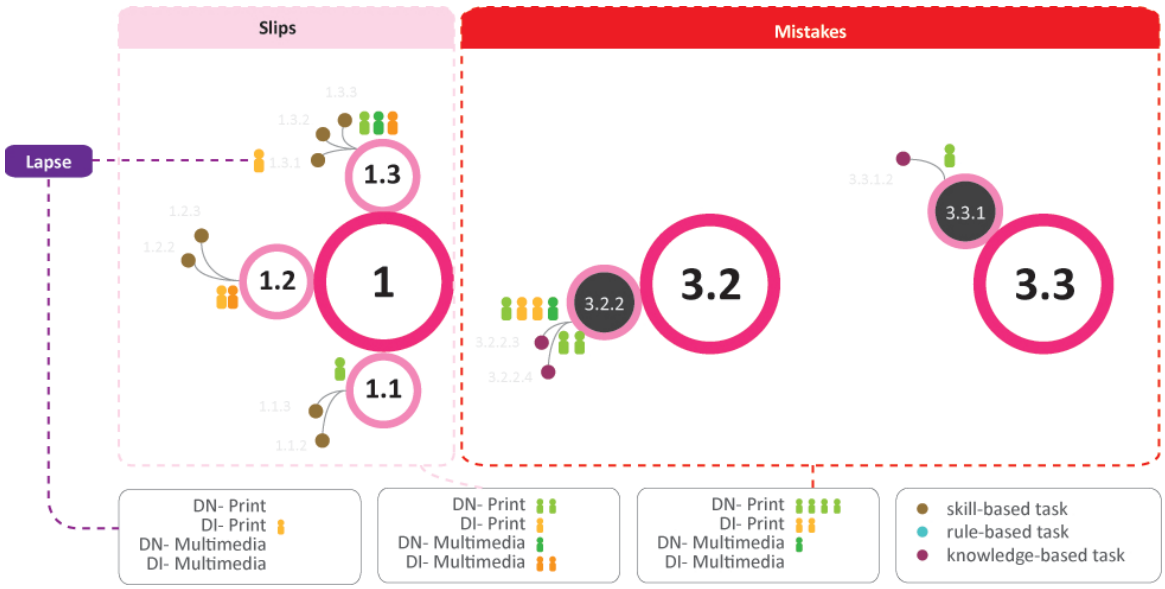


Figure 100: Uncorrected errors in each task section.

Users made most errors when they were carrying out task 1(finding information) and task 3(assembly). The remaining errors after their self-check (Figure 100) were with task1, task 3.2(finishing the frame) and task 3.3(attaching the accessory).

All uncorrected slips and lapses happened during task1, when users searched simple information from instructions and wrote them down. Changing the media of instructions did not effectively reduce the number of these types of errors.

Digital Natives, in general, made more mistakes than Digital Immigrants. The mistakes mainly occurred in the assembly process, especially during the most complicated steps in section 3.2. Many users spotted their own mistakes and corrected them by checking through the instructions. In comparison to printed instruction users, people made fewer mistakes when they used multimedia instructions.

7.2.3 Errors in thinking / acting process

All tasks in the experiment required a certain amount of thinking or action processes from users. They could be classified into four main categories: Recognition processes, transferable processes, spatial/ contextual judgements and critical decisions (Table 41). These processes are universal and can be applied when other types of products are used.

Nature of tasks	Explanation	Task example
ⓘ Recognition processes	Recognising a product; Check against instructions.	Check a pipe
▸ Transferable processes	Carry out an action without planning; Carry out an action as planned.	Tighten knobs Connect two parts
🕸 Spatial/ contextual judgements	Make visuo-spatial judgements base on individual's ability and knowledge.	Decide which side of a pipe faces up.
🗪 Critical decisions	Define the characteristics of tasks and their intention.	Decide if a task is completed correctly.

Table 41: Major types of tasks involved in the experiments.

For this study, the uncorrected mistakes were allocated and analysed depending on in which process the mistakes occurred (Table 42).

	Task No.	Level of errors	DN Print	DI Print	DN Multimedia	DI Multimedia	
ⓘ Recognition processes	1.1.2	Skill-based	✖				Slips & Lapse
	1.2.2	Skill-based		✖		✖	
	1.3.1	Skill-based		✖		✖	
	1.3.2	Skill-based			✖	✖	
▸ Transferable processes	1.1.3	Skill-based	✖				
	1.2.3	Skill-based		✖		✖	
	1.3.3	Skill-based	✖				
🕸 Spatial/ contextual judgements	3.2.2.3	knowledge-based	✖	✖✖	✖		Mistake
	3.2.2.4	knowledge-based	✖✖		✖		
	3.3.1.2	knowledge-based	✖				
			🗪 Critical decision				

Table 42: Uncorrected errors in thinking/acting processes.

ⓘ Recognition processes

All users recognised product parts correctly. Still, a few slips and lapses happened in the recognition processes. Participants either located wrong product information (e.g. task 1.3.1) or read information incorrectly (e.g. task 1.1.2). Different media did not seem to affect these

errors.

▸ Transferable processes

Although not all users had acted flawlessly, they did manage well and made sure all rule-based errors were correct in the end. For example pipes were connected and all knobs were tightened in the experiments. Still, people had a few slips in the process of writing down information, for example, misspelling “HK” as “HH” (task 1.2.3, write the contact email).

🕸 Spatial/ contextual judgements

The majority of uncorrected mistakes were caused by wrong visuo-spatial judgements in task 3.2.2 (fixing “F” x2 onto “E” x2). Users struggled to identify the orientations of complicated parts, bracket F (L) and F (R). 5 users experienced this problem when printed instructions were provided. The number of frustrated users on the same problem was reduced to 1 when multimedia instructions were in use. Further, a number of users with printed instructions chose the wrong side of the plastic sheet “J” (task 3.3.1, placing plastic “J” onto the top of the finished frame) and one of them left it uncorrected in the end. The same messages for checking the correct side were indicated in multimedia instructions. The multimedia users received the information well and all had it right in the first place.

🗪 Critical decisions

As stated previously, users in this experiment monitored their own errors during and after their performances. They made critical decisions on what they should do (aim), what actions were expected (plan), or if a consequence was right (result). The majority of errors were revealed and corrected by themselves during their critical decision making processes. The accepted mistakes meant that users assumed the results were right therefore they were counted as evidence of failed critical decisions.

7.2.4 Summary

Overall, both types of instructions worked similarly accurate in transferable processes. They did not make a difference in helping people avoiding slips and lapses. Yet it was evident that

multimedia instructions were better for avoiding mistakes on a knowledge-based level, when users needed to make spatial/ contextual judgements. For some tasks, for example task 3.2 (finishing the frame), both Digital Natives and Digital Immigrants made a few mistakes when traditional instructions were provided. With equivalent contents presented in multimedia instructions, most users either avoided mistakes straight away or realised errors on their own. Thus it is not difficult to conclude that multimedia instructions are better than traditional instructions (with only images and text) in terms of ensuring accuracy of actions on complicated tasks with more requirements spatial/ contextual judgements and decision-making.

7.3 Flexibility

	Print DN	Print DI	Print All	Multimedia DN	Multimedia DI	Multimedia All
Customise action order	3 persons	2 persons	5 persons	4 persons	2 persons	6 persons
Skip Instructions	1 person	0	1 person	1 person	2 persons	3 persons
Use alternative solution	0	1 (by 1 person)	1 person	3 (by 2 persons)	7 (by 5 persons)	10 (by 7 persons)

Table 43: Flexibility performance for all tasks.

Numbers (Table 43) suggested that Digital Natives appeared to require more freedom on the reading order of product instructions. More of them used instructions in a customised order to satisfy individual needs and habits than the Digital Immigrants, regardless which type of instructions they used. Digital Immigrants rarely skipped instructions when they were printed images and text. However, through multimedia, Digital Immigrants were more relaxed about skipping unnecessary instructions and decide alternative solutions. It was not difficult to conclude that participants were encouraged to use instruction guides more flexibly when they were delivered through multimedia. It could also be interpreted that multimedia instructions encourage users to think and build up their own understanding of the product.

7.4 Attitude

From the participants' feedbacks in the debriefing section discussions, it was discovered that users were mainly satisfied with the given instructions (Figure 101). No users thought their instructions were either difficult or very difficult to use.

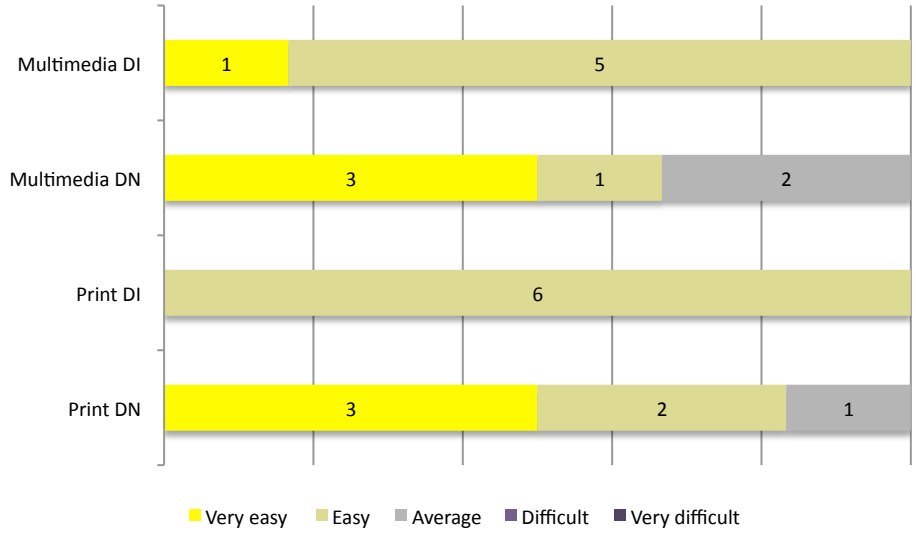


Figure 101: User comments on instructions.

All Digital Immigrants responded positively to both printed and multimedia instructions. 11 out 12 of them were satisfied with what they have used and one was very satisfied with the multimedia instruction. Digital Natives' attitudes were more diverse. Half of them were very happy with both instructions and another half were either happy or thought the instructions were average. Generally they expressed slightly higher satisfaction with the printed instructions. However, it was difficult to conclude which one they preferred more because sample numbers were small.

When talking about their experience, the majority of the users felt the instructions were clear and illustrations were helpful. Some of the printed instruction users complained about the size of pictures and they said it could be clearer if images were bigger. Although some users found the sound annoying, most multimedia instruction users said the voice guidance was very helpful especially during the assembly process. During the interviews, people showed strong personal preferences on learning and following instructions. Some would only read text, some preferred to look at images and others might have had to learn by hearing or animation. Some would like to follow systematic guides while others wanted the freedom to choose what to follow and when to follow. All users agreed that they were comfortable to read on screen but a few of them said they did not like to walk forwards backwards to read off computer screen then carry out actions.

All in all, users had very different opinions about what the best media for instructions should

be, but they generally thought both the printed and multimedia instructions were easy. No negative response was collected for either of them.

Chapter 8. Conclusions and Further Studies

Although multimedia instructions are not always more efficient than traditional ones, they ensure more accurate actions, especially for those complicated tasks with more requirements spatial/ contextual judgements and decision-making. They allow more flexibility in action and more importantly can help to reduce human errors like mistakes significantly in the working process. They are effortless to access, can be transferred between different digital platforms and easy to update or replace. By comparing data from both Digital natives and Digital Immigrants user groups, on efficiency (chapter 7.1.3), accuracy (chapter 7.2.4), flexibility (chapter 7.3) and attitudes (chapter 7.4), it is also proved that multimedia instructions can be used easily by people who have grown up with or without the presence of digital media and people are generally positive about using multimedia instructions. Still, there are comments like people do not always have computers to access digital instructions and computers are not easy to carry around. These objections are not questions any more with the emergence of new devices. During the time for the development of this project, technology has changed and improved as fast as usual. Smart phones have become more popular. More portable digital devices like the iPad have come into the market and our daily lives. People are more comfortable with and dependent on portable digital devices and we are better with networks. The author believes that multimedia instructions could be and soon will be better solutions for many of our daily products, to help us use products easily and safely.

However, this will not cause the complete death of traditional instructions. Although they are not as good to ensure accuracy of some performances, they can still be used in many cases. For example, they are a better choice for performing simple tasks on products in terms of efficiency, especially for Digital Natives, less patient or busy people. Therefore, in the future, instruction designers may want to analyse tasks for using a particular product, then decide either they need to design traditional instructions or multimedia ones to satisfy users' requirements for efficiency and accuracy of operation.

Every effort was made in this study to ensure that the chosen participants had similar levels of human performance characteristics. In other words, they all had the same degree of normal flexibility, intelligence, adaptability and dexterity. However, even with the test applied (dealing cards) and observations made on the participants, it was still impossible to completely eliminate the human factor. Four sets of test were applied (Appendix K) one year after the first tests. This was to ensure that the participants' memory about the product has faded before the re-test of a different set of instructions. The results proved that all re-tested users, including Digital Natives and Digital Immigrants, performed quicker with multimedia instructions and their errors were significantly reduced. This again proved that multimedia instructions are effective. They are more efficient, accurate and flexible than the traditional ones. They are also inclusive, can be easily used by both people who have grown up with or without digital devices.

8.1 Conclusions

This study has built upon many previous research studies but particularly upon the following areas: information design, product design, graphic design, cognition and learning, human factors plus design media and their users (Figure 102).

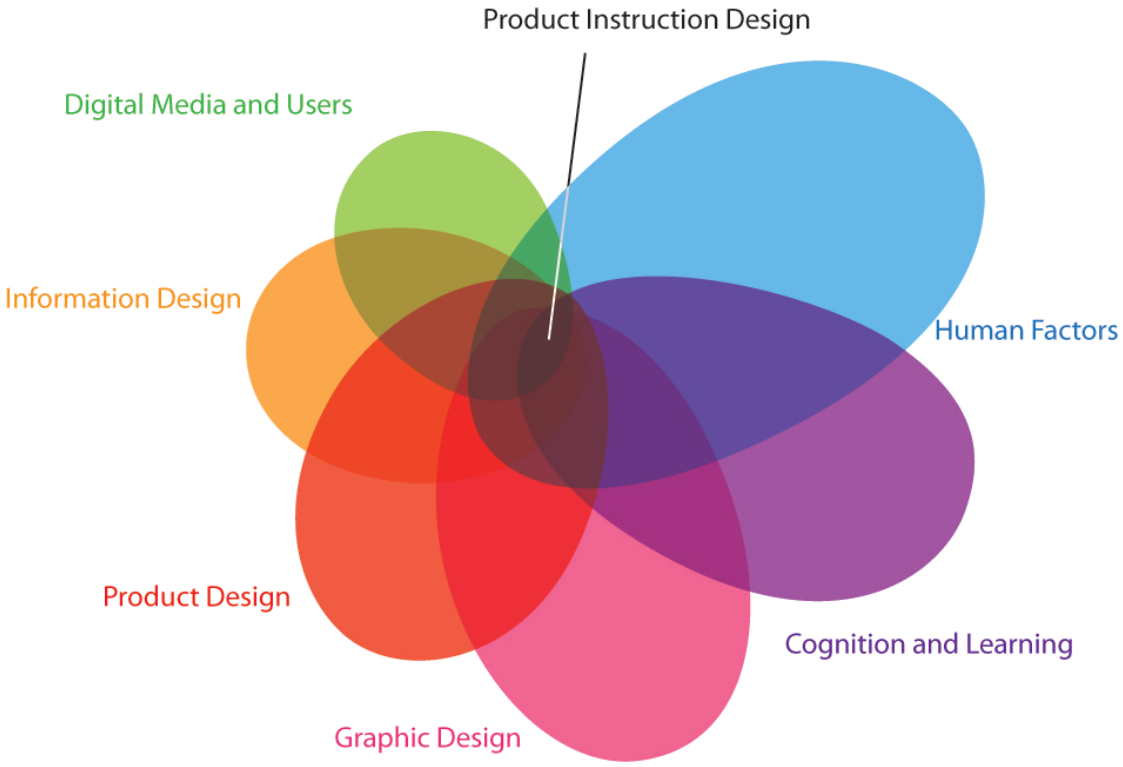


Figure 102: Related studies this research was built upon.

A problem-driven design strategy was adopted for this study to find out problems of product instructions as well as suggest possible explanations and solutions for these problems. Answers for the key research questions in chapter 1.3 were achieved:

8.1.1 Are product instructions still necessary?

Yes, they are necessary for both users and manufacturers. They are important for users to use products correctly and safely; most users still need them for learning new products and problem solving and their expectations on instructions are high; also, instructions are important for the manufacturers in terms of selling products and keeping their customers, not even to mention that they are legally required.

8.1.2 What are the main problems with product instructions?

Users are suffering from problems in three design aspects: the effectiveness, accessibility and inclusiveness.

8.1.3 What solutions are currently used to solve problems in product instructions?

Standards and regulations are available on the planning of product instructions but they are dated and not easy for designers to follow. Studies on info-graphics were carried out and suggestions on presenting information are given (Chapter 5.3.4). Research on the general design process of product instructions or on the accessibility and inclusive design of product instructions is relatively rare; suggestions particularly for digital instructions are still not sufficient.

8.1.4 Is it possible to make instructions effective, easy to access, universal, sustainable and cheap to produce at the same time? And are multimedia instructions the better choice?

This study revealed that Multimedia instructions performed well from different aspects:

- Effectiveness
  - Efficiency — Similarly efficient on all tasks for Digital Natives compare to traditional instructions; Similarly efficient on simple tasks involving automatic and subconscious actions for all users;

		More efficient on complicated tasks with spatial-contextual judgements and decision making for Digital Immigrants.
	- Accuracy	Can effectively reduce mistakes compared to traditional instructions.
	- Flexibility	Allow more flexibility to the users and encourage users to think and build their own understanding of the product.
•	Accessibility	Easily accessible. Can be quickly updated and distributed.
•	Inclusiveness	Can be used by people with different learning styles; Can be used by all digital users including Digital Natives and Digital Immigrants.

They are easy to access and can be used by all users with different learning styles. They are sustainable, cheap to distribute and can be easily distributed and updated. Moreover, they can be used comfortably by different users including those who did not grow up with digital technology (Digital Immigrants). Although it is not clear if it is going to be as effective on all types of products yet, multimedia instructions should definitely be used more in the future.

8.1.5 Is there a preferred method/media of producing successful product instructions?

Multimedia instructions are better for reducing errors particularly mistakes and are quicker to use for some tasks. Traditional printed instructions are more efficient to use for simple tasks with less thinking required. Designers need to decide what media to use, depending on the nature of the product, the complication of its instructions and requirements of intended users. A design process for accompanying product instructions is suggested in the next section.

8.2 Recommendations

As stated in Chapter 2, the current research and study on the design of general product instructions is relatively rare. There are no easy guidelines for designers to follow. Therefore, to conclude the findings from this research, the author suggests the following design process for instruction planners (Figure 103):

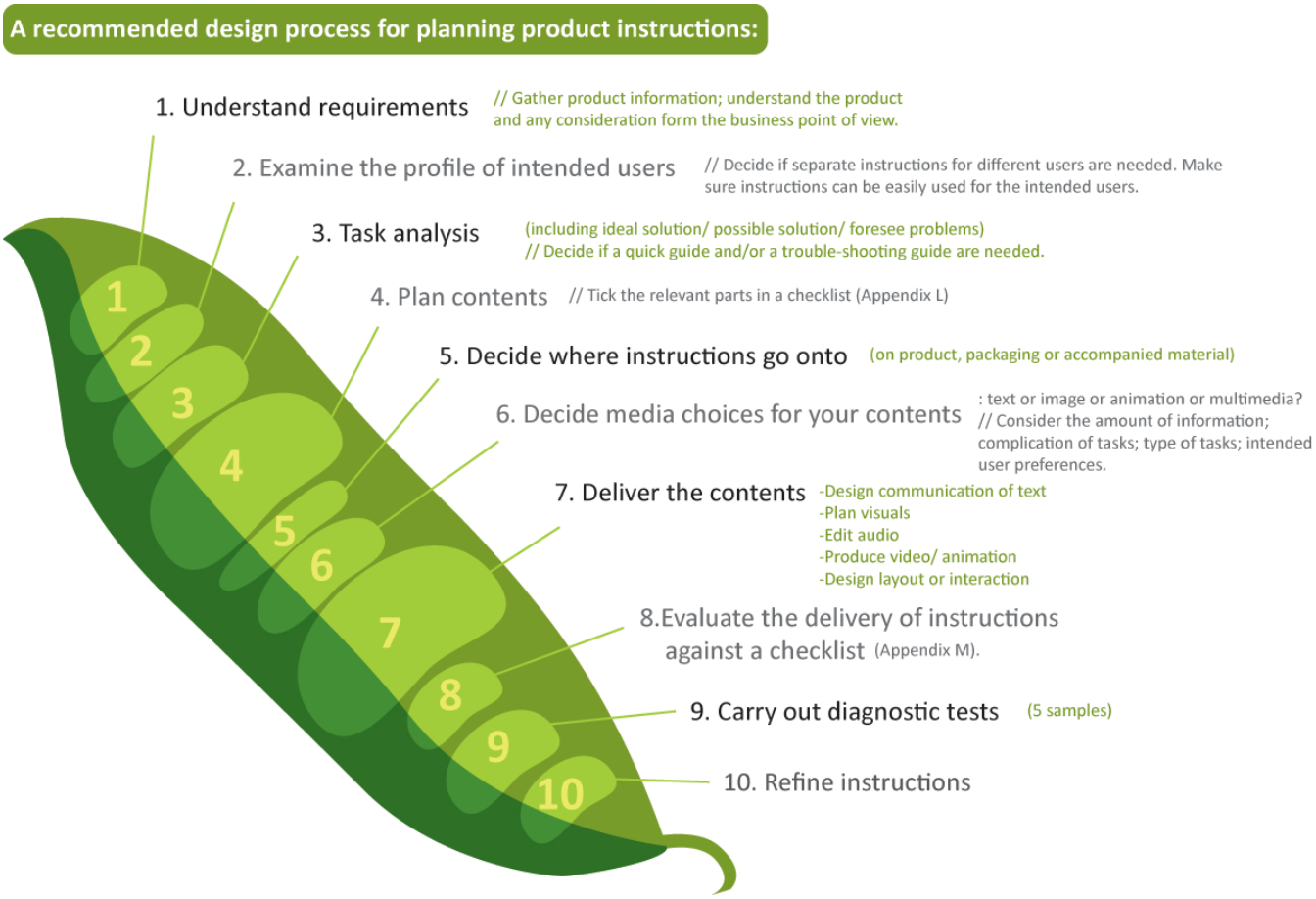


Figure 103: A recommended design process.

8.3 Contribution

Overall, in this study, a problem-driven design strategy was adopted to find solutions for improving the quality of product instructions. As related studies and standards are not sufficient to solve problems with product instructions especially in this digital age, this research should make an original contribution in planning and product organising instructions (Figure 104).

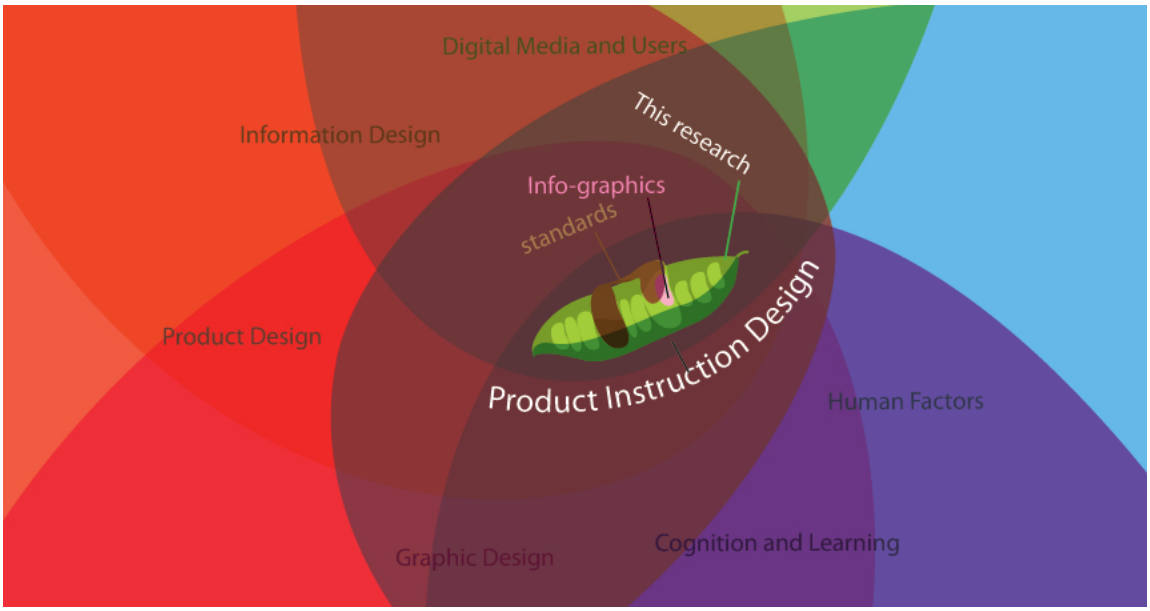


Figure 104: Contribution of this research.

The study confirmed the advantages of multimedia instructions on their accessibility and inclusiveness; proved their effectiveness improvements towards their accuracy and learning flexibility in comparison with traditional instructions. It also recognised the limited situations in which traditional product instructions perform more effectively according to their speed. These findings should help designers to make their decisions on media choices therefore design better product instructions to benefit both users and manufacturers.

Further, this research suggested a design process, which can be easily followed to organise and plan useful product instructions. This should benefit designers, especially those who are new to designing product instructions. In addition, this study should have economic value as the costs of product instructions can be reduced if instructions are better planned.

8.4 Limitations

The author accepts that, as with any research project, there are certain limitations associated with the study. They are:

- Type of products

  A selected type of product was used in the study. The results haven not been proven on all types of products yet.
- Design of the prototypes

The prototypes were not 100% completed. Some features did not fully function, for example changing the text size and choosing between different languages. However, they were not the main functions users would have needed for the tasks thus should not influence the results for the experiments.

- Diagnostic test sample size

  Due to the time limitation, there were only two diagnostic tests carried out when designing the instruction prototypes. The contents of two prototypes have the same quality therefore this should not affect the final conclusions.

- Human errors

  Despite taking every effort to ensure the similarity of participants' ability for performances, it is impossible to obviate all human errors.

- The changing technology

  The research was carried out over five years. Technology was moving and changing fast in the process. Therefore some choices on technology could be different today.

8.5 Further Studies

The author believes that product instruction design is an exciting yet developing subject. There are many potential issues to look at in this area and the research is an on-going project. Instructions of other types of products will be tested in the future and a website/ mobile phone app will be developed to enable users to quickly access all instructions and also allow companies to achieve their customers' information and feedback. As related studies and standards are not sufficient to solve problems with product instructions especially in this digital age, this research should make an original contribution in this field.

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Appendix A

The evaluation of original product instructions - contents

The product instructions were examined using these marks:

fulfilled/covered by the instructions being assessed	not fulfilled/covered by them	not applicable to them
+	-	0

Items to be checked	Evaluation (++/+/#/-/--/0)	Comments
Identification		
◆Brand and type designation	+	
◆Delivery No., version, type No., etc.	+	
◆Expiry date	0	
◆Up-to-date check, for example edition of the handbook coverage of a product version	-	Missing
Producer/ supplier, distributor or other information	-	Missing
◆Address of producer/supplier/service agency	-	Missing
◆Certification references	0	
◆Optional modules, extras	0	
Specification of the product		
◆Functions and range of application	0	
◆Safe and correct use	0	
◆Integrated design of the product and instructions - no compensation for design deficiencies	0 0	
◆Dimensions – mass –capacity	-	Unclear
◆Performance data and conditions	0	
◆Supply data for power, water and other consumables (for example detergents, lubricants)	0	
◆Energy consumption and conditions	0	
◆Emission of noise, gas, waste, radiation, etc. Conditions	0	

◆Information on personal protection for example clothing, goggles	0	
◆Information on dangers to particular groups of persons	-	Missing
◆Information on safe disposal	0	
Preparing the product for use		
◆Safety precautions before installation	0	
◆Unpacking	+	A part list is given
◆Safe disposal of packaging material	0	
◆Installation and assembly (for example special tools, space for maintenance, etc.)	+	
◆Storage and protection during intervals between periods of normal use	0	
◆Repackaging to prevent damage in transport	0	
◆Restrictions on operations by non-qualified persons. Separation of instructions to different groups of persons.	0	
◆Location of instructions	0	
Operating instructions		
➔Basic functions		
◆complete for correct, intended use	-	No operating information
◆complete for safe, intended use	0	
◆complete for reasonably foreseeable misuse	-	Missing. The product looks like a chair
◆conformity with minimum list in relevant product standard(s)	0	
➔Secondary functions	0	
➔Optional modules and extras	0	
➔Personal protection	0	
➔Quick reference instructions	0	
◆by reminder cards, stickers or labels		
◆by reference to handbook, user guidance system on display etc.		
➔Disposal of waste material	0	
Visual and/or audible indications	0	
➔Explanations provided in instructions		
➔Warning notices emphasized		
➔Indications		
◆emitted in time to allow user to take action		
◆clearly seen from user's position		
Maintenance and cleaning	0	
◆Safety precautions (for example protection of persons, special tools)		
◆Preventive maintenance and inspection necessary for safety		

◆Regular checking of warning devices ◆Maintenance and cleaning by users ◆Maintenance and cleaning by qualified persons ◆Trouble-shooting- fault diagnosis, repair ◆Support from agency/manufacturer		
Safety and health information		
➔General safety regulations summarized at the beginning of the instruction material	0	
➔Recognized technical regulations have been observed	0	
➔Clear guidance on what to do and what to avoid is provided	0	
➔Safety warnings /cautions	-	Missing
a) correct location:		
◆on product and/or	-	Missing
◆on packaging and/or	-	Missing
◆in accompanying material	-	Missing
b) if relevant, visibility at the point of sale	0	
c) correct use of terms	0	There is safety message
d) durability of warnings	0	
e) conformity with requirements in relevant product standards	0	
➔Safety signals	0	
➔Information on residual risk	0	
➔Environmental aspects of using the product	0	
➔Product disposal measures	0	
◆summarized in a special chapter ◆repeated in relevant passages of the text ◆disposal/collection points are listed		
Consistency of information		
◆Consistent terminology in all parts	+	
◆Consistent symbols used on the product and in accompanying documents	0	
◆Consistent warning terms used on the product and in accompanying material	0	

Appendix B

The evaluation of original product instructions - delivery quality

The product instructions were examined using these marks:

Very good	Good	Average, just acceptable	Poor	Very poor	Not applicable/not necessary
++	+	#	-	--	0

Items to be checked	Evaluation (++/+/#/-/--/0)	Comments
Legibility		
➔On-product information	--	No on-product label
◆Type size depending on reading distance	0	All parts should be labelled to enable
◆Brightness contrast (needs to be more than 70%)	0	easy assembling
◆Instructions incorporated in material of product	0	
➔Handbooks, manuals, leaflets		
◆paper quality	--	Black type on white poor quality
◆type size	+	paper, in good font size.
◆line spacing	+	
◆use of different typeface, type size etc.	+	
◆captions easy to read	+	
◆brightness contrast (needs to be more than 70%)	+	
◆use of colours	+	
◆general impression of the page is balanced and uncluttered	+	
Electronic media (audio, video, multimedia)	0	
➔Technical equipment		
◆minimum configuration		
◆"best result" configuration		
➔User-friendly system access and easy operation		
◆"How to use these instructions" clause		
◆linear structure in menu guidance and operating buttons		
◆navigation system eases finding answers to user's questions		

◆print utility ◆bookmark option ➔User-friendly design ◆general consistency in titling, high-lighting, fonts, text positioning ◆text(spoken and written) corresponds to video animation ◆duration of sequence and information quantity per unit does not stress the user's perception ◆screen design enables the user to pick up necessary information ◆optimal topic length (at most two screens, paragraphs maximum 20 lines long) ◆complex information broken down into smaller categories with secondary windows to subordinate information ◆helpful emphasis by font, font size, highlighting, colour, contrast and graphics ◆language appropriate to target group ◆graphics, animation and video sequences contribute to the understanding ◆the use of colours is consistent and not system dependant		
Indications ◆Quality and clarity of information provided to user ◆Explanation of signals	0	
Text and terms ➔Text/use of words ◆simple/meaningful ◆short ◆one sentence/ one command ◆active voice ◆action verbs ➔Term used ◆abbreviations explained at first occurrence ◆technical terms defined at first occurrence ◆well explained, understandable for ordinary readers ◆consistent use of terms ➔Structure of text ◆consistently structured ◆structure follows communication principles ◆structure from basic to sophisticated operations/ functions ◆meaningful separation between basic product and optional	 -- -- -- + + -- 0 -- + -- - + 0	 Complicated Long descriptions Too much information in one line Active voice Action verbs Pipes are not marked. Terms not explained Numbers used consistently Very confusing Illogical structure on the assembly instructions/ From basic to complicated

modules ◆informative headings ◆nonsense avoided ➔Communication principles ◆encouraging quick reactions (e.g. simple and easy instructions for an emergency) ◆setting out learning process for complex functions ◆answering the questions Where?Who?What?When?How?Why?	 - -- -- + -	 No heading for the assembly Assembly makes nonsense Difficult to follow Start from the easiest step Explain the basic steps but its confusing which part of the product is involved in each step.
Language ➔Information given in appropriate language(s) ➔Clear differentiation of languages ➔Clear connection between text and illustrations ➔Clear pronunciation (audio) ➔Absence of linguistic errors	 + 0 - 0 +	 It is in English. There is only one language No obvious connection No linguistic error observed
Illustrations ➔General quality ➔Sufficient number of illustrations for each one to provide clear and specific information ➔Illustrations supported by clear and helpful captions	 -- -- --	 Very poor Illustrations are unrecognisable No caption
Graphic symbols ◆internationally standardized where possible ◆clearly understandable or explained	0	
Figures ◆sized according to purpose ◆clear (i.e. same information –same structure) ◆text within figures clearly arranged and consistently used ◆figures and text that belong together shall appear close to each other	0	
Tables ◆approximately located ◆clearly set out and informative ◆repeated where necessary	0	
Flow-charts ◆provided where appropriate ◆supported with clear and helpful captions/ text	0	

◆adjacent to the text to which they belong		
Use of colours ◆functional ◆clear ◆consistent	 ++ + +	 The consistent use of black colour is functional and clear
Table of contents/ index ◆appropriate to length and complexity of text ◆headings identical to those in the text ◆clear, consistent and helpful ◆list of keywords if helpful ◆numbered pages	0	The instruction manual is less than four pages long
Trouble- shooting advice ➔Checklist of possible faults with repair instructions(paying due regard to safety) ➔Clear indication whether or not users can attempt repairs themselves	0	It is a simple product and there is no need for trouble shooting
Durability ➔Adequate provision against loss and deterioration in expected (normal) use	 --	 Adequate provision against loss is not mentioned and the instructions are printed on poor quality paper.
Target users ➔Target group is mentioned ➔Representation of contents is suitable for target group		
General performance		
◆clearly identify the product; ◆recognise the type of user and his/her capabilities; ◆provide all necessary information for correct and safe use of the product; ◆present warnings about hazards or restrictions effectively; ◆provide special handling information, warning notices for particular groups when necessary; ◆give information on the year of manufacture and/or of expiry and warning for products with a limited safe or effective life; ◆be readily available at the point of sale if they are necessary to make a reasoned purchasing decision among products; ◆be consistent with all other material about the same product such as advertising or packaging.	# - -- - 0 0 0 0	Basic information is presented; Lack of manufacturer's information. Not considered. The illustrations are poor and text is not clear. No warning message.

Appendix C

A checklist for planning the instruction contents

The product instructions were examined using these marks:

fulfilled/covered by the instructions being assessed	not fulfilled/covered by them	not applicable to them
+	-	0

Items to be checked	Evaluation (++/+/#/-/--/0)	Comments
Identification		
◆Brand and type designation	+	
◆Delivery No., version, type No., etc.	+	
◆Expiry date	0	
◆Up-to-date check, for example edition of the handbook coverage of a product version	+	Add updating information
◆Producer/ supplier, distributor or other information	+	Distributor information
◆Address of producer/supplier/service agency	+	Address and other contacts
◆Certification references	0	
◆Optional modules, extras	0	
Specification of the product		
◆Functions and range of application	0	
◆Safe and correct use	0	
◆Integrated design of the product and instructions - no compensation for design deficiencies	0 0	
◆Dimensions – mass –capacity	+	Dimensions
◆Performance data and conditions	0	
◆Supply data for power, water and other consumables (for example detergents, lubricants)	0	
◆Energy consumption and conditions	0	
◆Emission of noise, gas, waste, radiation, etc. Conditions	0	
◆Information on personal protection for example clothing, goggles	0	
◆Information on dangers to particular groups of persons	+	Not for children
◆Information on safe disposal	0	

Preparing the product for use		
◆Safety precautions before installation	0	
◆Unpacking	+	A part list
◆Safe disposal of packaging material	0	
◆Installation and assembly (for example special tools, space for maintenance, etc.)	+	Assembly instruction
◆Storage and protection during intervals between periods of normal use	0	
◆Repackaging to prevent damage in transport	0	
◆Restrictions on operations by non-qualified persons. Separation of instructions to different groups of persons.	0	
◆Location of instructions	0	
Operating instructions		
➔Basic functions		
◆complete for correct, intended use	+	Operating information(how to adjust)
◆complete for safe, intended use	0	
◆complete for reasonably foreseeable misuse	+	Avoid using the product looks as a
◆conformity with minimum list in relevant product standard(s)	0	chair
➔Secondary functions	0	
➔Optional modules and extras	0	
➔Personal protection	0	
➔Quick reference instructions	0	
◆by reminder cards, stickers or labels		
◆by reference to handbook, user guidance system on display etc.		
➔Disposal of waste material	0	
Visual and/or audible indications	0	
➔Explanations provided in instructions		
➔Warning notices emphasized		
➔Indications		
◆emitted in time to allow user to take action		
◆clearly seen from user's position		
Maintenance and cleaning	0	
◆Safety precautions (for example protection of persons, special tools)		
◆Preventive maintenance and inspection necessary for safety		
◆Regular checking of warning devices		
◆Maintenance and cleaning by users		
◆Maintenance and cleaning by qualified persons		

◆Trouble-shooting- fault diagnosis, repair ◆Support from agency/manufacturer		
Safety and health information ➔General safety regulations summarized at the beginning of the instruction material ➔Recognized technical regulations have been observed ➔Clear guidance on what to do and what to avoid is provided ➔Safety warnings /cautions a) correct location: ◆on product and/or ◆on packaging and/or ◆in accompanying material b) if relevant, visibility at the point of sale c) correct use of terms d) durability of warnings e) conformity with requirements in relevant product standards ➔Safety signals ➔Information on residual risk ➔Environmental aspects of using the product ➔Product disposal measures ◆summarized in a special chapter ◆repeated in relevant passages of the text ◆disposal/collection points are listed	0 0 0 + + 0 + 0 0 0 0 0 0 0 0	 Low level warning Add labels Should be given but not related to this research
Consistency of information ◆Consistent terminology in all parts ◆Consistent symbols used on the product and in accompanying documents ◆Consistent warning terms used on the product and in accompanying material	 + 0 0	 Parts name

Appendix D

Diagnostic testing of the revised printed instruction – task analysis

	Ideal solution	Acceptable solution	Possible errors
1. Preparing the product for assembly			
1.1 Unpacking 1.2 Matching every part to instructions	Taking everything Checking everything	Checking during assembling	Missing parts Mismatching
2. Assembling the product			
➔2.1 Making the frame base ◆2.1.1 Preparing A(L)", "A(R)", "B"× 2; 2.1.1.1 -finding A(L) 2.1.1.2 -positioning A(L) 2.1.1.3 -finding A(R) 2.1.1.4 -positioning A(R) 2.1.1.5 -finding "B" × 2 2.1.1.6 -positioning "B" × 2 ◆2.1.2 Connecting "C"× 2 to "A"legs and "B"legs; 2.1.2.1 -finding "C" × 2 2.1.2.2 -positioning "C" × 2 2.1.2.3 -connecting first "C" and A(L) 2.1.2.4 -tighten the knobs 2.1.2.5 -connecting first "C" and "B" 2.1.2.6 -tighten the knobs 2.1.2.7 -connecting second "C" and A(R) 2.1.2.8 -tighten the knobs 2.1.2.9 -connecting second "C" and "B" 2.1.2.10 -tighten the knobs ◆2.1.3 Connecting "D" legs to A"legs and "B"legs; 2.1.3.1 -finding "D" × 2 2.1.3.2 -connecting one "D" and A(L) 2.1.3.3-tighten the knobs	**Making the frame base in designed order** ◆Right parts facing correct directions; ◆Right parts are fixed in the right joints; Parts are safely fitted into each other; Knobs are tightened; ◆Right parts are fixed in the right joints; Parts are safely fitted into each	**Making base in any order**	◆Using wrong parts; Right parts facing wrong directions; ◆Connecting wrong legs; Connecting right legs in wrong joints; Parts do not sit into a secure position; Knobs are not tightened properly; ◆Connecting wrong legs; Connecting right legs in wrong joints; Parts do not sit into a secure position; Knobs are not tightened properly;

2.1.3.4 -connecting one “D” and A(R) 2.1.3.5 -tighten the knobs 2.1.3.6-connecting “B” and “B” 2.1.3.7-tighten the knobs	other; Knobs are tightened;		
➔2.2 Finishing the frame			
◆2.2.1 Fixing “E” tubes to “A” legs and “B” legs; 2.2.1.1 -finding “E(L)” 2.2.1.2 -finding “E(R)” 2.2.1.3 -fixing “E(L)” above A(L) and B 2.2.1.4 -tighten the knobs 2.2.1.5 -fixing “E(R)”above A(R) and B 2.2.1.6 -tighten the knobs	◆Right parts are fixed safely; Knobs are tightened;		◆Using wrong parts; Parts do not sit into a secure position; Knobs are not tightened properly; ◆Swapping “F(L)”&“F(R)”;
◆2.2.2 Fixing “F” × 2 onto “E” × 2; 2.2.2.1 -finding “F(L)” 2.2.2.2 -finding “F(R)” 2.2.2.3 -positioning “F(L)” 2.2.2.4 -positioning “F(R)” 2.2.2.5 -fixing “F(L)” onto the end of“E(L)” 2.2.2.6 -tighten the knobs 2.2.2.7 -fixing “F(R)” onto the end of“E(R)” 2.2.2.8 -tighten the knobs	◆Right parts are fixed safely; Handles on “F” × 2 facing out; Both shorter sides of “F” × 2 are connected to “E” × 2; Knobs are tightened;	◆Handles on “F” × 2 facing out; Both longer sides of “F” × 2 are connected to “E” × 2;	One longer side and one shorter side of “F” × 2 is connected to “E” × 2; ◆Using wrong parts; Parts do not sit into a secure position; Knobs are not tightened properly;
◆2.2.3 Fixing “G” × 2 onto “F” × 2; 2.2.3.1 -finding “G”× 2 2.2.3.2 -fixing one“G” onto the end of“F(L)” 2.2.3.3 -tighten the knobs 2.2.3.4 -fixing one “G” onto the end of“F(R)” 2.2.3.5 -tighten the knobs	◆Knobs on “E” facing backside; Parts are fixed safely; Knobs are tightened;	◆Knobs on “E” facing front side;	◆Using wrong parts; Parts do not sit into a secure position; Knobs are not tightened properly. ◆Same as above
◆2.2.4 Fixing one “H” onto end of “G” × 2; 2.2.4.1 -finding one “H” 2.2.4.2 -using “H” to connect “G” × 2 2.2.4.3 -tighten the knobs ◆2.2.5 Fixing “I” × 2 onto the front side of “A” × 2; 2.2.5.1 -finding “I”× 2 2.2.5.2 -fixing one“I” onto “A(L)”	◆Right parts are fixed safely; Knobs are tightened; ◆Right parts are fixed safely; Knobs are tightened.		◆Same as above

2.2.5.3 -tighten the knobs 2.2.5.4 -fixing another “I” onto “A(R)” 2.2.5.5 -tighten the knobs ◆2.2.6 Using another “H” to connect “I” × 2. 2.2.6.1 -finding “H” 2.2.6.2 -using “H” to connect “I” × 2 2.2.6.3 -tighten the knobs	◆Right parts are fixed safely; Knobs are tightened.		
➔2.3 Fixing the top sheet			
◆2.3.1 Placing plastic “J” onto the top of the finished frame; 2.3.1.1 -finding “J” 2.3.1.2 -identifying the upper side of “J” 2.3.1.3 -putting the rough side up 2.3.1.4 -placing “J” onto the top of the finished frame ◆2.3.2 Using “K” × 8 to hold “J”. 2.3.2.1 -finding “K”× 8 2.3.2.2 -positioning “K” clips 2.3.2.3 -attaching “K” clips to hold “J”	◆Rough side of “J” facing up;		◆Smooth side of “J” facing up;
➔2.4 Attaching the accessory			
◆2.4.1 Attaching “L” to any position on the frame. 2.4.1.1 -finding “L” 2.4.1.2 -positioning “L” 2.4.1.3 - tighten “L”	◆Attaching “L” to the front side of “D”. “L” is fitted tightly.	◆Attaching “L” to any position on the frame.	◆ “L” is loose.
3. Adjusting the product for photo shooting			
➔3.1 Adjust the angle of the top panel; 3.1.1 -loosening “F(L)” 3.1.2 -loosening “F(R)” 3.1.3 -resetting the angle of the top panel 3.1.4 -tighten “F(L)” 3.1.5 -tighten “F(R)”	Top panel is adjusted to a new angel; Two sides of the top are on the same horizontal level; The panel is tight.		Two sides of the top are not balanced; The panel is not tightened properly.

Appendix E

Diagnostic testing results of the revised printed instruction

Start time	Duration(s)	Thinking activity	Physical activity	Contents
0.00	12	Statement of intention	Reading instructions	If I start off by simply taking the "A" parts, and find those first.
0.12	8		Action	Err…
0.20	5	Considering		B…There suppose to be two "B"s
0.25	4	Solution found		Ah…look, that's B…
0.29	3	Considering		Ahh…Let's see…
0.32	4		Action	Silence
0.36	4	Solution found		That's a "B".
0.40	9		Action	B…Ems……
0.49	1	Solution found		That's a "B".
0.50	7	Statement of intention		Two of those. And there should be two "C"s.
0.57	5	Considering		Which… No . That's doesn't fit these.
1.02	5	Solution found		Err…m. Those are "E"s
1.07	3		Action	And "C"s…
1.10	6	Decision made		In fact, obviously, if they have marked. I can…
1.16	5		Action	Silence
1.21	6	Statement of intention		I don't really have to follow them, as I know they are coming in order.
1.27	11		Action	"C"…"G"…"G" which come after..will come. "H"…That's a"G",as welll.
1.38	18		Action	Err…Yeah. Those are "G"s, these are "D"s. That's a"D". That must be a "D". That's…a"E".And that's a "E".
1.56	7	Solution found		These are "G"s, hr..these are "H"es.
2.03	1	Statement of problems		So, I have no "F"s.
2.04	3		Action	Err…
2.07	2	Solution found		Arh. Yeah. There is a "F".
2.09	11	Confusion		And…that's…and .. That's.. Is this it? It's… en… is it a "F"? Em?
2.20	3	Solution found		Oh. That's a "F".
2.23	1	Solution found		And that's "G".
2.24	2		Action	Silence
2.26	3	Confusion		Those are for whatever. I don't know what those are.
2.29	4		Action	err……em…
2.33	7	Considering		"G","H" and an "I", and an "I",
2.40	4	Considering		That's a "L", so there must be a "J" somewhere. And that's a "L".
2.44	6	Considering		Em..Oh…We are on the….
2.50	10	Considering		So I've got my two "A"s, two "B"s with two "C"s, two "D"s, two "E"s.
3.00	3		Action	Arh…
3.03	6	Considering		"F"s, I've got those."G"…
3.09	7	Considering		I've got those "H". I've got those "I". I've got those…
3.16	4	Solution found		That's J. I assume.
3.20	5		Action	Arh… K…Err……K…
3.25	2	Solution found		Oh,yes. That's those things.
3.27	3	Solution found		And in the end "L".
3.30	6		Action	Well…
3.36	3		Action	L…
3.39	9	Confusion		Em. That is says here. According to this, there is only one L, but I've got two.
3.48	7		Action	Silence
3.55	12	Solution found		Ok..Ok..SO…OK.
4.07	6	Decision made		Well, I've got two rather that one, That's OK. That's not a problem.
4.13	5	Statement of intention		Right. Now...so I turn around. This is my list. So I 'v got my parts.
4.18	7	Statement of intention		It says so, prepare "AL"and "A" right.
4.25	3		Action	Err…
4.28	1		Action	"B" one and two.
4.29	1	Solution found		Ok.
4.30	3	Considering		So. If I..
4.33	2	Considering		A and B
4.35	1	Decision made		Right
4.36	7	Statement of intention		So. "B"s, if I….move along those a bit.
4.43	4		Action	Silence
4.47	5	Solution found		They are in order
4.52	2	Statement of intention		Keep things tidy up abit.
4.54	3		Action	Silence
4.57	7	Considering		And…right.I'v got A.And there's my two"B"s there.
5.04	3		Action	Silence
5.07	5	Considering		Right, and my two "A"s. So …
5.12	8	Solution found		"A" left and "A"right. OK
5.20	5		Reading instructions	And use C to connect "A "right and "B right".
5.25	2	Statement of intention		So I take "C"s
5.27	3		Reading instructions	now…
5.30	10		Reading instructions	I got the… I think… Yeah…. Yes… Em…
5.40	12	Confusion		This is interesting because I am not quite certain whether be like that or…or like that…
5.52	8	Considering		I think it got to be like that… It could be like that…So it's got to be like this…
6.00	6	Decision made		What I can do , perhaps is to work down here to see what…
6.06	6		Reading instructions	Aha,something goes…something goes on there… something goes…
6.12	5	Considering		Right, so therefore… must…em….
6.17	15	Considering		Err…right. If I look down here, I can see there has to be something here. So therefore…
6.32	8		Action	Silence
6.40	7	Considering		No, it's the only way around. So it has to be…
6.47	8	Confusion		Oh,Gosh…oh…em…
6.55	4	Statement of feelings		This is…this is difficult.
6.59	4	Statement of intention		I am just trying to figure it out which way around.
7.03	7	Decision made		This one is B, I think. I THINK it's this way.
7.10	10	Statement of intention		So I am going to go for it. And hope… That's…hang on…correct
7.20	4		Action	Silence
7.24	5	Solution found		Everything fits now. Nice and easy.
7.29	7		Action	Silence
7.36	4	Statement of problems		Oh… The wrong way.
7.40	6		Action	Silence
7.46	9	Considering		That can't be right. I put that side sticking in the wrong way.
7.55	2	Considering		Things like that I think.
7.57	15	Considering		Em…
8.12	2	Confusion		Oh, god. Err…
8.14	40		Action	Silence
8.54	3	Considering		That can not be correct.
8.57	4	Considering		This bit has got a tune. It got to be coming in here.
9.01	11	Statement of intention		So I've done that wrong. I'll turn around again. I think it's going to be correct this time.
9.12	68		Action	Em…
10.20	5	Solution found		Ok. Right
10.25	18		Reading instructions	Silence
10.43	3	Solution found		We worked around now. I think.
10.46	65		Action	Silence
11.51	13	Solution found		Again I feel confident now. I hope that's not a mistake
12.04	16		Reading instructions	Ok…
12.20	10		Action	Silence
12.30	8	Statement of intention	Reading instructions	Just to check, to make sure there are tubes around in the right way.
12.38	2	Solution found		Yes. Yeah.
12.40	42	Solution found		I can see quite clearly but, it just has to be further out.
13.22	2	Solution found		That's fine.
13.24	28		Action	Silence
13.52	6	Statement of feelings		I am actually feeling quite confident now.
13.58	6		Reading instructions	ah…This is relatively easy.
14.04	11	Statement of intention		So I take the two "F"s. And fix those on
14.15	25	Considering		Em…Em! That got to be…right. F. This is… Right…It's A. A left and A right. So this is… This one should be at
14.40	15	Considering		The only problem I can see is that… So doesn't matter which end is up because we can change it around
14.55	30	Considering		This is front right. Dose it? Front right…
15.25	17	Confusion	Reading instructions	A little bit confused here. Simply because according to this, this part should be out, and therefore…
15.42	2	Decision made		yes, therefore it must going like that. Yes.
15.44	6		Action	Silence
15.50	7	Decision made		Let's just get it on and see what happens. I think. I think it suppose to go like this.
15.57	15		Action	Silence
16.12	8		Action	I am feeling quite confident as I was a few minutes ago. And I think… I think that's all right.
16.20	5	Considering		This is …
16.25	8		Reading instructions	Em…
16.33	2	Considering		Ar. Wait a minute.
16.35	10	Decision made		Arh. I think that's wrong. I've done that wrong. This is… that…
16.45	5	Decision made		So…that must be like this.
16.50	12		Action	Silence
17.02	2	Solution found		Well…gonna...hey…I did it in the wrong way.
17.04	29		Action	Silence
17.33	7	Solution found		That's… arh, that's just you can take it off and you can use it to reposition.
17.40	4	Solution found		Hey, that must be right. I think.
17.44	14	Statement of intention	Reading instructions	Now, I use G, the two "G"s here, and it doesn't matter which side it is.
17.58	5		Action	Silence
18.03	4	Solution found		That'd it. That's nice and easy.
18.07	23		Action	Silence
18.30	22		Reading instructions	And I put a "H"… I put a "H"… I fix one "H"
18.52	14		Action	So I put one "H", and fix it across…
19.06	19	Statement of problems	Reading instructions	So… It doesn't specify whether these are… But according to the map,accroding to the plan, it should be
19.25	10	Considering		But it seems to me the screws on the plan is facing backwards. So therefore it should be that way around.
19.35	5	Considering		I don't know if that matters or not, but that's it according to the plan.
19.40	32		Action	Silence
20.12	13		Reading instructions	Ok, and then we fix the "I" tubes onto the front side of the "A "legs.
20.25	8	Statement of intention		So, that will go in here.
20.33	4		Action	Silence
20.37	14	Considering		Ah...if it's two ways to tight things up, I always go the wrong way.
20.51	13		Action	Silence
21.04	19	Confusion		Now that screw is down and that screw is up. Is that going to cause a problem?
21.23	2	Statement of intention		Well, let's run with it.
21.25	24	Confusion		And if I get a problem, I just wonder why one is up and one is down. If I haven't made a mistake, then, that
21.49	16	Decision made	Reading instructions	Never mind. Here you are. Then I can't actually see the screws on the plan so I don't know whether that's
22.05	7	Statement of intention		It is another "H" to connect the "I" tubes.
22.12	9	Considering		Doesn't seems to be really matter if one is up and one is down. Just seems to be strange.
22.21	4		Action	Silence
22.25	8	Decision made	Action	Going to assume there must be a reason for it. Maybe I'll find out later… if anything goes wrong.
22.33	15		Action	Silence
22.48	8	Statement of intention	Reading instructions	Okay… put the translucent plastic "J"on the top of the frame.
22.56	22	Considering		Em…first of all, what I could do is, actually is… Err... the spare labels are suppose to make sure that these are
23.18	5	Solution found		Arh, so it doesn't matter because as long as I can tight it at the position I want.
23.23	6	Decision made		So I'll take it to that position for the moment and that's it.
23.29	5	Statement of intention		So, then take the translucent sheet "J" .
23.34	5	Confusion		Now, which side?
23.39	20	Decision made		I assume, I assume it is the shiny side that goes up. Em, there is a rough texture. So let us assume it is the
23.59	7		Action	Silence
24.06	3	Considering		So this way is… It's this thing, isn't it?
24.09	5	Confusion	Reading instructions	Ah, hang on…How can I ?
24.14	8		Reading instructions	Put this on top of the frame. Use the "K" clips to hold "J" tightly.
24.22	9	Considering		The "K" clips. The "K"…"K" clips, eight.
24.31	2	Solution found		That's these.
24.33	11	Statement of intention		So therefore … I am literaturely just sitting it on top
24.44	9		Action	Silence
24.53	6	Statement of feelings		Mmm… This is me being... my usual comes itself
24.59	10	Statement of intention		Well, what I'll do is I'll lid it on there. I'll get it connected up to the top, first of all.
25.09	17		Action	Silence
25.26	13	Statement of intention		If I put $%^& *&* that. Move across abit.
25.39	66		Action	Silence
26.45	11	Confusion		Arh,god. It's a……
26.56	20		Action	Silence
27.16	20	Statement of feelings		I don't like this bit. Its what it is. it says just lid it on top, but that's easier says than done. There should… it
27.36	10	Statement of feelings		It's just me being awkward. It's not… it should be a easier thing. I'm doing something stupid. Am I?
27.46	12	Solution found		Turn it around.Ah...While, that's, that's… Ah, right. That's what I said at the beginning was it… I couldn't work it
27.58	24	Statement of problems		Which way was up? I thought was the…I thought it might be this move bit that was to go up, but I was wrong.
28.22	10		Action	Silence
28.32	7	Statement of intention		Okay, let's see if we are getting %^&*(further...
28.39	11		Action	Silence
28.50	10	Statement of feelings		Yes, I should have looked at it, but that again, simple for the design to told me .
29.00	16	Considering		Silence
29.16	14	Statement of feelings		I think this is the most awkward part. Everything else has been very straight forward, but this part seems a little
29.30	7	Solution found		En… It's more or less connect.
29.37	31		Action	Silence
30.08	4	Decision made		I think I've put those on up side down but I don' think it matters.
30.12	8	Considering		Yeah, I think it's probably suppose to be that way around but I don't think it necessary matter. Dose it say it in
30.20	6	Solution found		Err… Yes, it dose.
30.26	15	Considering		While the indicates, it indicates it should be that way around.
30.41	4	Statement of intention		I am moving it, correcting it.
30.45	44		Action	Silence
31.29	6	Considering		Well, I'm soon to be…
31.35	6		Action	Silence
31.41	14		Reading instructions	Attach clips "L" to any required position.
31.55	11	Confusion		What are they for?
32.06	11	Decision made		Ok, so I can put them on anywhere and then they'll just shift it later. And presumably, they go on…
32.17	24	Solution found		Yap, well, it doesn't matter for the moment until the photographer comes along.
32.41	1	Statement of intention		So I won't put them on too tight then.
32.42	35		Action	Silence
33.17	7	Considering	Tasks accomplished	I think…
33.24	9	Considering		Silence
33.33	2	Statement of intention		Adjust the angle? OK.
33.35	11		Action	Silence
33.46	8	Considering		Ar…I think…ar…
33.54	10	Considering		If I adjust the angle, maybe it appear that I have to loosen them all again and adjust this.
34.04	16	Statement of intention		So I'll adjust the angle, tight it back up. Take these off, unfortunately, this is the bit I didn't like.
34.20	38		Action	Silence
34.58	2	Statement of problems		I am going to make this mistake again.
35.00	4		Action	Silence
35.04	30	Comments on the		Perhaps it actually would be easier and more $%^& the angle. I just wish... it was slightly.... If it actually had a
35.34	46		Action	Silence
36.20	7	Statement of problems		I am not going to be able to… look after and clamp it, I am not be able connect it at the bottom.
36.27	5	Statement of problems		So I've done something wrong and I don't know what it is.
36.32	7	Considering		Or is it simply a design fault?
36.39	53	Decision made		So therefore if I was trying to use this, I would simply attach it there, there, there, there and there. And then I'll
37.32			Tasks accomplished	

Appendix F

Diagnostic testing of the multimedia instruction- task analysis

	Ideal solution	Acceptable solution	Possible errors
1. Finding general information			
1.1 Locating information 1.2 Reading information	Locating quickly Reading correctly	Locating slowly	Cannot locate Reading incorrectly
2. Preparing the product for assembly			
2.1 Unpacking 2.2 Matching every part to instructions	Taking everything Checking everything	Checking during assembling	Missing parts Mismatching
3. Assembling the product			
➔3.1 Making the frame base ◆3.1.1 Preparing A(L)", "A(R)", "B"× 2; 3.1.1.1 -finding A(L) 3.1.1.2 -positioning A(L) 3.1.1.3 -finding A(R) 3.1.1.4 -positioning A(R) 3.1.1.5 -finding "B" × 2 3.1.1.6 -positioning "B" × 2 ◆3.1.2 Connecting "C"× 2 to "A"legs and "B"legs; 3.1.2.1 -finding "C" × 2 3.1.2.2 -positioning "C" × 2 3.1.2.3 -connecting first "C" and A(L) 3.1.2.4 -tighten the knobs 3.1.2.5 -connecting first "C" and "B" 3.1.2.6 -tighten the knobs 3.1.2.7 -connecting second "C" and A(R) 3.1.2.8 -tighten the knobs 3.1.2.9 -connecting second "C" and "B" 3.1.2.10 -tighten the knobs ◆3.1.3 Connecting "D" legs to A"legs and "B"legs; 3.1.3.1 -finding "D" × 2 3.1.3.2 -connecting one "D" and A(L)	**Making the frame base in designed order** ◆Right parts facing correct directions; ◆Right parts are fixed in the right joints; Parts are safely fitted into each other; Knobs are tightened; ◆Right parts are fixed in the right joints; Parts are safely	**Making base in any order**	◆Using wrong parts; Right parts facing wrong directions; ◆Connecting wrong legs; Connecting right legs in wrong joints; Parts do not sit into a secure position; Knobs are not tightened properly; ◆Connecting wrong legs; Connecting right legs in wrong joints; Parts do not sit into a secure position; Knobs are not

3.1.3.3-tighten the knobs 3.1.3.4 -connecting one “D” and A(R) 3.1.3.5 -tighten the knobs 3.1.3.6-connecting “B” and “B” 3.1.3.7-tighten the knobs	fitted into each other; Knobs are tightened;		tightened properly;
➔3.2 Finishing the frame			
◆3.2.1 Fixing “E” tubes to “A” legs and “B” legs; 3.2.1.1 -finding “E(L)” 3.2.1.2 -finding “E(R)” 3.2.1.3 -fixing “E(L)” above A(L) and B 3.2.1.4 -tighten the knobs 3.2.1.5 -fixing “E(R)”above A(R) and B 3.2.1.6 -tighten the knobs	◆Right parts are fixed safely; Knobs are tightened;		◆Using wrong parts; Parts do not sit into a secure position; Knobs are not tightened properly; ◆Swapping “F(L)”&“F(R)”;
◆3.2.2 Fixing “F” × 2 onto “E” × 2; 3.2.2.1 -finding “F(L)” 3.2.2.2 -finding “F(R)” 3.2.2.3 -positioning “F(L)” 3.2.2.4 -positioning “F(R)” 3.2.2.5 -fixing “F(L)” onto the end of“E(L)” 3.2.2.6 -tighten the knobs 3.2.2.7 -fixing “F(R)” onto the end of“E(R)” 3.2.2.8 -tighten the knobs	◆Right parts are fixed safely; Handles on “F” × 2 facing out; Both shorter sides of “F” × 2 are connected to “E” × 2; Knobs are tightened;	◆Handles on “F” × 2 facing out; Both longer sides of “F” × 2 are connected to “E” × 2;	One longer side and one shorter side of “F” × 2 is connected to “E” × 2; ◆Using wrong parts; Parts do not sit into a secure position; Knobs are not tightened properly;
◆3.2.3 Fixing “G” × 2 onto “F” × 2; 3.2.3.1 -finding “G”× 2 3.2.3.2 -fixing one“G” onto the end of“F(L)” 3.2.3.3 -tighten the knobs 3.2.3.4 -fixing one “G” onto the end of“F(R)” 3.2.3.5 -tighten the knobs	◆Knobs on “E” facing backside; Parts are fixed safely; Knobs are tightened;	◆Knobs on “E” facing front side;	◆Using wrong parts; Parts do not sit into a secure position; Knobs are not tightened properly. ◆Same as above
◆3.2.4 Fixing one “H” onto end of “G” × 2; 3.2.4.1 -finding one “H” 3.2.4.2 -using “H” to connect “G” × 2 3.2.4.3 -tighten the knobs	◆Right parts are fixed safely; Knobs are tightened;		◆Same as above
◆3.2.5 Fixing “I” × 2 onto the front side of “A” × 2; 3.2.5.1 -finding “I”× 2	◆Right parts are fixed safely; Knobs are tightened.		

3.2.5.2 -fixing one“I” onto “A(L)” 3.2.5.3 -tighten the knobs 3.2.5.4 -fixing another “I” onto “A(R)” 3.2.5.5 -tighten the knobs	◆Right parts are fixed safely; Knobs are tightened.		
◆3.2.6 Using another “H” to connect “I” × 2. 3.2.6.1 -finding “H” 3.2.6.2 -using “H” to connect “I” × 2 3.2.6.3 -tighten the knobs			
➔3.3 Fixing the top sheet			
◆3.3.1 Placing plastic “J” onto the top of the finished frame; 3.3.1.1 -finding “J” 3.3.1.2 -identifying the upper side of “J” 3.3.1.3 -putting the rough side up 3.3.1.4 -placing “J” onto the top of the finished frame	◆Rough side of “J” facing up;		◆Smooth side of “J” facing up;
◆3.3.2 Using “K” × 8 to hold “J”. 3.3.2.1 -finding “K”× 8 3.3.2.2 -positioning “K” clips 3.3.2.3 -attaching “K” clips to hold “J”			
➔3.4 Attaching the accessory			
◆3.4.1 Attaching “L” to any position on the frame. 3.4.1.1 -finding “L” 3.4.1.2 -positioning “L” 3.4.1.3 - tighten “L”	◆Attaching “L” to the front side of “D”. “L” is fitted tightly.	◆Attaching “L” to any position on the frame.	◆ “L” is loose.

Appendix G

Diagnostic testing results of the multimedia instruction

Start time	Duration(s)	Thinking activity	Physical activity	Contents
0.00	15		Action	Silent
0.15	5		Reading instructions	That was easy. Get the…em... alot of information.
0.20	5		Reading instructions	Contact, email...
0.25	1	Solution found		Yes
0.26	17		Action	Silent
0.43	8		Action	……com.hk
0.51	4	Statement of feelings		so that was easy
0.55	5		Reading instructions	dimensions of assembled product...
1.00	24		Action	yes, set up dimensions…130 and 60 cms.back is 60 cms.
1.24	4	Solution found		That gives me a good idea of the scale.
1.28	3	Statement of feelings		It was easy to find instructions
1.31	2	Statement of intention		Look back into the drop down menu.
1.33	5	Statement of intention		And…and check all parts of the product.
1.38	3	Solution found		So I've got the parts list here.
1.41	32		Action	Silent
2.13	18	Considering		I've got three compartments here. So I assume they should bring things from compartments.
2.31	4		Action	and keep them separate initially.
2.35	38		Action	Silent
3.13	3	Solution found		Now, there is pocket down there.
2.16	7	Statement of intention		So I'll put these…
3.23	12	Solution found		I think that's all the parts, of course , this was come out of three containers.
3.35	11		Reading instructions	So, A, please check all parts according to the parts list. Move over a part to see a larger picture.
3.46	6		Reading instructions	So. parts list, 50 cm legs.
3.52	5	Considering		50 cm legs, which I got two.
3.57	1		Action	6 sets on them.
3.58	2	Considering		How many of these do we have?
4.00	4	Considering		Now, I suppose…
4.04	6		Action	Silent
4.10	1	Considering		I've got…
4.11	5		Action	Silent
4.16	8		Reading instructions	Silent
4.24	5	Solution found		Ah…right.
4.29	7	Solution found		I can see now there are letters on these.
4.36	4	Statement of intention		So, I'm looking for…
4.40	4	Solution found		that's B…
4.44	3		Action	and…
4.47	4	Statement of problems		there should be another one… like that.
4.51	4		Action	This is A.
4.55	3		Action	That's a B.
4.58	4		Action	That's an A.
5.02	3	Solution found		right.
5.05	7	Considering		so… that's a B.
5.12	10		Reading instructions	So, B comes to the….
5.22	5	Statement of intention		So I should get A left,
5.27	1	Solution found		That's A left.
5.28	11	Considering		There should be an A right, which look something like that, I assumes.
5.39	1	Solution found		That's a B.
5.40	7		Action	Silent
5.47	4	Considering		I have got an A left
5.51	12		Action	Silent
6.03	4	Considering		I haven't got an A right.
6.07	5	Confusion		So, why was that. Have I miss something in it?
6.12	11		Action	Silent
6.23	5		Reading instructions	A, A left, A right
6.28	5	Decision made		let's carry on. Times two, two Bs.
6.33	9	Considering		I've got one B, and another B.
6.42	2	Solution found		Ah! A right.
6.44	4	Statement of feelings		Ah, getting it now.
6.48	4	Statement of intention		B, two Bs.
6.52	5	Statement of feelings		Right… So, I'm fine so far.
6.57	5		Reading instructions	C, supporting rods, times two.
7.02	9		Action	Silent
7.11	3	Solution found		C...C, supporting rods, times two.
7.14	8		Action	Silent
7.22	4		Reading instructions	D… supporting rods, times two.
2.26	11		Action	Silent
7.37	5		Reading instructions	E, 60 cm tubes
7.42	13	Solution found		E,right and E left.
7.55	8		Reading instructions	Tilting brackets, F
8.03	8		Action	right and left.
8.11	17	Solution found		Two Gs, which are those.
8.28	10	Solution found		Two Hs, which must be these.
8.38	4		Action	Silent
8.42	14		Reading instructions	Is, which are those
8.56	9		Reading instructions	Plastic sheets, which are there. Clips, 1,2,3,4,5,6,7,8.
9.05	6	Solution found		1,2,3,4,5,6,7,8. Correct.
9.11	5	Solution found		And one clump, which is there.
9.16	2	Solution found		Okay, we've got everything.
9.18	5	Statement of intention		So…Assembling.
9.23	23		Reading instructions	Silent
9.46	23		Action	Silent
10.09	3		Reading instructions	Silent
10.12	16		Action	Silent
10.28	28		Reading instructions	Silent
10.56	87		Action	C…
12.23	5	Considering		Ok, I had to…I hope I got that right, but I know I haven't got that right.
12.28	5	Statement of intention		those…So I'll take that one out.
12.33	8	Decision made		those got to face…outside.
12.41	2	Solution found		That's better, I think.
12.43	4		Action	Silent
12.47	2	Statement of intention		And I'm going to change…
12.49	7	Statement of feelings		I'll probably regret this, but I recon the logic tells me…
12.56	5	Statement of feelings		Do I have logic?
13.01	6	Statement of intention		I am going to try to pretend that I've got some logic.
13.07	13		Action	Silent
13.20	6	Considering		Ah, mind you I can… I can't turn that around.
13.26	4	Statement of problems		Obviously I have made a mistake.
13.30	10	Considering		Perhaps not. Perhaps not.
13.40	4	Decision made		Let's see what happens at stage three
13.44	29		Reading instructions	Silent
14.13	4	Statement of feelings		I think I'm okay.
14.17	26		Action	Silent
14.43	25		Reading instructions	Silent
15.08	5		Action	Silent
15.13	5	Statement of intention		This is E right. I'll put it on here.
15.18	9		Action	Silent
15.27	14		Action	E left…put on here.
15.41	6	Confusion		Ah! Why wouldn't I be able to…Where was those two?
15.47	2		Reading instructions	
15.49	5	Solution found		A, that's right. Erm… Yeah.
15.54	2	Statement of intention		Those got to point to the same direction.
15.56	10	Solution found		So…which make sense.
16.06	26		Action	Silent
16.32	4	Considering		Now, so the next step?
16.36	3		Reading instructions	4, step 5
16.39	5		Reading instructions	Silent
16.44	6		Action	Silent
16.50	2	Considering		Now, which way dose this go?
16.52	24		Reading instructions	Silent
17.16	16		Action	Silent
17.32	6	Statement of problems		Ah, this is left right.
17.38	2	Solution found		That's correct. It's correct.
17.40	6	Considering		It's going to be absolutely $%^
17.46	18		Action	Silent
18.04	8	Confusion		Em… I would expect that to be...
18.12	6		Reading instructions	Silent
18.18	36		Action	Silent
18.54	12		Reading instructions	Silent
19.06	4	Statement of problems		The biggest problem I got was have to move backwards and forwards.
19.10	3		Action	If I have a piece of paper, I can just have it there.
19.13	15	Considering		So I should have positioned the computer better, so that I could simply reach it, or have it much closer to me
19.28	15		Reading instructions	Silent
19.43	24		Action	Silent
20.07	6		Reading instructions	Silent
20.13	13		Action	Silent
20.26	9	Considering		It seem a bit logical to me that if I could have both nails outside but it can't matter I can take the part of operation perhaps afterwards.
20.35	5	Solution found		and presumably…
20.40	8		Reading instructions	Silent
20.48	10		Action	Silent
20.58	1	Statement of feelings		It's still very simple.
20.59	27		Action	Silent
21.26	2	Statement of feelings		Interesting.
21.28	8		Reading instructions	Now…
21.36	28		Action	Silent
22.04	10		Reading instructions	Okay, so we are mostly…
22.14	17		Action	Rough side up.
22.31	3	Decision made		I think it's gonna to be clapped on first,
22.34	6	Considering		cos you cannot just place it on there. It will slip off.
22.40	6		Reading instructions	Eleven.
22.46	27		Action	Silent
23.13	4		Reading instructions	Silent
23.17	51		Action	Silent
24.08	20		Reading instructions	Silent
24.28	4	Statement of intention		I was just trying to see if it tells you whether they should be up or down.
24.32	6	Statement of problems		These are bit… It doesn't seem to say any particularly. So …
24.38	6		Action	ah,ah, right.
24.44	5	Decision made		A bit of adjustment is required I'm afraid.
24.49	22		Action	Silent
25.11	2	Statement of problems		It's a bit awkward.
25.13	49		Action	Silent
26.02	56	Statement of feelings		So I think it would been good if they had told me to do the top ones first and to get them up as far as I could, then to catch the bottom, push this back and attach the bottom first. I think would have helped, rather than have me go through all the bits that nuisance to find out I had not...I left too much board to get on at the bottom.
26.58	14	Statement of intention		That's still probably not probably aligned but I would have to make adjustments to the particular items been put left.
27.12	5	Decision made		Needed more, but looks okay for the moment.
27.17	13		Reading instructions	last stage
27.30	30		Action	Well, I'll hook it when it's got a light, but I'll just put it there in the entre for the moment, and they can be changed depending what light you want.
28.00	1680.00			Done.

Appendix H

Final user testing – task analysis

	Level of behaviour	Ideal solution	Acceptable solution	Possible errors
1. Finding information **（This can be carried out in random order and move onto either plan2 or plan3 at any stage.）**				
➔1.1 write down manufacturer's name				
1.1.1 locating information	skill-based	Locating quickly	Locating slowly	Cannot locate
1.1.2 reading information	skill-based	Reading correctly		Reading wrongly
1.1.3 writing information	skill-based	Writing correctly		Writing wrongly
➔1.2 write down the contact email				
1.2.1 locating information	skill-based	Locating quickly	Locating slowly	Cannot locate
1.2.2 reading information	skill-based	Reading correctly		Reading wrongly
1.2.3 writing information	skill-based	Writing correctly		Writing wrongly
➔1.3 write down dimensions of the assembled product				
1.3.1 locating information	skill-based	Locating quickly	Locating slowly	Cannot locate
1.3.2 reading information	skill-based	Reading correctly		Reading wrongly
1.3.3 writing information	skill-based	Writing correctly		Writing wrongly
2. Preparing the product for assembly **（This can be carried out in random order and move onto plan3 at any stage.）**				

➔2.1 Unpacking	skill-based	Taking everything		Missing parts
➔2.2 Matching parts with instructions		Using instructions to	Checking	Mismatching parts
2.2.1 Checking A (L)	skill-based	check everything	everything during	with instructions
2.2.2 Checking A (R)	skill-based		assembling (plan	
2.2.3 Checking B × 2	skill-based		3)	
2.2.4 Checking C × 2	skill-based			
2.2.5 Checking D × 2	skill-based			
2.2.6 Checking E (L)	skill-based			
2.2.7 Checking E (R)	skill-based			
2.2.8 Checking F (L)	skill-based			
2.2.9 Checking F (R)	skill-based			
2.2.10 Checking G × 2	skill-based			
2.2.11 Checking H × 2	skill-based			
2.2.12 Checking I × 2	skill-based			
2.2.13 Checking J	skill-based			
2.2.14 Checking K × 8	skill-based			
2.2.15 Checking L	skill-based			
3. Assembly **（Go back to plan 2 at any stage. Repeat plan2 and plan3 until 3.4.1 is complete.）**				
➔3.1 Making the frame base		**Making the frame base in designed order**	**Making base in any order**	
◆3.1.1 Preparing A(L)", "A(R)", "B"× 2;	skill-based	◆Right parts facing		◆Using wrong parts;
3.1.1.1 -picking A(L)	knowledge-based	correct directions;		Right parts facing
3.1.1.2 -positioning A(L)	skill-based			wrong directions;
3.1.1.3 -picking A(R)	knowledge-based			
3.1.1.4 -positioning A(R)	skill-based			
3.1.1.5 -picking "B" × 2	knowledge-based			
3.1.1.6 -positioning "B" × 2				
◆3.1.2 Connecting "C"× 2 to "A"legs and "B"legs;		◆Right parts are		◆Connecting wrong
3.1.2.1 -picking "C" × 2	skill-based	fixed in the right		legs;
3.1.2.2 -positioning "C" × 2	knowledge-based	joints;		Connecting right
3.1.2.3 -connecting the first "C" and A(L)	rule-based	Parts are safely		legs in wrong joints;
3.1.2.4 -tighten the knobs	skill-based	fitted into each		Parts do not sit into
3.1.2.5 -connecting the first "C" and "B"	rule-bassed	other;		a secure position;
3.1.2.6 -tighten the knobs	skill-based	Knobs are		Knobs are not
3.1.2.7 -connecting second "C" and A(R)	rule-based	tightened;		tightened properly;

3.1.2.8 -tighten the knobs	skill-based			
3.1.2.9 -connecting second “C” and “B”	rule-based			
3.1.2.10 -tighten the knobs	skill-based			
◆3.1.3 Connecting “D” legs to A”legs and “B”legs;		◆Right parts are		◆Connecting wrong
3.1.3.1 -picking “D” × 2	skill-based	fixed in the right		legs;
3.1.3.2 -connecting one “D” and A(L)	rule-based	joints;		Connecting right
3.1.3.3-tighten the knobs	skill-based	Parts are safely		legs in wrong joints;
3.1.3.4 -connecting one “D” and A(R)	rule-based	fitted into each		Parts do not sit into
3.1.3.5 -tighten the knobs	skill-based	other;		a secure position;
3.1.3.6-connecting “B” and “B”	rule-based	Knobs are		Knobs are not
3.1.3.7-tighten the knobs	skill-based	tightened;		tightened properly;
➔3.2 Finishing the frame				
◆3.2.1 Fixing “E” tubes to “A” legs and “B” legs;		◆Right parts are		◆Using wrong parts;
3.2.1.1 -picking “E(L)”	skill-based	fixed safely;		“E” tubes facing
3.2.1.2 -picking “E(R)”	skill-based	“E” tubes facing		wrong directions;
3.2.1.3 -positioning “E(L)”	knowledge-based	correct directions;		Parts do not sit into
3.2.1.4 -positioning “E(R)”	knowledge-based	Knobs are		a secure position;
3.2.1.5 -fixing “E(L)” above A(L) and B	rule-based	tightened;		Knobs are not
3.2.1.6 -tighten the knobs	skill-based			tightened properly;
3.2.1.7 -fixing “E(R)”above A(R) and B	rule-based			
3.2.1.8 -tighten the knobs	skill-based			
◆3.2.2 Fixing “F” × 2 onto “E” × 2;		◆Right parts are	◆ Swapping	◆One longer side
3.2.2.1 -picking “F(L)”	skill-based	fixed safely;	“F(L)”&“F(R)” so	and one shorter side
3.2.2.2 -picking “F(R)”	skill-based	Handles on “F” × 2	that handles on	of “F” × 2 is
3.2.2.3 -positioning “F(L)”	knowledge-based	facing out;	“F” × 2 facing out;	connected to “E” ×
3.2.2.4 -positioning “F(R)”	knowledge-based	Both shorter sides	Both longer sides	2;
3.2.2.5 -fixing “F(L)” onto the end of“E(L)”	rule-based	of “F” × 2 are	of “F” × 2 are	
3.2.2.6 -tighten the knobs	skill-based	connected to “E” ×	connected to “E”	
3.2.2.7 -fixing “F(R)” onto the end of“E(R)”	rule-based	2;	× 2;	
3.2.2.8 -tighten the knobs	skill-based	Knobs are		
		tightened;		
◆3.2.3 Fixing “G” × 2 onto “F” × 2;				◆Using wrong parts;
3.2.3.1 -picking “G”× 2	skill-based	◆Right parts are		Parts do not sit into
3.2.3.2 -fixing one“G” onto the end of“F(L)”	rule-base	fixed safely; Knobs		a secure position;
3.2.3.3 -tighten the knobs	skill-based	are tightened;		Knobs are not
3.2.3.4 -fixing one “G” onto the end of“F(R)”	rule-based			tightened properly;
3.2.3.5 -tighten the knobs	skill-based			

◆3.2.4 Fixing one “H” onto end of “G” × 2; 3.2.4.1 -picking one “H” 3.2.4.2 -using “H” to connect “G” × 2 3.2.4.3 -tighten the knobs	 skill-based rule-based skill-based	◆Knobs on “H” facing backside; Parts are fixed safely; Knobs are tightened;	◆Knobs on “H” facing front side;	◆Using wrong parts; Parts do not sit into a secure position; Knobs are not tightened properly.
◆3.2.5 Fixing “I” × 2 onto the front side of “A” × 2; 3.2.5.1 -picking “I”× 2 3.2.5.2 -fixing one “I” onto “A(L)” 3.2.5.3 -tighten the knobs 3.2.5.4 -fixing another “I” onto “A(R)” 3.2.5.5 -tighten the knobs	 skill-based rule-based skill-based rule-based skill-based	◆Right parts are fixed safely; Knobs are tightened;		◆Same as above
◆3.2.6 Using another “H” to connect “I” × 2. 3.2.6.1 -picking “H” 3.2.6.2 -using “H” to connect “I” × 2 3.2.6.3 -tighten the knobs	 skill-based rule-based skill-based	◆Right parts are fixed safely; Knobs are tightened;		◆Same as above
➔3.3 Fixing the top sheet				
◆3.3.1 Placing plastic “J” onto the top of the finished frame; 3.3.1.1 -picking “J” 3.3.1.2 -identifying the upper side of “J” 3.3.1.3 -putting the rough side up 3.3.1.4 -placing “J” onto the top of the finished frame	 skill-based knowledge-based skill-based skill-based	◆Rough side of “J” facing up;		◆Smooth side of “J” facing up;
◆3.3.2 Using “K” × 8 to hold “J”. 3.3.2.1 -picking “K”× 8 3.3.2.2 -positioning “K” clips 3.3.2.3 -attaching “K” clips to hold “J”	 skill-based knowledge-based rule-based	◆ Arrange “K” like shown in photos. ◆ “J” fixed on to the frame tightly. ◆ Two ends of “J” match the ends of frame.	◆ customize “K” positions. ◆ “J” fixed on to the frame tightly. ◆ Two ends of “J” match the ends of frame.	◆ “J” is not fixed on to the frame tightly. ◆ Two ends of “J” do not match the ends of frame.
➔3.4 Attaching the accessory				
◆3.4.1 Attaching “L” to any position on the frame. 3.4.1.1 -picking “L” 3.2.1.2 -deciding the position for “L” 3.4.1.2 -positioning “L” 3.4.1.3 - tighten “L”	 skill-based knowledge-based skill-based skill-based	◆Attaching “L” to the front side of “D”. “L” is fitted tightly.	◆Attaching “L” to any position on the frame.	◆ “L” is loose.

Appendix I

Final user testing results - speed

				ID:01	ID:02	ID:03	ID:04	ID:05	ID:06	ID:07	ID:08	ID:10	ID:11	ID:12	ID:13	ID:14	ID:15	ID:16	ID:17	ID:18	ID:19	ID:20	ID:21	ID:22	ID:23	ID:24	ID:26
	Tasks		Nature of tasks	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)	Duration (s)
1	Finding information (This can be carried out in random orderand move onto either plan2 or plan3 at any stage.)			63	110	115	100	105	95	251	162	69	76	62	68	87	109	95	95	88	96	115	116	108	93	83	105
1.1	write down manufacturer's name			30	50	42	70	58	46	82	120	28	24	16	34	54	61	54	55	63	54	64	16	50	51	52	55
	1.1.1	locating information	① Recognition processes																								
	1.1.2	reading information	① Recognition processes																								
	1.1.3	writing information	▸ Transferable processes																								
1.2	write down the contact email			20	41	26	13	19	30	38	19	20	32	23	19	20	18	20	17	14	22	21	28	28	17	14	25
	1.2.1	locating information	① Recognition processes																								
	1.2.2	reading information	① Recognition processes																								
	1.2.3	writing information	▸ Transferable processes																								
1.3	write down dimensions of the assembled product			13	19	47	17	28	19	131	23	21	20	23	15	13	30	21	23	11	20	30	72	30	25	17	25
	1.3.1	locating information	① Recognition processes																								
	1.3.2	reading information	① Recognition processes																								
	1.3.3	writing information	▸ Transferable processes																								
2	Preparing the product for assembly（This can be carried out in random order and move onto plan3 at any stage.）			287	168	245	155	130	200	126	275	316	299	248	375	246	174	243	300	220	194	185	350	292	259	167	340
2.1	Unpacking		▸ Transferable processes																								
2.2	Checking all parts																										
	2.2.1	Checking A (L)	① Recognition processes																								
	2.2.2	Checking A (R)	① Recognition processes																								
	2.2.3	Checking B × 2	① Recognition processes																								
	2.2.4	Checking C × 2	① Recognition processes																								
	2.2.5	Checking D × 2	① Recognition processes																								
	2.2.6	Checking E (L)	① Recognition processes																								
	2.2.7	Checking E (R)	① Recognition processes																								
	2.2.8	Checking F (L)	① Recognition processes																								
	2.2.9	Checking F (R)	① Recognition processes																								
	2.2.10	Checking G × 2	① Recognition processes																								
	2.2.11	Checking H × 2	① Recognition processes																								
	2.2.12	Checking I × 2	① Recognition processes																								
	2.2.13	Checking J	① Recognition processes																								
	2.2.14	Checking K × 8	① Recognition processes																								
	2.2.15	Checking L	① Recognition processes																								
3	Assembly （Go back to plan 2 at any stage. Repeat plan2 and plan3 until 3.4.1 is complete.）			918	804	1180	1182	1065	783	1199	1146	1392	1023	889	1003	1157	1373	648	845	803	1343	1218	1040	690	1136	1187	942
3.1.1	Preparing A(L)", "A(R)", "B"× 2;			20	57	55	48	39	77	63	90	53	56	80	92	80	90	67	30	96	145		83	92	225	322	0
	3.1.1.1	picking A(L)	① Recognition processes																								
	3.1.1.2	positioning A(L)	✯Spatial/ contextual judgements																								
	3.1.1.3	picking A(R)	① Recognition processes																								
	3.1.1.4	positioning A(R)	✯Spatial/ contextual judgements																								
	3.1.1.5	picking "B" × 2	① Recognition processes																								
	3.1.1.6	positioning "B" × 2	✯Spatial/ contextual judgements																								
3.1.2	Connecting "C"× 2 to "A"legs and "B"legs;			163	110	123	265	84	81	280	100	120	195	195	200	97	137	93	225	90	111		121	40	116	88	0
	3.1.2.1	picking "C" × 2	① Recognition processes																								
	3.1.2.2	positioning "C" × 2	✯Spatial/ contextual judgements																								
	3.1.2.3	connecting first "C" and A(L)	▸ Transferable processes																								
	3.1.2.4	tighten the knobs	▸ Transferable processes																								
	3.1.2.5	connecting the first "C" and "B"	▸ Transferable processes																								
	3.1.2.6	tighten the knobs	▸ Transferable processes																								
	3.1.2.7	connecting second "C" and A(R)	▸ Transferable processes																								
	3.1.2.8	tighten the knobs	▸ Transferable processes																								
	3.1.2.9	connecting second "C" and "B"	▸ Transferable processes																								
	3.1.2.10	tighten the knobs	▸ Transferable processes																								
3.1.3	Connecting "D" legs to A"legs and "B"legs;			62	125	87	92	137	82	85	162	161	78	57	43	348	333	44	81	70	164	337	156	67	122	176	375
	3.1.3.1	picking "D" × 2	① Recognition processes																								
	3.1.3.2	connecting one "D" and A(L)	▸ Transferable processes																								
	3.1.3.3	tighten the knobs	▸ Transferable processes																								
	3.1.3.4	connecting one "D" and A(R)	▸ Transferable processes																								
	3.1.3.5	tighten the knobs	▸ Transferable processes																								
	3.1.3.6	connecting "B" and "B"	▸ Transferable processes																								
	3.1.3.7	tighten the knobs	▸ Transferable processes																								
3.2.1	Fixing "E" tubes to "A" legs and "B" legs;			77	92	80	75	237	77	122	63	116	75	46	80	168	78	86	74	74	44	67	36	51	104	117	46
	3.2.1.1	picking "E(L)"	① Recognition processes																								
	3.2.1.2	picking "E(R)"	① Recognition processes																								
	3.2.1.3	positioning "E(L)"	✯Spatial/ contextual judgements																								
	3.2.1.4	positioning "E(R)"	✯Spatial/ contextual judgements																								
	3.2.1.5	fixing "E(L)" above A(L) and B	▸ Transferable processes																								
	3.2.1.6	tighten the knobs	▸ Transferable processes																								
	3.2.1.7	fixing "E(R)"above A(R) and B	▸ Transferable processes																								
	3.2.1.8	tighten the knobs	▸ Transferable processes																								
3.2.2	Fixing "F" × 2 onto "E" × 2;			76	58	84	151	73	107	87	83	126	88	78	86	98	75	75	137	142	186	208	116	103	103	101	152
	3.2.2.1	picking "F(L)"	① Recognition processes																								
	3.2.2.2	picking "F(R)"	① Recognition processes																								
	3.2.2.3	positioning "F(L)"	✯Spatial/ contextual judgements																								
	3.2.2.4	positioning "F(R)"	✯Spatial/ contextual judgements																								
	3.2.2.5	fixing "F(L)" onto the end of"E(L)"	▸ Transferable processes																								
	3.2.2.6	tighten the knobs	▸ Transferable processes																								
	3.2.2.7	fixing "F(R)" onto the end of"E(R)"	▸ Transferable processes																								
	3.2.2.8	tighten the knobs	▸ Transferable processes																								
3.2.3	Fixing "G" × 2 onto "F" × 2;			42	26	73	27	39	24	64	87	131	89	25	71	22	42	40	34	58	19	15	42	53	51	53	12
	3.2.3.1	picking "G"× 2	① Recognition processes																								
	3.2.3.2	fixing one"G" onto the end of"F(L)"	▸ Transferable processes																								
	3.2.3.3	tighten the knobs	▸ Transferable processes																								
	3.2.3.4	fixing one "G" onto the end of"F(R)"	▸ Transferable processes																								
	3.2.3.5	tighten the knobs	▸ Transferable processes																								
3.2.4	Fixing one "H" onto end of "G" × 2;			72	28	23	47	138	22	44	62	66	50	47	46	64	389	25	29	51	19	34	38	48	33	50	46
	3.2.4.1	picking one "H"	① Recognition processes																								
	3.2.4.2	using "H" to connect "G" × 2	▸ Transferable processes																								
	3.2.4.3	tighten the knobs	▸ Transferable processes																								
3.2.5	Fixing "I" × 2 onto the front side of "A" × 2;			28	33	317	45	28	26	50	35	270	89	30	44	16	25	20	46	39	250	311	18	46	49	60	21
	3.2.5.1	picking "I"× 2	① Recognition processes																								
	3.2.5.2	fixing one"I" onto "A(L)"	▸ Transferable processes																								
	3.2.5.3	tighten the knobs	▸ Transferable processes																								
	3.2.5.4	fixing another "I" onto "A(R)"	▸ Transferable processes																								
	3.2.5.5	tighten the knobs	▸ Transferable processes																								
3.2.6	Using another "H" to connect "I" × 2.			56	28	44	80	23	18	55	54	44	40	25	40	20	27	31	24	28	21	20	44	39	30	40	39
	3.2.6.1	picking "H"	① Recognition processes																								
	3.2.6.2	using "H" to connect "I" × 2	▸ Transferable processes																								
	3.2.6.3	tighten the knobs	▸ Transferable processes																								
3.3.1	Placing plastic "J" onto the top of the finished frame;			49	69	45	50	171	54	100	25	26	35	43	29	46	47	23	33	48	142	98	61	32	45	43	31
	3.3.1.1	picking "J"	① Recognition processes																								
	3.3.1.2	identifying the upper side of "J"	✯Spatial/ contextual judgements																								
	3.3.1.3	putting the rough side up	▸ Transferable processes																								
	3.3.1.4	placing "J" onto the top of the finished frame	▸ Transferable processes																								
3.3.2	Using "K" × 8 to hold "J".			235	141	167	255	41	199	197	349	236	180	191	224	163	94	91	85	74	218	87	170	90	166	96	91
	3.11.1	picking "K"× 8	① Recognition processes																								
	3.11.2	positioning "K" clips	✯Spatial/ contextual judgements																								
	3.11.3	attaching "K" clips to hold "J"	▸ Transferable processes																								
3.4.1	Attaching "L" to any position on the frame.			38	37	82	47	55	16	52	36	43	48	72	48	35	36	53	47	33	24	41	155	29	92	41	66
	3.12.1	picking "L"	① Recognition processes																								
	3.12.2	deciding the position for "L"	✯Spatial/ contextual judgements																								
	3.12.3	positioning "L"	▸ Transferable processes																								
	3.12.4	tighten "L"	▸ Transferable processes																								
Total (s)				1268	1082	1540	1437	1300	1078	1576	1583	1777	1398	1199	1446	1490	1656	986	1240	1111	1633	1518	1506	1090	1488	1437	1387

Appendix J

Final user testing results - errors

Appendix K

Re-test results

				ID:02-print	ID:02-multimedia				ID:03-print				ID:03-multimedia				ID:11-print				ID:11-multimedi	ID:13-print				ID:13-multimedia			
	Tasks	Level of errors	Nature of tasks	Duration (s)	Duration (s)	Error	Correction	Flexibility	Duration (s)	Error	Correction	Flexibility	Duration (s)		Error	Correction	Flexibility	Duration (s)	Error	Correction	Flexibility	Duration (s)	Duration (s)	Error	Correction	Flexibility	Duration (s)	Error	Correction	Flexibility
1 Finding information	1 Finding information (This can be carried out in random orderand move onto either plan2 or plan3 at any stage.)			110	96				115				96					76				124	68				133			
	1.1 write down manufacturer's name			50	49			go to 1.3	42				52					24				52	34				49			
	1.1.1 locating information	Skill-based	① Recognition processes																										
	1.1.2 reading information	Skill-based	① Recognition processes																										
	1.1.3 writing information	Skill-based	▸ Transferable processes																										
	1.2 write down the contact email			41	34				26				18					32				31	19				27			
	1.2.1 locating information	Skill-based	① Recognition processes																										
	1.2.2 reading information	Skill-based	① Recognition processes																										
	1.2.3 writing information	Skill-based	▸ Transferable processes																										
	1.3 write down dimensions of the assembled product			19	13			go to 1.2	47				26					20				41	15				57			
	1.3.1 locating information	Skill-based	① Recognition processes																										
	1.3.2 reading information	Skill-based	① Recognition processes																										
	1.3.3 writing information	Skill-based	▸ Transferable processes																										
2 Preparing the product for assembly	2 Preparing the product for assembly（This can be carried out in random order and move onto plan3 at any stage.）			168	262				245				146					299				377	375				183			
	2.1 Unpacking	Skill-based	▸ Transferable processes		54								83									377					31			
	2.2 Checking all parts				208								63														152			
	2.2.1 Checking A (L)	Skill-based	① Recognition processes																										
	2.2.2 Checking A (R)	Skill-based	① Recognition processes																										
	2.2.3 Checking B × 2	Skill-based	① Recognition processes																										
	2.2.4 Checking C × 2	Skill-based	① Recognition processes																										
	2.2.5 Checking D × 2	Skill-based	① Recognition processes																										
	2.2.6 Checking E (L)	Skill-based	① Recognition processes																										
	2.2.7 Checking E (R)	Skill-based	① Recognition processes																										
	2.2.8 Checking F (L)	Skill-based	① Recognition processes																										
	2.2.9 Checking F (R)	Skill-based	① Recognition processes																										
	2.2.10 Checking G × 2	Skill-based	① Recognition processes																										
	2.2.11 Checking H × 2	Skill-based	① Recognition processes																										
	2.2.12 Checking I × 2	Skill-based	① Recognition processes																										
	2.2.13 Checking J	Skill-based	① Recognition processes																										
	2.2.14 Checking K × 8	Skill-based	① Recognition processes																										
	2.2.15 Checking L	Skill-based	① Recognition processes																										
3.1 Making the frame base	3 Assembly （Go back to plan 2 at any stage. Repeat plan2 and plan3 until 3.4.1 is complete.）			804	633				1180				626					1023				849	1003				534			
	3.1.1 Preparing A(L)", "A(R)", "B"× 2;			57	91	Error 1: A(L), A(R) facing wrong sides.			55				60					56				154	92				60	Error 1: A(L) A (R) upside down.		
	3.1.1.1 picking A(L)	skill-based	① Recognition processes																										
	3.1.1.2 positioning A(L)	knowledge-based	Spatial/ contextual judgements																										
	3.1.1.3 picking A(R)	skill-based	① Recognition processes																										
	3.1.1.4 positioning A(R)	knowledge-based	Spatial/ contextual judgements																										
	3.1.1.5 picking "B" × 2	skill-based	① Recognition processes																										
	3.1.1.6 positioning "B" × 2	knowledge-based	Spatial/ contextual judgements																										
	3.1.2 Connecting "C"× 2 to "A"legs and "B"legs;			110	79		Correct error 1.		123	Error 2:Tube "D"s were used instead of "C"s.			0					195				174	200				121		Coorect error 1.	
	3.1.2.1 picking "C" × 2	skill-based	① Recognition processes																										
	3.1.2.2 positioning "C" × 2	knowledge-based	Spatial/ contextual judgements																										
	3.1.2.3 connecting first "C" and A(L)	rule-based	▸ Transferable processes																										
	3.1.2.4 tighten the knobs	skill-based	▸ Transferable processes																										
	3.1.2.5 connecting the first "C" and "B"	rule-based	▸ Transferable processes																										
	3.1.2.6 tighten the knobs	skill-based	▸ Transferable processes																										
	3.1.2.7 connecting second "C" and A(R)	rule-based	▸ Transferable processes																										
	3.1.2.8 tighten the knobs	skill-based	▸ Transferable processes																										
	3.1.2.9 connecting second "C" and "B"	rule-based	▸ Transferable processes																										
	3.1.2.10 tighten the knobs	skill-based	▸ Transferable processes																										
	3.1.3 Connecting "D" legs to A"legs and "B"legs;			125	140				87	Error 3: Tube "D"s were used instead of "C"s.			179					78				81	43				75			
	3.1.3.1 picking "D" × 2	skill-based	① Recognition processes																										
	3.1.3.2 connecting one "D" and A(L)	rule-based	▸ Transferable processes																										
	3.1.3.3 tighten the knobs	skill-based	▸ Transferable processes																										
	3.1.3.4 connecting one "D" and A(R)	rule-based	▸ Transferable processes																										
	3.1.3.5 tighten the knobs	skill-based	▸ Transferable processes																										
	3.1.3.6 connecting "B" and "B"	rule-based	▸ Transferable processes																										
	3.1.3.7 tighten the knobs	skill-based	▸ Transferable processes																										
3.2 Finishing the frame	3.2.1 Fixing "E" tubes to "A" legs and "B" legs;			92	48				80	Error 4: E tubes were facing the opposite direction.			42					75				80	80				35			
	3.2.1.1 picking "E(L)"	skill-based	① Recognition processes																										
	3.2.1.2 picking "E(R)"	skill-based	① Recognition processes																										
	3.2.1.3 positioning "E(L)"	knowledge-based	Spatial/ contextual judgements																										
	3.2.1.4 positioning "E(R)"	knowledge-based	Spatial/ contextual judgements																										
	3.2.1.5 fixing "E(L)" above A(L) and B	rule-based	▸ Transferable processes																										
	3.2.1.6 tighten the knobs	skill-based	▸ Transferable processes																										
	3.2.1.7 fixing "E(R)"above A(R) and B	rule-based	▸ Transferable processes																										
	3.2.1.8 tighten the knobs	skill-based	▸ Transferable processes																										
	3.2.2 Fixing "F" × 2 onto "E" × 2;			58	53				84	Error 5:"F(R)" was fixed in the wrong way. Its handle should face the out side.			70					88				60	86				45			Swapped F(L) and F(R))" ; handles facing out; Both longer sides of "F" are connected to "E";
	3.2.2.1 picking "F(L)"	skill-based	① Recognition processes																										
	3.2.2.2 picking "F(R)"	skill-based	① Recognition processes																										
	3.2.2.3 positioning "F(L)"	knowledge-based	Spatial/ contextual judgements																										
	3.2.2.4 positioning "F(R)"	knowledge-based	Spatial/ contextual judgements																										
	3.2.2.5 fixing "F(L)" onto the end of"E(L)"	rule-based	▸ Transferable processes																										
	3.2.2.6 tighten the knobs	skill-based	▸ Transferable processes																										
	3.2.2.7 fixing "F(R)" onto the end of"E(R)"	rule-based	▸ Transferable processes																										
	3.2.2.8 tighten the knobs	Skill-based	▸ Transferable processes																										
	3.2.3 Fixing "G" × 2 onto "F" × 2;			26	40				73				34					89				51	71				11			
	3.2.3.1 picking "G"× 2	skill-based	① Recognition processes																										
	3.2.3.2 fixing one"G" onto the end of"F(L)"	rule-based	▸ Transferable processes																										
	3.2.3.3 tighten the knobs	skill-based	▸ Transferable processes																										
	3.2.3.4 fixing one "G" onto the end of"F(R)"	rule-based	▸ Transferable processes																										
	3.2.3.5 tighten the knobs	Skill-based	▸ Transferable processes																										
	3.2.4 Fixing one "H" onto end of "G" × 2;			28	22				23				16			Alternative solution: knobs on "H" faced font.		50				35	46			Alternative solution: knobs on "H" faced font.	18			Alternative solution: knobs on "H" faced font.
	3.2.4.1 picking one "H"	skill-based	① Recognition processes																										
	3.2.4.2 using "H" to connect "G" × 2	rule-based	▸ Transferable processes																										
	3.2.4.3 tighten the knobs	skill-based	▸ Transferable processes																										
	3.2.5 Fixing "I" × 2 onto the front side of "A" × 2;			33	25				317		Correct error 2& 3.		28			back to 3.2.2 tight all knobs.		89				20	44				19			
	3.2.5.1 picking "I"× 2	skill-based	① Recognition processes																										
	3.2.5.2 fixing one"I" onto "A(L)"	rule-based	▸ Transferable processes																										
	3.2.5.3 tighten the knobs	skill-based	▸ Transferable processes																										
	3.2.5.4 fixing another "I" onto "A(R)"	rule-based	▸ Transferable processes																										
	3.2.5.5 tighten the knobs	skill-based	▸ Transferable processes																										
	3.2.6 Using another "H" to connect "I" × 2.			28	22				44		Correct error 4	to task 3.4.1	22					40				26	40				20			
	3.2.6.1 picking "H"	skill-based	① Recognition processes																										
	3.2.6.2 using "H" to connect "I" × 2	rule-based	▸ Transferable processes																										
	3.2.6.3 tighten the knobs	skill-based	▸ Transferable processes																										
3.3 Fixing the top sheet	3.3.1 Placing plastic "J" onto the top of the finished frame;			69	31				45	Error 6:Use the wrong side of plastic "J" to face up.			39					35	Error 1: Use the wrong side of plastic "J" to face up.		37	29	Error3: Use the wrong side of plastic "J" to face up.		19	Error3: Use the wrong side of plastic "J" to face up.		
	3.3.1.1 picking "J"	skill-based	① Recognition processes																										
	3.3.1.2 identifying the upper side of "J"	knowledge-based	Spatial/ contextual judgements																										
	3.3.1.3 putting the rough side up	skill-based	▸ Transferable processes																										
	3.3.1.4 placing "J" onto the top of the finished frame	skill-based	▸ Transferable processes																										
	3.3.2 Using "K" × 8 to hold "J".			141	47				167		Correct error 6: plastic "J".		124					180				96	224		Correct error3, plastic "J".		96		Correct error3, plastic "J".	
	3.11.1 picking "K"× 8	Skill-based	① Recognition processes																										
	3.11.2 positioning "K" clips	Knowledge-based	Spatial/ contextual judgements																										
	3.11.3 attaching "K" clips to hold "J"	rule-based	▸ Transferable processes																										
3.4 Attaching the accessory	3.4.1 Attaching "L" to any position on the frame.			37	35				82			followed by task 3.10.	12					48		Corrected error1		35	48				15			
	3.12.1 picking "L"	skill-based	① Recognition processes																										
	3.12.2 deciding the position for "L"	knowledge-based	Spatial/ contextual judgements																										
	3.12.3 positioning "L"	skill-based	▸ Transferable processes																										
	3.12.4 tighten "L"	skill-based	▸ Transferable processes																										
Observed error				1082	991	1			1540	6			868					1398	1			1350	1446	3			850	1		
Corrected					1					4									1					1				1		
Final error				None	0				2									0				None	1				0			
Slip									1														1							
Lapse																							1							
Mistake									1																					
Alternative solution															2										1				1	
				Followed the designed order.	task 1 in random order.					task 3 in random order					Followed the designed order.				Followed the designed order.			Followed the designed order.	Corrected error 2 after the test.		Followed the designed order.			Corrected error 2 after the test.		Followed the designed order.

Appendix L

A checklist for planning instruction contents

fulfilled/covered by the instructions being assessed	not fulfilled/covered by them	not applicable to them
+	-	0

Items to be checked	Evaluation (++/+/#/-/--/0)	Comments
Identification ◆Brand and type designation ◆Delivery No., version, type No., etc. ◆Expiry date ◆Up-to-date check, for example edition of the handbook coverage of a product version Producer/ supplier, distributor or other information ◆Address of producer/supplier/service agency ◆Certification references ◆Optional modules, extras		
Specification of the product ◆Functions and range of application ◆Safe and correct use ◆Integrated design of the product and instructions - no compensation for design deficiencies ◆Dimensions – mass –capacity ◆Performance data and conditions ◆Supply data for power, water and other consumables (for example detergents, lubricants) ◆Energy consumption and conditions ◆Emission of noise, gas, waste, radiation, etc. Conditions ◆Information on personal protection for example clothing, goggles		

◆Information on dangers to particular groups of persons ◆Information on safe disposal		
Preparing the product for use ◆Safety precautions before installation ◆Unpacking ◆Safe disposal of packaging material ◆Installation and assembly (for example special tools, space for maintenance, etc.) ◆Storage and protection during intervals between periods of normal use ◆Repackaging to prevent damage in transport ◆Restrictions on operations by non-qualified persons. Separation of instructions to different groups of persons. ◆Location of instructions		
Operating instructions ➔Basic functions ◆complete for correct, intended use ◆complete for safe, intended use ◆complete for reasonably foreseeable misuse ◆conformity with minimum list in relevant product standard(s) ➔Secondary functions ➔Optional modules and extras ➔Personal protection ➔Quick reference instructions ◆by reminder cards, stickers or labels ◆by reference to handbook, user guidance system on display etc. ➔Disposal of waste material		
Visual and/or audible indications ➔Explanations provided in instructions ➔Warning notices emphasized ➔Indications ◆emitted in time to allow user to take action ◆clearly seen from user's position		
Maintenance and cleaning ◆Safety precautions (for example protection of persons, special tools) ◆Preventive maintenance and inspection necessary for safety ◆Regular checking of warning devices		

◆Maintenance and cleaning by users ◆Maintenance and cleaning by qualified persons ◆Trouble-shooting- fault diagnosis, repair ◆Support from agency/manufacturer		
Safety and health information ➔General safety regulations summarized at the beginning of the instruction material ➔Recognized technical regulations have been observed ➔Clear guidance on what to do and what to avoid is provided ➔Safety warnings /cautions a) correct location: ◆on product and/or ◆on packaging and/or ◆in accompanying material b) if relevant, visibility at the point of sale c) correct use of terms d) durability of warnings e) conformity with requirements in relevant product standards ➔Safety signals ➔Information on residual risk ➔Environmental aspects of using the product ➔Product disposal measures ◆summarized in a special chapter ◆repeated in relevant passages of the text ◆disposal/collection points are listed		
Consistency of information ◆Consistent terminology in all parts ◆Consistent symbols used on the product and in accompanying documents ◆Consistent warning terms used on the product and in accompanying material		

Appendix M

A checklist for evaluating the delivery of product instructions

Very good	Good	Average, just acceptable	Poor	Very poor	Not applicable/not necessary
++	+	#	-	--	0

Items to be checked	**Evaluation (++/+/#/-/--/0)**	**Comments**
Legibility ➔On-product information ◆Type size depending on reading distance ◆Brightness contrast (needs to be more than 70%) ◆Instructions incorporated in material of product ➔Handbooks, manuals, leaflets ◆paper quality ◆type size ◆line spacing ◆use of different typeface, type size etc. ◆captions easy to read ◆brightness contrast (needs to be more than 70%) ◆use of colours ◆general impression of the page is balanced and uncluttered		
Electronic media (audio, video, multimedia) ➔Technical equipment ◆minimum configuration ◆"best result" configuration ➔User-friendly system access and easy operation ◆"How to use these instructions" clause ◆linear structure in menu guidance and operating buttons ◆navigation system eases finding answers to user's questions		

◆print utility ◆bookmark option ➔User-friendly design ◆general consistency in titling, high-lighting, fonts, text positioning ◆text(spoken and written) corresponds to video animation ◆duration of sequence and information quantity per unit does not stress the user's perception ◆screen design enables the user to pick up necessary information ◆optimal topic length (at most two screens, paragraphs maximum 20 lines long) ◆complex information broken down into smaller categories with secondary windows to subordinate information ◆helpful emphasis by font, font size, highlighting, colour, contrast and graphics ◆language appropriate to target group ◆graphics, animation and video sequences contribute to the understanding ◆the use of colours is consistent and not system dependant		
Indications ◆Quality and clarity of information provided to user ◆Explanation of signals		
Text and terms ➔Text/use of words ◆simple/meaningful ◆short ◆one sentence/ one command ◆active voice ◆action verbs ➔Term used ◆abbreviations explained at first occurrence ◆technical terms defined at first occurrence ◆well explained, understandable for ordinary readers ◆consistent use of terms ➔Structure of text ◆consistently structured ◆structure follows communication principles ◆structure from basic to sophisticated operations/ functions ◆meaningful separation between basic product and optional		

modules ◆informative headings ◆nonsense avoided ➔Communication principles ◆encouraging quick reactions (e.g. simple and easy instructions for an emergency) ◆setting out learning process for complex functions ◆answering the questions Where?Who?What?When?How?Why?		
Language ➔Information given in appropriate language(s) ➔Clear differentiation of languages ➔Clear connection between text and illustrations ➔Clear pronunciation (audio) ➔Absence of linguistic errors		
Illustrations ➔General quality ➔Sufficient number of illustrations for each one to provide clear and specific information ➔Illustrations supported by clear and helpful captions		
Graphic symbols ◆internationally standardized where possible ◆clearly understandable or explained		
Figures ◆sized according to purpose ◆clear (i.e. same information –same structure) ◆text within figures clearly arranged and consistently used ◆figures and text that belong together shall appear close to each other		
Tables ◆approximately located ◆clearly set out and informative ◆repeated where necessary		
Flow-charts ◆provided where appropriate ◆supported with clear and helpful captions/ text ◆adjacent to the text to which they belong		
Use of colours ◆functional		

◆clear ◆consistent		
Table of contents/ index ◆appropriate to length and complexity of text ◆headings identical to those in the text ◆clear, consistent and helpful ◆list of keywords if helpful ◆numbered pages		
Trouble- shooting advice ➔Checklist of possible faults with repair instructions(paying due regard to safety) ➔Clear indication whether or not users can attempt repairs themselves		
Durability ➔Adequate provision against loss and deterioration in expected (normal) use		
Target users ➔Target group is mentioned ➔Representation of contents is suitable for target group		
General performance		
◆clearly identify the product; ◆recognise the type of user and his/her capabilities; ◆provide all necessary information for correct and safe use of the product; ◆present warnings about hazards or restrictions effectively; ◆provide special handling information, warning notices for particular groups when necessary; ◆give information on the year of manufacture and/or of expiry and warning for products with a limited safe or effective life; ◆be readily available at the point of sale if they are necessary to make a reasoned purchasing decision among products; ◆be consistent with all other material about the same product such as advertising or packaging.		