Inclusive Colour and Information Design

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Abstract

Background The roles and responsibilities of designers today include considering how design outcomes can have a positive influence on people's lives and our society. However, inaccessible design outcomes that are created by designers are commonplace. This is an issue identified by scholars from various fields of design research.

Aim The main aim of this research is to explore the fundamental reasons behind the phenomenon of design exclusion in our society by gaining an interpretive understanding of the meaning of the behaviour of individual designers. This is based on the belief that individuals in designer groups will share aspects of the same reality and express these through language, based on sociolinguistic approaches combining theories of the community of practice and linguistic relativity. The ultimate purpose is to consider more effective ways of offering user-related colour information to designers from a perspective of inclusive design within the socially responsible design paradigm.

Methods There were three designer studies in this research project which apply multidisciplinary methodological approaches. These were think-aloud protocol, surveys, interviews, focus groups, and colour design experiments. The data collected was analysed both qualitatively by adopting linguistic analysis, thematic analysis, and content analysis, and quantitatively by applying descriptive statistics.

Results In the first designer study, a think-aloud protocol was utilised to explore characteristics of designers by analysing their language use while doing a colour description task. This involved comparing a designer group and a non-designer group. Behavioural features also were observed. The fundamental characteristics of designers were explored by applying linguistic analysis considering four key adjectives (associative, evocative, emotive, and imaginative). These indicate why designers continue to produce inaccessible design artefacts. Three adverbs (artistically, emotionally, and creatively) may indicate ways to provide information for designers to motivate them to think about users of design artefacts.

Based on the findings from the first study, the second designer study considered how we can apply and use fundamental characteristics of designers to encourage them to change their designing behaviour towards a more user-centred inclusive perspective. For this, a new attempt at providing information was made by creating a set of Affective Imaginary Information [AII]

card formats in both digital and physical forms. These included facial images that conveyed emotions. The contents of each of the AII card formats were decided on based on a small additional user study. The actual set of AII card formats was created collaboratively by the author of this thesis with a professional graphic designer and an information design researcher. Focus group interviews were carried out subsequently with design doctoral students to gain feedback for refinement, and evaluate the usefulness of the AII formats. Due to the emotional and creative characteristics of designers, when looking at the AII formats, design participants tended to imagine the situation of information users and create a story when they look at the facial emotion. More refined AII card formats were created following this stage.

In the third designer study, the set of AII card formats were used for actual colour design tasks to test the practical use of the format. The actual use of colour information and designers' experience while doing tasks were investigated among designer groups with different levels of experience, using online surveys and email interviews. Furthermore, professional design educators were involved to evaluate the usefulness of the AII card formats and gain their suggestions for future directions for these AII formats. This was done by email interviews. Thus, in this stage, the AII card formats were tested by designers with different levels of experience, and positively evaluated by professional design educators.

Conclusion Designers display emotion and subjectivity toward design tasks. In tasks they tended to focus on expressing their personal feelings, experiences, or preferences, even neglecting design tasks. Also, a subjective outlook, and use of personal factors (design sensibilities, previous subjective experiences, imagination, intuition, perceptions of common sense, and conjecture) along with their effect on design tasks were discovered throughout designer studies. Considering the fundamental characteristics of designers, it is likely that AII card formats with use of facial expressions would be useful in communicating user experiences to designers as this encourages designers to imagine the situation of users and empathise with their feelings. Further investigation is needed about the appropriate amount of text in combination with appropriate images for designers as a source of information and inspiration. Research is needed also on what makes designers heavily react emotionally and subjectively to design tasks and the positive or negative impact of this on design and our society.

Contribution Various research methods and analysis techniques were applied throughout this research project. This has enhanced the reliability of the outcomes of the research by providing in-depth findings. Furthermore, sociolinguistic theories and concepts were applied to the design research project to examine the phenomena of design exclusion and inclusion by analysing designers' linguistic characteristics. This is a new theoretical and methodological approach in the area of design which broadens ways of approaching and understanding the behaviour of designers. Also, based on understanding of characteristics of designers, the AII card formats were created. These were tested, evaluated, and revised several times by designers (with different years of work experience and also different levels of design education) in addition to design education experts. All the procedures for creating the AII formats and final outcomes may encourage design researchers to consider how the characteristics of designers can be used to create visual information formats for them, and to consider how providing information effectively to designers may change their behaviour to empathise more with information users from an inclusive perspective.

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Chapter 1 INTRODUCTION

This introduction begins with a brief outline of the current doctoral research project. It also includes information about the rationale for the selection of the topic. After this, the worldview of the researcher is presented briefly along with her view on the meaning of research. These have led to the overall research process. Also, the aims and objectives, which will be explored throughout the present research project, are addressed here. The overall structure of the research is briefly described and visually illustrated at the end of this chapter.

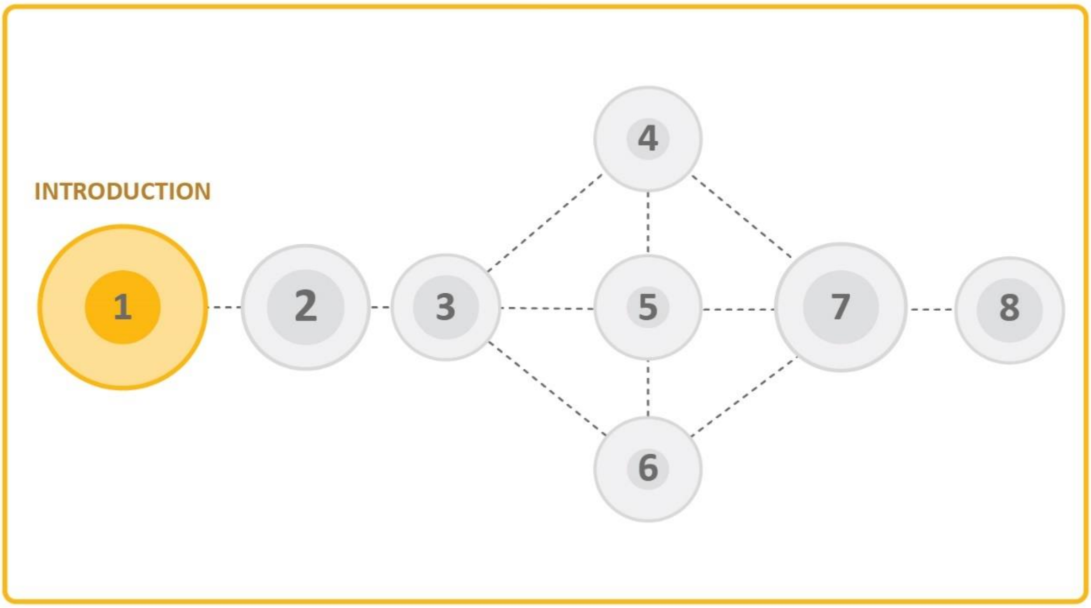


Figure 1.1 Position and context of Chapter One within the whole research process.

1.1 Research Background

1.1.1 Rationale behind the Research Project

Socially Responsible Design [SRD] is an umbrella term (Cipolla and Bartholo, 2014) that has not been formally defined (Busch, 2008; Mangold, 2014). SRD is given different names: “design activism, public interest design, human-centred design, social impact design, and social design” (Mangold, 2014). It stresses that it is valuable for the design professional to empathise with the user to give an understanding of user needs (Cipolla and Bartholo, 2014). Cooper (2005, p.12) adds that “social responsibility is in part derived from the individual ethical values of designers, but it is also a response to the needs of their clients”. Thus, SRD has both a practical and ethical basis.

The approaches of SRD have been applied in specific design areas: service design (e.g. Joly *et al*., 2019), sustainable product design (e.g. Tang, 2010; Melles *et al*., 2011), furniture design (e.g. Weeks, 2008), space design (e.g. Blokland, 2014), and inclusive information design (e.g. Lee, 2015). This shows how the perspective of designers toward social responsibility in design influences design outcomes across the design field. This also indicates that the roles and responsibilities of designers, today, are not limited to considering aesthetic issues in design work but include consideration of how design outcomes may have a positive influence on people's lives and our society.

Scholars (e.g. Sparke, 1983; Cross, 2001; Frascara, 2002; Dorst, 2003a; Dorst, 2018) agree that designers are problem-solvers or problem-improvers whose role is to solve contradictions. In the same vein, Dorst (2003a) states that good designers are expected to know how to deal with design problems successfully. Designers are not just facilitators who create aesthetically focused design outcomes, rather the design activities can give either positive or negative value to design artefacts which impact on our society. Cross (1982, 2011) and Lawson (1997, 2004, 2006) have stressed the importance of the designer as a subject of study. However, as Frascara (2004) has argued, the activities of designers themselves do tend to be overlooked on the whole.

From an inclusive design standpoint, nevertheless, prior researchers have investigated the reasons behind the continual production of inaccessible design outcomes by designers in the field of design. For instance, the creativity of designers (Coleman *et al*., 2003) can be a problem, along with the mis-conceptual belief that inclusive design is less relevant to communication and interface design (Cassim and Dong, 2005). Also, the use of intuition by designers can be problematic (Wilkinson and Angeli, 2014). There is a mistaken assumption that designers will learn about users and approach their work with a user-driven mindset without being encouraged to do it (Vredenburg *et al*., 2001). Thus, we already know some of the reasons for production of inconsiderate design outcomes by designers. It might be expected that this knowledge would help to improve the situation. However, it continues. Therefore, this research will argue that there are undisclosed factors that lead designers to neglect a diverse range of users. The behaviour of designers will be investigated and analysed in order to explain design exclusion caused by designers.

The overall framework and scope for the current research project are indicated in Figure 1.2. This shows that the whole project falls within SRD. Inclusive design is part of this and from an inclusive design standpoint the thesis looks at visual communication design, specifically colour and information design, adopting an interdisciplinary approach to research.

Figure 1.2 Scope of the present doctoral research project.

1.1.2 Researcher Positionality

1.1.2.1 Philosophical Stance of Researcher

The German word *verstehen* is commonly mentioned by social scientists in relation to understanding people's actions. According to Moriceau (2010, p.963), *verstehen* refers to

> participative understanding from the first person, from the case locals' point of view, in a never-ending process and taking into account history, culture, and previous understandings.

In Weber's interpretive sociology,

> *Understanding* lies in the connection between the subjectively lived meaning experienced by individuals and the big sociological and historical evolutions (Moriceau, 2010, p.964).

Weber's concept of *verstehen* referring to "understanding of people's actions" is the "method par excellence of sociology" (Scott, 2015).

The fundamental goal of this research project is to explore design phenomena in our society by interpretively understanding (verstehen) the meaning of the behaviour of individual designers based on belief that the individuals in a designer group would share aspects of the same reality.

Within the approach arising from Weber's *verstehen*, the sociolinguistic concept of the community of practice will be useful to achieve the fundamental goal of the current research project. According to Korhonen (2010, p.213),

> Communities of practice are groups whose members share a certain set of goals, beliefs and social practices and within which learning and knowing is fostered.

This description suggests that groups of designers could be thought of as communities of practice. A more detailed explanation of the concept will be outlined in section 2.3.1 in Chapter Two. The community of practice is in accordance with an ontologically constructivist standpoint which posits that "reality can only be known through multiple mental constructions that are based on experience and socialisation" (Guba and Lincoln, 2005 cited in Hershberg, 2014, p.184).

To conclude this section, with the motivation to conduct a designer-focused research project, the researcher adopts the constructionist and epistemologically interpretivist position. This stance by the researcher exercises a great influence on every phase of the research process throughout the research project. This will be demonstrated in section 3.1 in detail.

1.1.2.2 Meaning of Research for the Author as a Designer

Definitions of research are different from the perspectives of various disciplines (Table 1.1). The emphasis in the current research is on a problem-solving dimension which is supported by Noble and Bestley's (2011, p.9) perspective given below:

> Research in the context of the practice of graphic design can be seen as an underpinning and defining activity, based in large part on the notion of problem solving using visual tools and methods.

The above definition of research is focused on the design area (others are more general). This perspective is supported by Van de Ven (2007) who argues that the process of research involves "problem formulation, theory building, research design, and problem solving" (p.10).

Synthesising the worldview of the author behind this research together with diverse definitions from other scholars, the author believes that research can be construed as a purposive systematic process of investigation from the formulation of a problem, to problem solving, in order ultimately to contribute to knowledge.

Table 1.1 Definitions of research (the wording in the table is taken directly from sources here).

Source	Definition
Rummel (1964, p.2)	Research is careful inquiry or examination to discover new information or relationships and to expand and to verify existing knowledge.
Sommer and Sommer (1986, p.3)	Research is careful, patient, and methodical inquiry done according to certain rules.
Gray (2004, xvii)	Often, we can only arrive at these answers through a systematic process of investigation – that is, research.
Leedy and Ormrod (2010, p.2)	Research is a systematic process of collecting, analysing, and interpreting information (data) in order to increase our understanding of a phenomenon about which we are interested or concerned.
Bailey and Handu (2013, p.2)	Research is a systematic process based on the scientific method that facilitates the identification of relationships and determination of differences in order to answer a question.
McGivern (2013, p.4)	Research is about enquiry; it is about systematic observation or investigation to find things out. It is the process by which we produce evidence or knowledge about the world.
Morley (2015, p.88)	Research may be defined as a systematic process which consists of three elements or components: (1) a question, problem, or hypothesis, (2) data, and (3) analysis and interpretation of data.
Saunders *et al*. (2015, p.726)	The systematic collection and interpretation of information with a clear purpose, to find things out.
Creswell (2015, p.3)	Research is a process of steps used to collect and analyse information to increase our understanding of a topic or issue.
Collins Dictionary (2021)	(*noun*) systematic investigation to establish facts or principles or to collect information on a subject. (*verb*) to carry out investigations into (a subject, problem, etc).

1.2 Aims and Objectives of Research Project

The overall aim of this research is to explore fundamental issues lying behind the production of inaccessible information by designers, in order ultimately to identify effective ways forward to provide information to designers themselves within an inclusive design context. The overall research aim will be supported by two sub-aims and four objectives.

Sub-aim 1. To reveal how situations and problem are perceived and understood by designers in the context of colour and information design.

- **Objective 1-1.** To compare responses to colour between participants from design and non-design backgrounds and identify differences between them.
- **Objective 1-2** To examine features of various types of information sources that are preferred for use by different designer groups, specifically user-related colour information.
- **Objective 1-3.** To show how colours and information about colour are dealt with by designers with different levels of experience in real-world design contexts.

Sub-aim 2. To discuss appropriate formats and their contents for providing user-related colour information to designers based on the characteristics of designers themselves, in order to encourage them to take a user-first approach.

- **Objective 2-1.** To investigate effective ways of providing colour information to designers by reflecting on the emotional characteristics of designers.

1.3 Research Overview

The overall structure of the research project takes the form of eight chapters within five distinctive phases (Table 1.2). The paragraphs below also address the central ideas of each chapter in a summary form.

Chapter 1. Introduction

This chapter provides an overall background for the present research project: a rationale for the research and positionality of the researcher. Also, research scope, aims, and objectives are presented.

Table 1.2 Research composition: phases and main purpose of each of the eight chapters.

Phase	Chapter(s)	Main Purpose
1	1 and 2	Defining research problems
2	3	Designing the research project
3	4, 5, and 6	Data collection and analysis
4	7	Communicating research findings
5	8	Contributions to knowledge

Chapter 2. Literature Review

This part of the thesis critically reports on and evaluates previous studies, analysing and synthesising these in order to confirm the necessity for the present research project. New overarching research questions arise from the findings in this part of the thesis, which lead to three main designer studies in the current research project (Chapters Four, Five, and Six).

Chapter 3. Research Methodology

The third chapter is concerned with the methodology used for this research project, describing how this thesis has been planned and performed. Theoretical background, methodological approaches, selection and application of research strategies, research types, and the data collection and analysis methods for the present research project are described along with justifications of the approaches used. Issues of the researcher’s role, research reliability, research bias, research reproducibility, and research ethics are also presented.

Chapter 4. Designer Study 1

This chapter explores differences between design and non-design groups of participants centring around the linguistic and behavioural characteristics that are found while they describe colour samples. This verbal and behavioural evidence is used to demonstrate how designers perceive colours. Sociolinguistic theories are adopted to provide theoretical background for this chapter.

Chapter 5. Designer Study 2

This chapter reports on focus groups of PhD design students using design prototypes (for an accessible bus route map for users, and Affective Imaginary Information [AII] format cards for designers) in order to investigate the knowledge, attitudes, and experience of design participants in relation to providing more accessible information, as well as explore factors which influence use by designers of user-related colour information. Narrative data from the focus groups is thematically analysed.

Chapter 6. Designer Study 3

Surveys, email interviews and colour design experiments are conducted in Chapter Six to examine designers' actual colour use (through colour application and modification tasks) and colour information use (colour information search tasks). The data is comparatively analysed based on different levels of designer groups by experience (student, novice, and expert). As part of this, a set of design prototypes (Affective Imaginary Information formats) developed in Chapter Five is provided to designers during the colour modification task. In addition to this, a discussion is offered in terms of the usefulness of the AII formats and suggestions for future directions based on the evaluation and opinions from professional design educators in Higher Education in the United Kingdom.

Chapter 7. Discussion

In this chapter, a discussion is offered based on findings from three main designer studies (Chapters Four, Five, and Six). The implications of findings from the three designer studies are reflected upon and evaluated to answer six overarching research questions which emerge from Chapters Two and Four. The findings of previous chapters are reconsidered together to explore interconnections between them.

Chapter 8. Conclusion

The conclusion gives a brief summary and critique of the research findings. The ways the aims and objectives of the research project are fulfilled are demonstrated. Contributions of the research project to knowledge are evaluated. Opportunities for further research identified through the findings of the project, along with areas for further research arising from some limitations in the project are identified.

1.4 Funding Source

Funding from Leeds Anniversary Research Scholarships (LARS) made this doctoral research project possible.

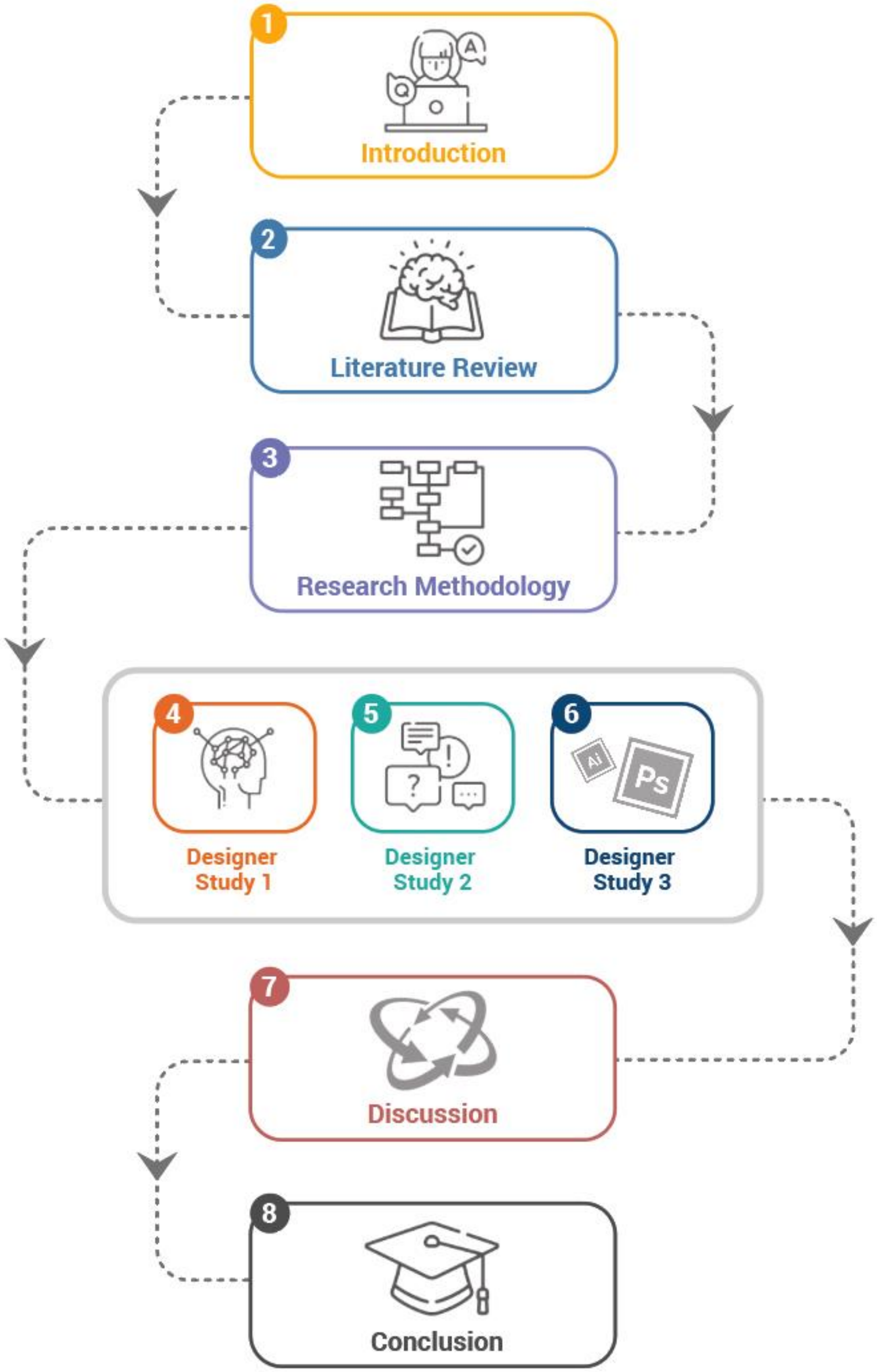


Figure 1.3 Illustration of overall flow of the present doctoral research project.

Chapter 2 LITERATURE REVIEW

This chapter represents the beginning of the present research project. The foremost purpose of this chapter is to show the necessity for the research by providing background to it through the analysis and synthesis of relevant literature.

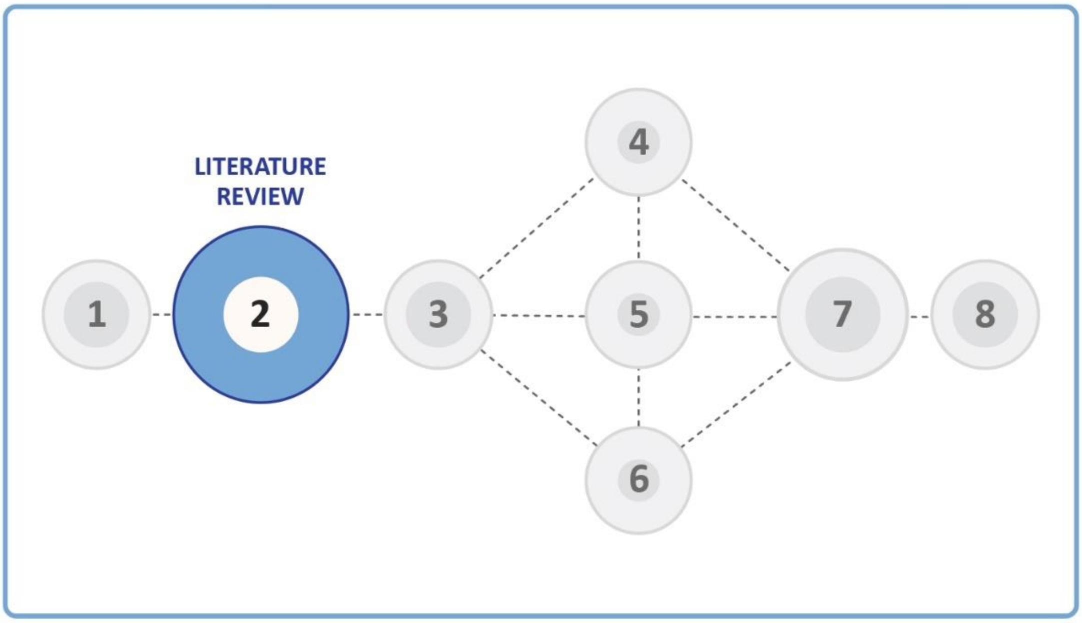


Figure 2.1 Position and context of Chapter Two within the whole research process.

The chapter starts by explaining the meaning of design within this thesis which indicates the view of the author of this thesis about how she understands the roles of design in our society. Based on the researcher's standpoint on design, the roles and responsibilities of designers will be critically reviewed particularly in the area of communication-oriented design. After this, characteristics of designers will be reviewed across design fields in order to explore common and differentiating features of designers by their levels of experience or education while performing problem solving design tasks. Concurrently, details of twenty-seven designer studies (e.g. data collection methods, numbers of participants, the criteria for differentiating designer groups, and purpose of research) will be systematically and comprehensively outlined to seek to find an appropriate approach to reach the goal of the present doctoral research project. While reviewing literature, it has become clear that colour and information is an area that has been given little attention in designer-focused research. As the current research focuses on characteristics of designers in a particular design context (the problem-solving situation) by analysing two types of language (verbal and visual) used by designers, the typology of designers' language will be reviewed to provide background. Lastly, based on a synthesis of the literature review, this chapter will offer five overarching research questions which provide the research framework and guide the whole research project.

2.1 Design for People in Our Society

2.1.1 Design as Problem Solving

The term design has a complex history. The meaning of design has been expanding constantly owing to the changing nature of society (Rowland, 1993; Muratovski, 2015). This could be one of the reasons why scholars (e.g. Navinchandra, 1991; Lawson, 2006; Miller, 2012; Rae, 2014) agree that definition of the term design is a difficult matter and not well understood in general.

In most English dictionaries, the meaning of design can be described with both noun and verb forms (Flusser, 1999). Cambridge English Dictionary (2020a) defines the noun design as follows:

> *(Plan)* a drawing or set of drawings showing how a building or product is to be made and how it will work and look.
>
> *(Pattern)* a pattern used to decorate something.
>
> *(Intention)* plans, often ones that are not honest, to get something or someone for yourself.

According to the Oxford English Dictionary [OED] (2020a), the first listed definition of the verb design is:

> to mark out, nominate, appoint, designate.

However, the current domain meaning of design has broadened and become complex. It embraces the related sense of the activity of designers while designing. It is described as (OED, 2020a)

> to conceive and make drawings and plans for a building, device, product, etc.; to act as or be a designer.

Table 2.1 Description of design as a problem-solving activity (the wording in the table is taken directly from sources here).

Author(s)	Descriptions of Design
Blumrich (1970, p.1551)	Design establishes and defines solutions to and pertinent structures for problems not solved before, or new solutions to problems which have previously been solved in a different way.
Wong (1993, pp.41-42)	We must not forget that the designer is a problem-solving person. The problems he is to face are always given. This means that he cannot alter any of the problems but must find appropriate solutions.
Rowland (1993, p.80)	Design is a disciplined inquiry engaged in for the purpose of creating some new thing of practical utility. It involves exploring an ill-defined situation, finding - as well as solving - a problem(s), and specifying ways to effect change.
Cooper and Press (1995, p.16)	Most accounts of design refer, at least in passing, to the fact that design is about conceiving which meet specific needs.
Lawson (2004, p.19)	In the most general sense, we can view problem solving as a very basic human activity and designing can be seen as a kind of problem solving.
Aspelund (2006, p.1)	Designer's work is concerned primarily with problem solving by developing and explaining ideas.
Pettersson (2012, p.12)	The term design represents the identifying of a problem and the intellectual creative effort of an originator, manifesting itself in drawings or plans that include schemes and specifications to solve the problems.

Many researchers seem to hold the view that design as a verb represents certain activities or processes of design by designers. Nevertheless, this type of definition of design may be interpreted diversely in light of designers' or design scholars' areas of focus. Pettersson (2002) argues that the design process contains not just some of the cognitive abilities of humans, but also that practical aspects, activities and steps in the design process can be called design activities. Design activities aim to seek solutions that meet needs in people's lives (Hembree, 2008). This involves creativity, synthesis and problem solving (Cross *et al*., 1996; Dorst, 2018). Problem solving is one of the typical characteristics of human cognition (Lawson, 2004; Langley and Cooper, 2017).

Table 2.1 reflects the general belief among various scholars over the last few decades that design is a problem-solving activity. The common basic point among those authors mentioned above suggest the design describes performance by designers which allows our world to be utilisable or otherwise. In this thesis, the term design is concerned with problem solving activities dealt with by design professionals.

2.1.2 Disability and Design Inclusion

Disability is one of the major issues and difficulties that face humanity and among the priorities to be tackled by society. Disability will become an even greater issue in the near future due to the growth of the aging population and increasing possibility of disability caused by rises in chronic health conditions (World Health Organization [WHO] and World Bank, 2011). Since disability presents complicated and multi-dimensional characteristics changes in the conceptual models of disability have resulted in changes in its definition over the years (Grönvik, 2007).

Previously, disability was classified on a medical basis (1900s-1970) (Rosenbaum and Stewart, 2004). In this model emphasising a medical basis for disability, disability was seen as a personal problem, and thus, concepts of universal and accessible design are irrelevant from this point of view as individual functioning cannot be recovered by these approaches to design (Erlandson, 2007).

New definitions, however, have emerged. On the basis of the World Health Organization’s new International Classification of Functioning and Disability, disability is regarded as a consequence of an interaction between individuals and environmental factors, as people's environment can enable or disable them (House of Commons Women and Equalities Committee, 2017). This approach called the ‘social model’ (developed in 1980s) is preferred by disabled people and their organisations as a way of encouraging society to better understand disability and to become more inclusive (Barrett et al., 2003). Further, the social model of disability has been encouraged as a basis for interaction with people with disability to identify solutions to barriers facing them by the UK government (Department of Education, Equalities Office, and Disability Issues, 2015). Erlandson (2007) explains that the point is that this shift in the conceptualisation of disability implies the need for social and environmental changes to remove disabling barriers.

The social model of disability is behind the principles and philosophy of inclusive design. The British Standards Institution [BSI] BS 7000-6:2005: 'Design Management Systems – Part 6: Managing Inclusive Design - Guide' refers to inclusive design as "design of mainstream products and/or services that are accessible to, and usable by, people with the widest range of abilities within the widest range of situations without the need for special adaptation or design" (BSI, 2005, p.4). Inclusive design uses various names, for example, universal design in the USA and design for all in Europe (Clarkson and Coleman, 2015) depending on the continent or region (Bianchin and Heylighen, 2018). However, the fundamental idea is about "understanding users' capabilities, needs and expectations" (Johnson *et al.*, 2010, p.275). The more inclusive approach to design emphasises a close relationship between designers and users (Newell *et al*., 2010).

Accessibility and inclusivity have received great attention under the inclusive design philosophy. The concept of inclusivity for design needs to be considered as a central part of the design process at an early stage of design (Carter, 2014), to allow insights into problems and possible solutions (Erlandson, 2007). Thus, scholars increasingly believe that it is essential for designers to incorporate inclusive design within their responsibilities in order, ultimately, to make society more accessible.

2.1.3 Disabling Information Provision by Designers

The term disability is associated with impairments that require design interventions. Designers and communication professionals have increasingly been concerned with provision for disabled people, and issues of accessibility or awareness are important (Gieben-Gamal and Matos, 2017). Nevertheless, existing research reveals that there are indeed challenges which prevent designers from designing information with inclusive design in mind.

Scholars (e.g. Roth, 1999; Forlizzi and Lebbon, 2002; Cornish *et al.,* 2015) agree that communication-oriented design (e.g. graphic, communication, information design) particularly when print-based, presents problems in relation to accessibility. It is an under-represented research area from the inclusive design view point in comparison with other design areas such as industrial product design (Roth, 1999) or web design (Cornish *et al*., 2015). Previous scholars have found various reasons for this. For example, printed communications are regarded as transitory unlike industrial design outputs (Roth, 1999). In addition, Cornish *et al*. (2015) state that in the print-based graphic area users cannot alter or have input on the appearance of print in the design process. This may mean that somebody other than users creates or designs the information format or provision and relies on their own design knowledge, intuition or design skills. Designers take such roles in real world information provision. In addition, communication designers are more likely to rely on their personal insight because of lack of user data compared to the product design area (Forlizzi and Lebbon, 2002). This may lead to the problem that design professionals unthinkingly create designs that are suitable for those with the same level of ability and competence as themselves, resulting in a lack of connection with potential users, and the exclusion and alienation of many people (Wilkinson and De Angeli, 2014).

The present research agrees with the arguments that prior researchers have made above. However, problems are not limited only to the issue of printed communication but include all kinds of communication materials or contexts such as websites, videos, press releases and information-based events. Some of the reasons for problems mentioned above by other scholars could be applied to any communication materials or context at some point.

Questions still remain as to why designers consistently continue to create inaccessible communication materials even though we have already identified problematic factors that have made them do so in the past. This research now poses a brief question:

> Is too little information available to allow designers to make communication artefacts accessible and more inclusive?

This seems not to be the case. The simplest answer to this question seems to be Pettersson's claim that:

> Designers do not read their handbooks, or their scientific journals, and they are not prepared to apply experimental data to their work. Often designers are not even aware that this guideline information exists (Pettersson, 2015c, p.23).

Frascara's (2015, p.49) argument may also give an answer to the above question:

> There is enough knowledge today to produce good information design, but this knowledge is not getting to where it should be.

Pontis and Babwahsingh (2016, pp.255-256) explain specific reasons for production of inaccessible information provision as below:

> Information design solutions repeatedly display basic problems (e.g., lack of information hierarchy, poor choice of colour use, unclear message, inappropriate use of graphic language).

Although researchers (e.g. Pettersson, 2015c; Frascara, 2015; Pontis and Babwahsingh, 2016) suggest reasons for the phenomenon of continuous production of inaccessible information by designers, it may be that the question posed above has no simple answer. One reason is because design problems are rather complex. It may be that the responses and behaviours of designers toward the problematic phenomenon of communication accessibility cannot be changed by production of guidelines which tell designers what to do or what not to do.

Building on the argument above, this research asserts that there needs to be a more fundamental approach to seeking reasons for the continuous production of inaccessible communication materials, in order to provide more radical and effective solutions.

2.2 Designer Practice

2.2.1 Design, Designers, and Communication

It is beyond question that humans need to communicate to convey information. The word communication derives from Latin noun *communicatio*, which means “a sharing or imparting” (Peters, 2008, p.1). Communication is an area of research which has been studied in various disciplines including design (Pettersson, 2015a). All communicative design is brought about by the requirement for a message to be communicated and the desire for a response (Frascara, 2004).

In this section, some widely recognised communication models and theories will be addressed across academic fields. Also, some communication-oriented design areas such as information design, graphic design, and visual communication design will be compared. In addition, the role of designers focusing specifically on the communicative design area from a designer perspective will be discussed.

2.2.1.1 Theories and Models of Communication

In a traditional view, communication is understood as a type of horizontal (Ma, 2015) and one way transmission where a sender conveys desired messages to one or more receivers (Pettersson, 2002). Shannon and Weaver’s well-known communication-system model (Figure 2.2) is an example of a one way communication model and was introduced based on a mathematical theory in 1949 (Pettersson, 2016).

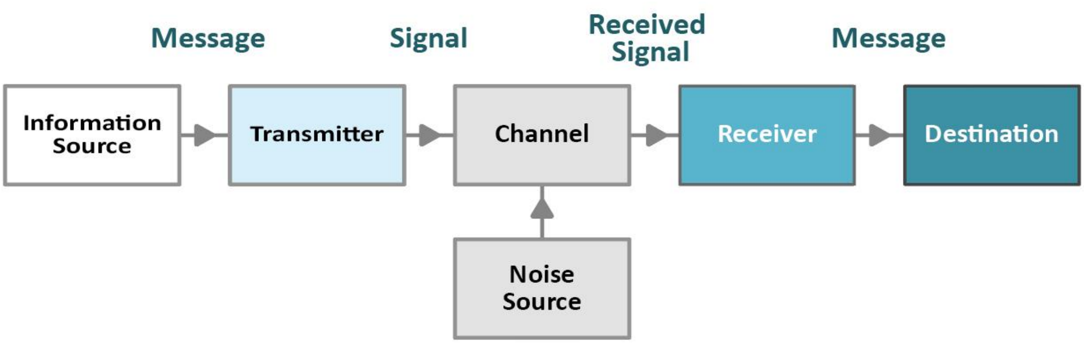


Figure 2.2 Shannon and Weaver’s data transmission model of 1949 (source: adapted from Shannon and Weaver, 1963, p.34 and redrawn by the author of this thesis).

However, the Shannon and Weaver model has been criticised by other scholars. Examples of such criticism are given below.

> Nothing to do with human communication (Pettersson, 2015a, p.10).
>
> Only formal does not account for content (Kaminski, n.d. cited in Al-Fedaghi, 2012, p.13).
>
> Only proved that it can be described as transfer of a bitstream (Flensburg, 2009, p.32).

Nevertheless, this model of communication is not just frequently used at the technical level (Al-Fedaghi, 2012), but also has affected other later communication models which have discussed human communication. Shannon and Weaver (1963) also note that there are three levels of interrelated levels of communication problems (listed in Table 2.2). Despite the criticisms mentioned above, the Shannon-Weaver model may be one of the earliest visual explanations of how a Level A problem of communication (see Table 2.2) could be resolved in a simple way.

Table 2.2 Three levels of communication problem (source: reformatted and adapted from Shannon and Weaver, 1963, p.4 with the wording in the table taken directly from the source).

Level A	Technical problem	How accurately can the symbols of communication be transmitted?
Level B	Semantic problem	How precisely do the transmitted symbols convey the desired meaning?
Level C	Effectiveness problem	How effectively does the received meaning affect conduct in the desired way?

Another widely cited model is Lasswell's 5W model of communication (Figure 2.3) (Fiske, 2010) which is regarded as "one of the earliest and most influential communication models" (Shoemaker *et al*., 2004, p.109). It applies specifically to mass communication (Fiske, 2010). The 5W model was formulated for the analysis of communication activities in human society (Ma, 2015), focusing on answers to five questions: "who, says what, in which channel, to whom, and with what effect?" (Lasswell, 1948, p.117 cited in Shoemaker *et al*., 2004, p.109). Fiske (2010) states that the 5W model is thought of as a verbal version of Shannon-Weaver's communication model because of its linear process. Lasswell's 5W model was further expanded by Braddock in 1958 with a 7W model (McQuail and Windahl, 2013; Ma, 2015).

Figure 2.3 Lasswell's 5W communication model.

A further model developed and revised in the 1950's based on the Shannon-Weaver model is Schramm's model. Figure 2.4 below shows the second version of Schramm's model of communication. Pettersson (1989) states that Schramm's second model makes clear that for communication to occur the sender and receiver must have some shared experience. Ma (2015) claims that Schramm's second model is crucial because this highlights real human behaviour within the communication process. These three models mentioned so far (e.g. Shannon and Weaver, 1949; Lasswell, 1948; Schramm, 1954) are some of the most widely recognised traditional communication models.

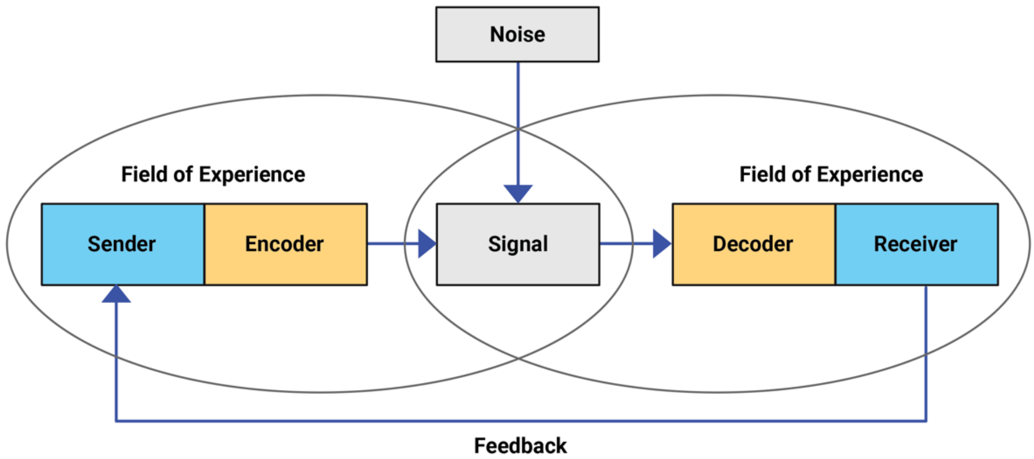
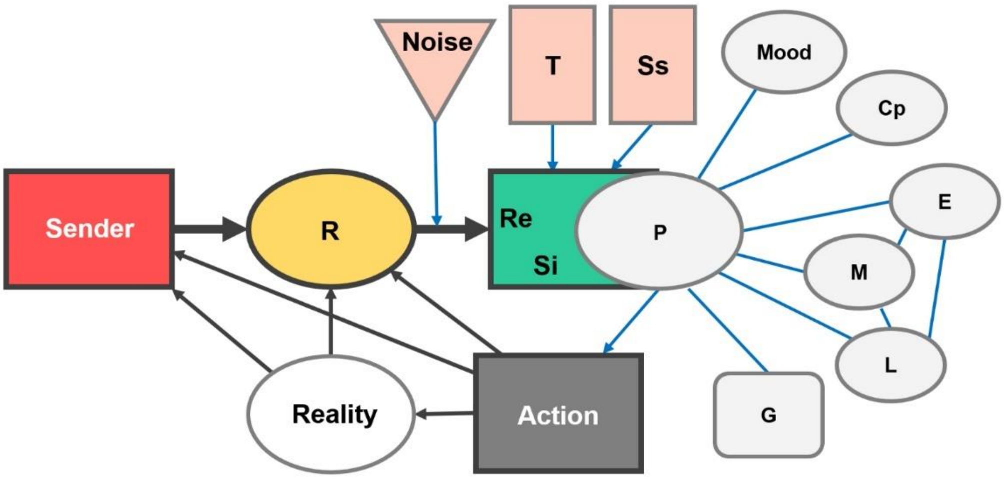


Figure 2.4 Schramm's (1954) model of communication (source: adapted from Pettersson, 2015a, p.11 and redrawn by the author of this thesis).

Pettersson suggested a more complex communication model in 1983 (Figure 2.5). This model illustrates how various factors are interconnected in a complex way. Pettersson (2015a) describes his communication model of 1983 as below:

> In the production of information, a sender conveys information on a part of reality via a representation to an information receiver who, via sensory impression, is able to obtain a perception of that reality. This perception may then evoke a response that affects the reality and/or creates some feedback to the original sender.

> The receiver's perception varies as a result of a number of factors e.g., his or her current cultural and social states, the time and stage of development, mood, experience, memory, and other cognitive processes, such as creativity. Perception is divorced from the representation that, in turn, is divorced from the reality. Some of our sensory impressions give rise to 'garbage' and some to learning (Pettersson, 2015a, pp.11-12).



T *= time and stage of development,* ***Ss****= Cultural and social status,* ***R****=Representation,* ***Re*** *= Receiver,* ***Si*** *= Sensory Impression,* ***P*** *= Perception,* ***Cp*** *= Cognitive process such as intelligence and creativity,* ***E*** *= Experience,* ***L*** *= Learning,* ***M*** *= Memory, and* ***G*** *= Garbage*

Figure 2.5 Pettersson's (1983) communication model (source: adapted from Pettersson, 2015a, p.12 and redrawn by the author of this thesis).

Finally, Baldwin and Roberts (2006) discuss Shannon and Weaver's communication model from a visual communication standpoint (Figure 2.6). They modify Shannon and Weaver's model by reflecting three interrelated levels of communication problems (listed in Table 2.2).

Baldwin and Roberts (2006) argue that in their visual communication process (Figure 2.6) "the designer is just one part of a larger team concerned with getting the mix of technical, semantic and effectiveness levels right" (p.27). These authors also note that "key to this" and "the final link in the communication process" is "the recipient of the message or audience" (p.27). Thus, "identifying the intended audience, and what types of message and media they respond to best, is an important part of visual communication" (p.27). This model is worth noting as it calls attention to the designer's role and position in this communication process.

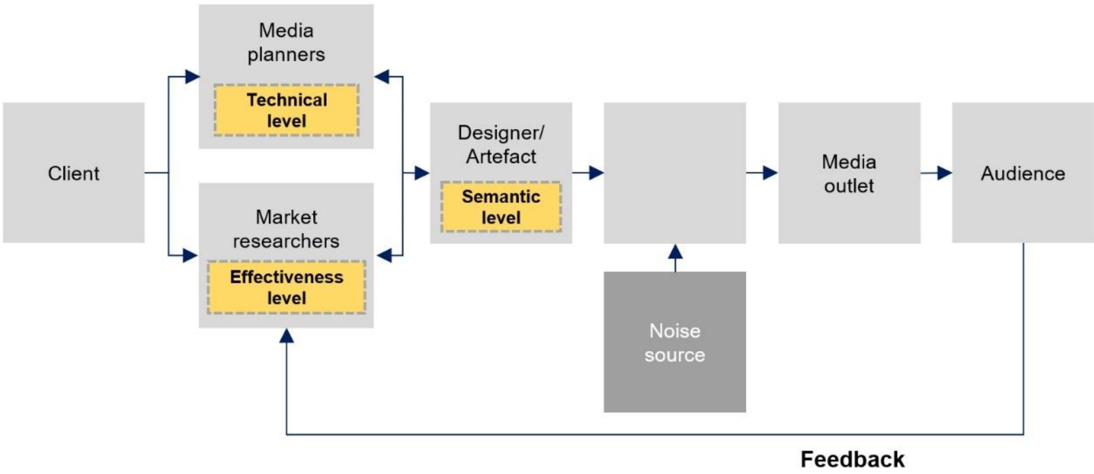


Figure 2.6 Visual communication model (source: adapted from Baldwin and Roberts, 2006, p.27 and redrawn by the author of this thesis).

There is a countless number of communication models and theories (e.g. Newcomb's ABX model, 1953; Gerbner's model, 1956; Westley and MacLean's model, 1957; Kakobson's model, 1960; Berlo's model, 1960; Dance's helical model, 1967; DeFleur's psychodynamic model, 1970; Barnlund's model, 1970; Saussure de, 1971; Hall's reception theory; 1980; Rogers and Kincaid's convergence model, 1981; Petty and Cacioppo, 1981; Graber's new-processing model, 1984; McQuail's display/attention model, 1987; Fiske's media discourse model, 1987; Ericson, Baranak, and Chan's model, 1987; among others). These developed from diverse areas of scholarship.

Despite only five models being addressed in detail in this section so far, what can be seen is that communication models have been developed in a complex manner with various factors influencing each other. This may be because our society is changing rapidly and is increasingly intertwined based on technological developments. Communication models and theories are becoming complex. Nevertheless, there are three main components which cannot be replaced. These are a sender, receiver, and channel (medium) - which acts like a bridge between sender and receiver. The roles and types of channel may vary depending on the researchers' area of focus.

Design is not a new area of communication research. Design can influence the "efficiency, effectiveness, and character of communication experiences" (Davis and Hunt, 2017, p.13). However, many communication models seem to have been created and further developed in areas other than the field of design. For this reason, the roles designers play between senders and receivers seems to be overlooked.

In reality, there is a large difference between information senders and receivers in terms of what are perceived as effective information materials. Table 2.3 shows the results of an experiment by Hellspong *et al*. (1987) which was conducted among groups of university students on the quality of information materials. The results show that senders rate text, visuals, and graphic design more positively than do receivers.

Table 2.3 Assessment of 'good' and 'bad' qualities in information materials rated by senders and receivers from an experiment conducted by Hellspong *et al*. in 1987.

Variable	Intended Rating (senders)		Perceived Rating (receivers)		Difference	
	Good	Bad	Good	Bad	Good	Bad
Text	84	32	60	25	24	7
Visuals	77	34	53	17	24	17
Graphic design	70	27	50	14	20	13
Total impression	80	26	51	24	29	2

It is argued in this thesis that designers may be able to reduce the gaps identified between senders and receivers of information (see Table 2.3) based on their design abilities or skills, as this is one of the roles of designers in the process of communicative design. Their ability to do this may be explained according to four categories of activity.

Firstly, designers often consult the information provider (sender or customer/client) in order to understand their intention. They make an expert judgement about the main point of the senders' intention and how it can be transformed visually and graphically. They do so by applying their design skills based on understanding of the needs of senders. Secondly, designers present their understanding via visual interpretation. This is an 'expert judgement skill' and a 'visual interpretation ability' of designers. Thirdly, because most receivers are not trained to be designers, it is essential for designers to understand an information users' (receivers) position – how the receivers would feel about and perceive visual messages that designers create. This could be called an 'ability of aesthetic empathy'. Fourthly, designers transform raw data (this is abstract, invisible, or only textual in many cases) to visual/graphic messages. Ideally, this allows it to be delivered effectively and efficiently to receivers. This could be termed a 'sensible imaginative design skill' of designers. These are some of the key roles of designers in communication-oriented design practice. Certainly such abilities and skills are invaluable, but these roles are often overlooked, underestimated, or seem to be conceived of as rather passive in linking the sender to receivers.

2.2.1.2 Communication-oriented Design Disciplines

According to Pettersson (2015b), there are different message design genres. These are “graphic design, information design, instruction design, mass design, and persuasion design” (Pettersson, 2015b, p.38), which have varied objectives in their messages.

Many scholars point out the difficulties in distinguishing some of the professional design terms: information design [ID], visual communication design [VC], and graphic design [GD] because of their interrelated and overlapping nature. Although GD is closely related to ID with both areas focused on how information can be displayed (Passini, 1999), scholars have different opinions in terms of hierarchical categories for such design terms. For example, Hurlburt (1982) and Kim (1997) have opposed views about ID and GD. Hurlburt (1982) argues that ID is a broader concept often covering all areas of two-dimensional design. Yet, he also points out that setting clear boundaries between the three disciplines ID, GD, and VC are not easy because of their broad nature.

Hurlburt (1982, p.22) states that:

> Terms like information design, visual communication, and even graphic design are so broad in their connotations that it is impossible to use them accurately to describe specific functions.

Kim (1997), however, takes the view that ID is a sub-discipline of GD which deals with “sign systems, charts, tables, maps, explanatory panels, etc” (p.1).

In terms of GD and VC, Noble and Bestley (2011, p.9) argue that there are common features of the designers’ role as:

> The act of designing, in terms of visual communication and graphic design, centres on the ways in which a designer addresses practical and theoretical problems through a broad range of often two-dimensional (print-based), but increasingly also three-dimensional or time-based, media, materials and processes.

Other scholars, however, claim that the realm of VC is wider encompassing ID and GD. For them, the topic of VC includes a wide range of academic fields of research, which among others include “advertising, audio-visual instruction, communication design, communication models, communication theories, computer science, critical perspective theory, creative process, information interpreter, information provider, persuasion design, mediated communication, creative processes, instructional message design, information, knowledge, visual literacy, media literacy, instructional technology, encoding model, decoding model, human-computer interaction, mass-communication, media and communication, planned communication" and so on (Pettersson, 2015a, p.13). In addition, VC may include "colour connotations, graphic communication, implicit meaning, pictorial communication, typeface personality, visual language, visual perception" (Chandler and Munday, 2020). The definitions of VC given by various scholars are listed in Table 2.4.

Table 2.4 Definitions of visual communication (the wording in the table is taken directly from sources here).

Researcher(s)	Description
Frascara (2004, p.2)	An activity, is the action of conceiving, programming, projecting, and realising visual communications that are usually produced through industrial means and are aimed at broadcasting specific messages to specific sectors of the public.
Hembree (2008, p.14)	Visual communication combines speech, written language, and imagery into messages that are aesthetically pleasing, connect with the audience on intellectual and emotional levels, and provide them with pertinent information.
Kenney (2009, p.1)	A social process in which people exchange messages that include visuals.
Chandler and Munday (2020)	The generation and interpretation of messages and connotations in visual forms, particularly still and moving images but also body language (especially gestures and facial expression) and non-linguistic forms in written texts (such as typography and emoticons). These are very often used in close association with verbal language.

Frascara (2004) contends that the term graphic designer tends to place emphasis heavily on physical and graphic elements, so that the core activity of the design profession is often removed – "the main aim of which is not the creation of graphic forms but the creation of effective communications" (p.4). Thus, he proposes that the term visual communication designer is more appropriate and descriptive because this covers "three essential elements of the profession: a method (design); an objective (communication); and a medium (vision)" (p.4).

London College of Contemporary Arts [LCCA] (2019) also offers a comparison between VC and GD (Table 2.5). In their description, VC refers to "any non-verbal communication that uses the sense of sight” whereas GD is described as having “a narrow focus as it only focuses on creating graphics for websites, advertising campaigns and marketing materials”. LCCA (2019) posits VC as a superordinate concept of design disciplines more than GD.

In summary, communication is the main reason for the existence of some of the important design disciplines: ID, GD, and VC. Although these design areas have different names, there is a common point. Such design disciplines are all explained within communication-oriented design practice aiming at ultimately solving communicative problems between senders and receivers by adopting design skills/abilities in an effective and efficient manner. These three design disciplines would seem to overlap each other at some points. Since clear boundaries between ID, GD, and VC are somewhat problematic, it is important to clarify how terms are used in this thesis. Recent scholarship (e.g. Frascara, 2004; Buwert, 2016; LCCA, 2019) would suggest that VC seems to be more expansive and inclusive and incorporates ID and GD (Table 2.6). Therefore, in this thesis, the term VC will represent the domain as a whole incorporating ID and GD.

Table 2.5 Differences between visual communication design and graphic design (source: reformatted and adapted from LCCA, 2019 with the wording in the table taken directly from the source).

Parameters	Visual Communication	Graphic Design
Focus	Communicating with consumers using visual mediums, so students may be required to learn graphic design, animation, photography, illustration or airbrushing.	Has a narrow focus as it only focuses on creating graphics for websites, advertising campaigns and marketing materials.
Tasks	Tasks involve anything within the domain of visual communication, whether photography, editing, video-filming, preparing materials to share information with clients, etc.	The tasks here include designing elements for print and digital platforms.
Tools Used	Illustrator, Adobe XD, Sketch and Photoshop.	Illustrator, Photoshop, InDesign, Affinity Photo and Affinity Designer.
Another Term	Viscom.	Communication design.

Table 2.6 Hierarchical relationships between ID, GD, and VC indicated by prior scholarship.

Author(s)	Superordinate Concept	Subordinate concept
Hurlburt (1982)	ID	GD
Easterby and Zwaga (1984)	ID	GD
Kim (1997)	GD	ID
Frascara (2004)	VC	GD
Buwert (2016)	VC	GD
LCCA (2019)	VC	GD

2.2.1.3 Roles of Designers in Visual Communication Design

With respect to the designer's role in the field of VC, Hembree (2008) states that there are three groups of people involved: the information sender, the encoder (moderator), and the receivers (information users). Designers are not commonly thought of as a source of the messages in real world (Frascara, 2004). Hembree (2008) emphasises the designer's role as an independent moderator who translate sender's needs by visual language into images and contents for the information receivers.

On the other hand, Pettersson (2010) demonstrates a more flexible view and expands the role of the designer as a mediator who finds a solution to information problems in information design. This author argues that a 'sender' wishing to communicate with users of information, might at times take responsibility for developing and designing information in a range of forms and take on the job of producing and distributing it. In VC, Pettersson (2010) argues that in numerous cases this job is given to a design professional who is required to determine what the sender's actual desired goal is. This view is significant and means that designers do not only represent contents visually, but also, as they design information and messages, they actively encourage people in general to think and act according to an intended purpose.

Taking Pettersson's (2010) perspective on the designers' role in VC, in this research project, designers are positioned as active information senders at the same time as being encoders (Figure 2.7).

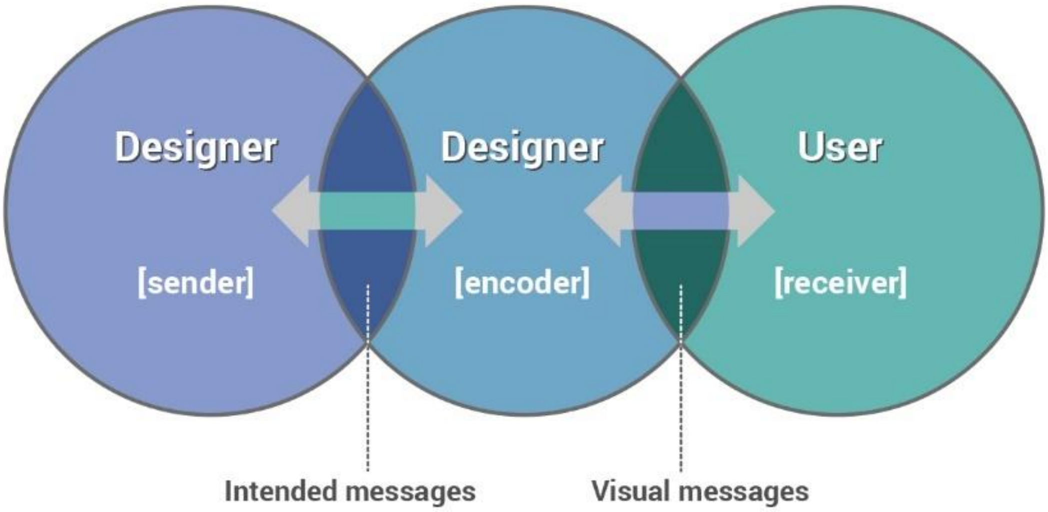


Figure 2.7 The position of designers within this research project.

The next section will review literature about how designers think and work in problematic situations (particular design tasks) and compare designers by level of experience in terms of their problem-solving behaviours. The section will also examine which are the main fields that design studies have been focused upon, and how such studies dealt with the subject.

2.2.2 The Characteristics of Designers

2.2.2.1 The Designerly Way of Thinking

How the brain works or “how we think, remember and learn” - is a fascinating interest in the area of brain science and cognitive psychology, according to the American Psychological Association [APA] in 2014. People in many other areas such as architects, engineers, scientists, curriculum designers, and graphic designers among others also wish to know about this topic (how the brain works) as well (APA, 2014).

Cross (2007) notes that because design activities are so rich and complex this has resulted in wide-ranging studies on how the designer actually thinks while engaged in design. According to Gero and Milovanovic (2020, p.2), “the cognitive activity carried out by designers while they are designing” can be regarded as “design thinking”. They suggest three paradigmatic approaches to design thinking research: design cognition, design physiology, and design neurocognition. Among these, design cognition is the most well-established area (Gero and Milovanovic, 2020). It measures the cognitive behaviours of designers while designing by adopting direct (protocol analysis) or indirect techniques (e.g. interviews, surveys, and black-box experiments) (Gero and Milovanovic, 2020).

Cognition refers to "the mental processes relating to the input and storage of information and how that information is then used to guide" individual "behaviour" (Cambridge Cognition, 2015). Cognitive skills encompass convergent thinking [CT], divergent thinking [DT], visual thinking [VT], and problem formulation [PF] (Shah *et al*., 2012). Measuring CT and DT is one of the main aims of design cognition research (Gero and Milovanovic, 2020).

Psychological definitions related to the terms 'convergent' and 'divergent' can be found in OED in 2020:

> *(Psychol.)* Of thinking, reasoning, etc.: of a kind that tends towards only one answer to a problem (OED, 2020b, 'convergent').

> *(Psychol.)* Of thinking, reasoning, etc.: of a kind that produces a wide variety of possible answers to a problem (OED, 2020c, 'divergent').

Split brain experiments conducted by Roger Sperry who received the Nobel Prize in 1981 in Physiology or Medicine showed the two brain hemispheres are functionally different (Lienhard, 2017). On the basis of Roger Sperry's research, many scholars (e.g. Tovey, 1984; Gabora, 2010; Kahneman, 2012; Razumnikova, 2013; Goel, 2014; Allan, 2018) cite two cognitive styles related to the different hemispheres: DT (right hemisphere) and CT (left hemisphere). Cross and Nathenson (1981 cited in Cross, 1990) claim that understanding the dual structure of the human brain is important for design methodology and design education. More elaborate explanations of the differences between dual processes of thinking modes are listed in Table 2.7.

Table 2.7 Differences between hemispheres in terms of CT and DT (source: reformatted and adapted from Razumnikova, 2020, p.759 with the wording in the table taken directly from the source).

Characteristics	DT (right)	CT (left)
Problem type	Poorly defined	Well-defined
Responses	Multiple	Single
Psychometric index	Creativity	Intelligence
Attention	Defocused and global	Focused and local
Mood	Positive	Negative
Predominating thinking strategy	Intuitive and irrational	Analytical and rational
Specific strategy of response selection	Insight	Deductive retrieval
Brain activation	Low-level and widespread	High-level and localised
Domain of specific giftedness	Art	Science

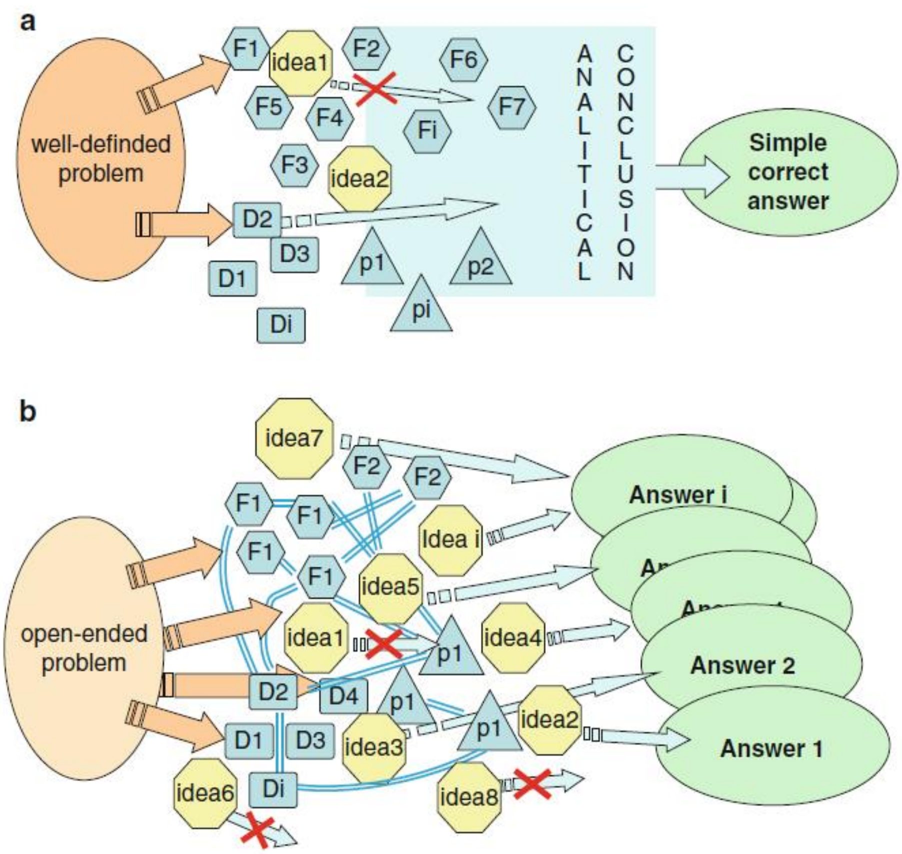


Figure 2.8 Scheme of organisation of (a) convergent and (b) divergent thinking F1…I, D1...I, and P1… I sign different semantic categories in multiple knowledge structures (source: adopted from Razumnikova, 2020, p.760).

With regard to problem-solving processes based on each side of the brain, there are important distinctions between CT an DT investigated by prior researchers (Figure 2.8). According to Razumnikova (2020), conventional understanding is that ‘associational knowledge’ results in new ways of thinking with various connections made between ‘remote concepts’ (see Figure 2.8b). Razumnikova (2020) also states that ‘convergent thinking’ reduces the number of responses possible with an aim of ensuring the right one is chosen (see Figure 2.8a). It can also reduce creative thinking as it stays with the most likely ideas (Razumnikova, 2020).

The left side of the brain is said to support CT which is “propositional, focused, linear, serialist” (Cross, 1990, p.133), characterised by “vertical transformations” (Goldschmidt, 2016, p.116), and “rational, logical, and slow-thinking” (Allan, 2018, p.10). It is also said to be a “rule-based, and analytic mode of thought” (Gabora, 2010, p.3). CT is about “finding the single correct answer, and standard intelligence tests are similarly believed to measure convergent thinking” (Razumnikova, 2013, p.551).

On the other hand, DT is said to be sustained by the right brain relying on “mental operations, such as heuristics” (Allan, 2018, p.10). The activities of the right brain are said to be related to “drawing, use of images or metaphors, reading poetry – to help groups surface unspoken assumptions, feelings, and opposing viewpoints that might aid in navigation of back roads” (Jaffe, 2019, p.43). DT is characterised as associative, lateral, flexible, intuitive, appositional, holistic, instinctual, creative, and related to fast-thinking (Cross, 1990; Clarkson, 2005; Goel, 2014; Sloman, 2014; Allan, 2018). Gabora (2010) notes that descriptions of associative thought say it is “intuitive, unconstrained, and conducive to unearthing remote or subtle associations between items that share features or are correlated but not necessarily causally related” (p.2). This may offer solutions or ideas that have potential, but in forms that may lack polish and full clarity (Gabora, 2010). According to Razumnikova (2013), DT focuses on the production of numerous alternative responses that are “appropriate and adequate” (p.551). In addition, it frequently has associations of creativity as responses are made to open-ended tasks, in which “varied, original, or unusual ideas” are generated (Razumnikova, 2013, p.551).

Table 2.8 Similarities between hemispheric characteristics related to CT and DT (source: reformatted and adapted from Razumnikova, 2013, p.549 with the wording in the table taken directly from the source).

Characteristics	DT (right) and CT(left)
Sensory processes	Careful observation of their environments to gather information through the senses.
Memory	▪ Large working memory capacity. ▪ Implicit and explicit memory resources.
Knowledge	Effective application of requisite processing operations to relevant domain-specific and general knowledge.
Task types	Verbal, figural, numerical, and social.
Cognitive structures and abstraction	Using different concept maps and abstract models to understand the world.
Emotional regulation	Negative emotions induce increased motivation to task performance, but positive emotion facilitates associative and semantic priming and supports the processing of global perceptual information.
Brain activity	Interaction of specific and associative brain areas in line with individual strategies of problem solving.
Adaptation to variable environment	Integration of intellectual and creative abilities to introduce change, innovation, or improvement over what exists.

Although each of these two cognitive thinking styles is quite discrete as described, they share similarities with each other (Table 2.8). Some scholars stress the need for two thinking modes. For example, Runco and Basadur (1993) claim that “divergent ideation and convergent evaluation” (p.168), together with “appropriate attitudes” (p.170) are required for creative problem solving performance. In real cases, shifting between two thinking modes often occurs in creative problem solving in design (Tversky and Chou, 2010; Goldschmidt, 2016).

A double diamond model (Figure 2.9) was proposed in an original form by British Design Council [BDC] in 2005, based on Banathy's (1996) divergence-convergence model. BDC (2015) explains its original model as follows: “two diamonds represent a process of exploring an issue more widely or deeply (divergent thinking) and then taking focused action (convergent thinking)”.

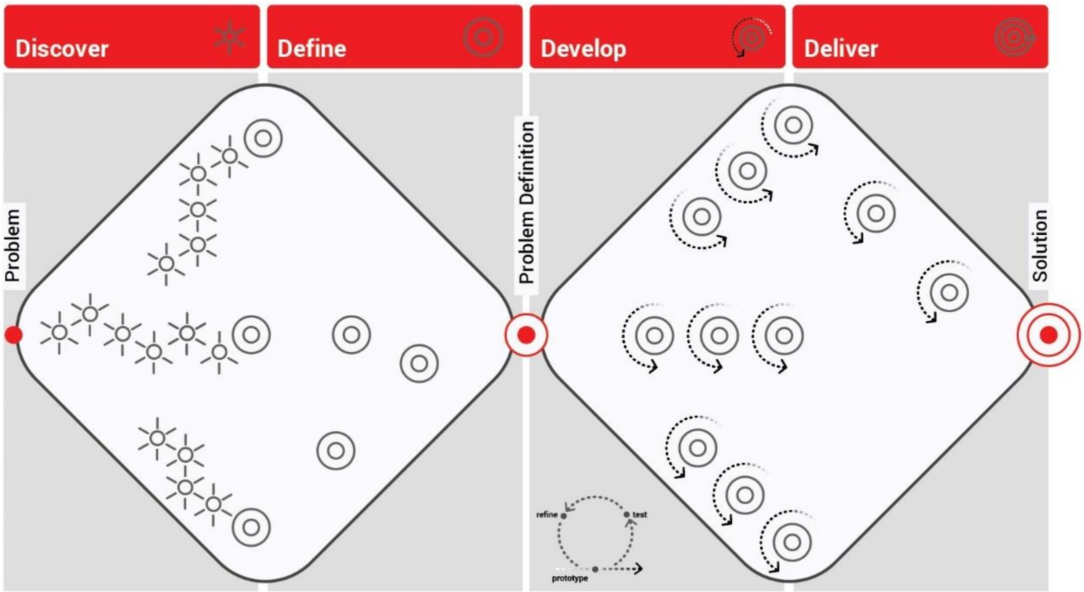


Figure 2.9 Original double diamond model (source: adapted from British Design Council, 2007, p.10 and redrawn by the author of this thesis).

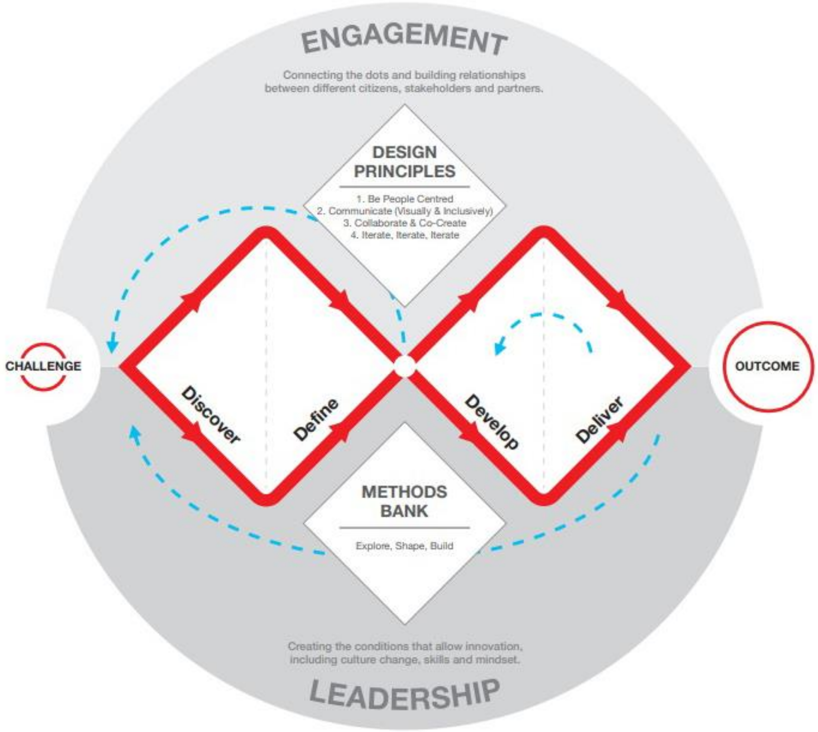


Figure 2.10 The new double diamond model: framework for innovation (source: adopted from BDC, 2019).

A new double diamond model illustrated in Figure 2.10, which was developed in 2019 based on its original version from 2005, shows in a more visually descriptive way how less-structured (divergent) and well-structured (convergent) styles work mutually and iteratively in design problem solving situation. It represents the idea that both cognitive thinking styles are essential for design problem solving. Overall, it appears that both CT and DT are needed for the most effective problem solving in the area of design.

2.2.2.2 A Designerly Mindset and Reflection

In design, reflection involves setting space, generating alternative answers to problems, and testing these by recasting the problems repeatedly (Schön, 1983). Reflection has the following features: “consciousness, retrospection, introspection, and self-knowledge” (Quayle and Paterson, 1989, p.30). According to Quayle and Paterson (1989), these points show that our minds have the capacity for action and observation, and that they can take on the task of solving problems, while also ‘wondering’ about the process of finding solutions to the problems.

The concept of reflection can be linked to one of the fundamental design paradigms known as ‘reflective practice’ established by Schön (1983). Reflective practice is divided into two areas: reflection-in-action and reflection-on-action. Bolton (2014, p.6) describes “reflection-in-action is the hovering hawk in the mind”, allowing us to recall and apply our skillset, our prior learning and experiences at the appropriate moment. Design is closely connected through its activities with reflection-in-action (Schön, 1987; Dorst, 1997). During reflection in action, the practitioner is permitted to use the knowledge base of the profession in an explicit manner (Thompson and Pascal, 2012).

Design involves designers’ adapting their knowledge to a specific piece of work. Design knowledge is often unavailable in format that is easily retrievable (Wong and Radcliffe, 2000). The term “knowing-in-action” (Schön, 1983, p.61) was introduced and described as a tacit knowledge held by designers. Schön (1983) states that professionals tacitly reflect their knowledge in the design task. The term tacit knowledge suggests “we can know more than we can tell” (Polanyi, 2009, p.4). Mareis (2012) claims that tacit knowledge has close links to expressions used by previous scholars, for instance, “designerly ways of knowing” (Cross, 1982) and “design thinking” (Rowe, 1987). The latter concerns “the study of how designers work and think” (Cross, 1984 cited in Cross, 1993, p.66). Tacit knowledge is mainly demonstrated through the actions of each individual rather than what they appear to know (Polanyi, 2009).

The evidence reviewed above so far suggest that the notion of design activity can be understood as reflection-in-action based on an individual designer’s action. Thus, design can be seen as a situated activity of designers (how designers act in a particular problematic situation). This is the way theorists understand design in practice. This landmark paradigm has been highly influential among design scholars.

Evidence of the usefulness of reflective practice and how the reflection can be detected in design practice can be seen in prior design studies. For example, Valkenburg and Dorst (1998) describe design activities by observing design teams. The authors found that using the reflective practice paradigm is useful to understand what a team is doing and provides researchers with an effective examination and overview of the project. Kamil *et al.* (2018) show how Schön’s (1983) theoretical idea (reflection-in-action) is seen during empirical design tasks done by practicing designers. In particular, these authors explore designers’ cognitive processes during sketching activities by using verbal protocol analysis. They argue that reflective practice (reflection-in-action) can offer new interpretations and ideas for solutions to designers in specific situations.

Reflection-in-action seems also to be related to conjecture analysis theory proposed by Hillier *et al*. (1972) which investigates the relationship between knowledge and design. Hillier *et al*. (1972) argue that designers pre-structure design problems as well as pre-determine the solutions based on their knowledge and previous experiences. Strong evidence of conjecture analysis theory has been supported by various scholars in architectural design practice. For instance, Darke (1979, p.43) asserts “designers have to find a way of reducing the variety of potential solutions to the as yet imperfectly understood problem, to a small class of solutions that is cognitively manageable”. Lawson's (1979) study shows further illustrative examples by comparing and discovering different cognitive problem-solving strategies among architecture and science students. It was concluded that scientifically trained students adopted what was called a ‘problem focusing strategy’ while architecture students applied a ‘solution focusing strategy’ to design (Lawson 1979). The latter involved going through a series of ranked solutions until one proved to be acceptable (Lawson 1979). Later, Lloyd and Scott (1994) showed in research with design participants that the solution oriented approach appears to be connected to the levels and types of prior experience among designers.

Such research as that above demonstrate the value and evidence for reflective practice in design. Of course, designers may not recognise that they are following a particular theory or paradigm. The paradigms are ways that theorists describe and understand how designers think and work. Designers may think in certain ways, whereas they do not necessarily adopt a certain identifiable paradigm consciously. Nevertheless, the studies reviewed above provide important insights into distinctive behavioural characteristics of design practitioners in terms of seeking solutions to problems. This could be called a “solution-oriented” (Wynn and Clarkson, 2005, p.36) approach. Findings from the studies reviewed put emphasis on design professionals’ design knowledge, experience and actions during a design task that coincide with Schön’s view (1983) of design as "reflective conversation with the situation" (p.79).

2.2.2.3 A Designerly Way of Doing

Although the designers’ distinctive features were uncovered in a broad sense in section 2.2.2.2, it still needs to be proven concretely how design practitioners actually tackle problems in specific design situations, in order to explore more explicit characteristics of designers in actual practice. For this reason, this section will examine existing empirical design studies mainly on design practice scattered across diverse design fields.

Twenty-seven scholarly published outputs were reviewed in order to achieve the section’s goal (listed in Table 2.9). Each of the papers reviewed is coded numerically from 1 to 27 chronologically. Outputs from the journal Design Studies make up more than half (14 out of 27). These academic resources were identified through University of Leeds library website, academic repository, and google scholar using keywords such as ‘design expert’, ‘how designers think’, ‘design activity’, ‘design cognition’, ‘design experiment’, ‘levels of designer’ and so on. In order to be included in the present study resources were required to be peer-reviewed and include an empirical investigation of cognitive aspects of design and designers. All studies were required to focus on the different characteristics of experienced and inexperience designers or between designers and non-designers through comparison during design tasks. The selected articles were searched from 1992 up to and including 2017. The aims of each of the published articles are listed in Table 2.10.

Table 2.9 Reviewed academic articles in this part of the study.

Type of Output	Name of Journal or Conference	Number of Outputs Used	Study No. within this thesis
Journal article	Design Studies	14	2, 3, 4, 7, 10, 11, 13,14,15,16, 21, 22, 24, 26
	The Design Journal	1	20
	Research in Engineering Design	1	5
	Computers in Human Behaviour	1	6
	Performance Improvement Quarterly	3	8, 9, 17
	Educational Technology Research and Development	1	12
	Human–Computer Interaction	1	19
	International Journal of Art & Design Education	1	23
	Design and technology education	1	25
	Cognitive Systems Research	1	27
Conference paper	Design Theory and Methodology (DTM)	1	1
	International Working Conference on advanced visual interfaces	1	18

Table 2.10 List of empirical design studies reviewed within this thesis based on research purposes and design areas in chronological order.

Study No.	Author(s) (year)	Purpose of Study	Design Area
1	Christiaans and Dorst (1992)	▪ To produce a cognitive model of the design process, focusing on domain-specific knowledge exploration.	Industrial and engineering design
2	Atman *et al.* (1999)	▪ To develop an in-depth understanding of how freshman and senior engineering students approach a complex open-ended design problem.	Engineering design
3	Casakin and Goldschmidt (1999)	▪ To verify to what extent the use of visual analogy helps novice and expert designers to improve design problem-solving.	Architecture design
4	Seitamaa-Hakkarainen and Hakkarainen (2001)	▪ To explore how visual ideas could be represented differently through weaving between novice and expert designers.	Textile (weaving) design
5	Ahmed *et al.* (2003)	▪ To investigate how novice and experienced designers approach design tasks.	Engineering design
6	Uduma and Morrison (2007)	▪ To explore the different usage of an instructional design tools by different participant groups.	Instructional design
7	Menezes and Lawson (2006)	▪ To investigate differences in the use of formal and symbolic references by different groups of design students.	Architecture design
8	Ertmer *et al.* (2008)	▪ To explore how experienced designers solve ill-structured problematic situations in instructional design using their previous knowledge and experience.	Instructional design
9	Ertmer *et al.* (2009)	▪ To compare the differences in problem representation between non-expert and expert designers. ▪ To examine the influence of guidelines on the representation of problems by novice designers.	Instructional design
10	Liikkanen and Perttula (2009)	▪ To examine problem decomposition in the solution search phase of conceptual product design (in particular, for physical products).	Conceptual product design
11	Stones and Cassidy (2007)	▪ To examine the influence of sketching (as a tool) on the process of interpretation during graphic design ideation.	Graphic design
12	Williams *et al.* (2011)	▪ To understand how instructional designers evaluate design activities.	Instructional design
13	Vallet *et al.* (2013)	▪ To gain understanding of the eco-design approach practiced in design teams.	Product design

(continued)

14	Björklund (2013)	▪ To explore differences in the initial mental representations of real-life product development problems between novice and expert designers.	Eco-design
15	Ozkan and Dogan (2013)	▪ To investigate differences by level of expertise in problem solving related to analogical reasoning.	Architecture design
16	Goldschmidt and Rodgers (2013)	▪ To compare the design thinking approaches of three groups of student designers.	Various design fields (Industrial and architectural)
17	Fortney and Yamagata-Lynch (2013)	▪ To investigate how designers deal with ill-defined problems in the workplace.	Instructional design
18	Bigelow *et al.* (2014)	▪ To explore challenges experienced and the perspectives of designers in terms of data visualisations.	Visual interface design
19	Kim and Ryu (2014)	▪ To reveal the differences in ability between novice and expert designers in framing design problems during problem solving.	Human-computer interaction design
20	Self *et al.* (2014)	To investigate the influence of design expertise on attitudes in terms of use of various design tools.	Industrial design
21	Crilly (2015)	▪ To explore professional designers' attitudes towards fixation and how they adopt and address it.	Product design
22	Chai *et al.* (2015)	▪ To explore the impact of the level of expertise of designers during analogical reasoning.	Industrial design
23	Wong *et al*. (2016)	▪ To investigate how designers are trained or re-educated within the design workplace.	Design education
24	Liang *et al*. (2017)	▪ To analyse the brainwave patterns for visual attention and association among expert designers and inquiring about the differences caused by three kinds of pictorial representations.	Psychology (cognitive science)
25	Schaeffer and Palmgren (2017)	▪ To assess and examine the effect of prototyping exercises in design education.	Design and technology education
26	Deininger *et al*. (2017)	▪ To investigate how novice designers conceptualise and report on prototypes during the design process.	Mechanical and biomedical engineering design
27	Yao *et al.* (2017)	▪ To analyse differences between expert and novice designers in their brain activity when they are engaged in visual association.	Electrical engineering (cognitive science)

Across a wide range of design disciplines over the last decade, a number of outputs are focussed heavily on the distinctiveness of different levels of designers by level of experience. Therefore, a number of scholars investigate how designers think and work under certain design tasks through observing their behaviour while problem solving (e.g. setting the design strategies, prototype making, sketching, or use of design CADs, and cognitive performance).

In this section, in particular, while reviewing design studies, five sub-sections and five research sub-questions arose (Table 2.11). The answers to these research sub-questions will be described in the following section. Answering the research sub-questions will provide background and justifications for building up later stages in the thesis: methodological approaches (Chapter Three) and experimental designer studies (Chapters Four, Five, and Six) based on general tendencies and patterns of designers.

Table 2.11 Sub-sections and related research sub-questions within this section.

Sub-section	Research Sub-question
Design ability by level of experience of designers	**Sub-question 2.1** What distinctive and differentiating characteristics can be shown between different levels of designers in terms of problem-solving behaviour during design tasks?
Criteria for designer classification	**Sub-question 2.2** What are the criteria for designers to be called either student, novice, or expert designers?
Appropriate research methods for design studies	**Sub-question 2.3** What types of research methods do scholars employ to explore distinctive characteristics of designers during problem solving tasks?
Design experimentation setup	**Sub-question 2.4** What sample size and duration are needed for experimental designer comparison research?
Design activities in colour design context	**Sub-question 2.5** Is there any research about characteristics of designers in the area of colour design?

2.2.2.3.1 Design Ability by Level of Experience of Designers

Sub-question 2.1 What distinctive and differentiating characteristics can be shown between different levels of designers in terms of problem-solving behaviour during design tasks?

The design activity or work of designers has been characterised as “surprisingly flexible” (Buchanan, 1992, p.5) and “literally indescribable in linguistic terms” (Daley, 1982, p.137). In terms of design problems, there are several important features which can be characterised as follows: vague, complex, open-ended, less-structured, and ill-defined or wicked (Rittel and Webber, 1973; Buchanan, 1992; Ghosh, 1993; Dorst, 2006; Goel, 2014). However, designers share common features in terms of their approach toward design tasks. Pontis and Babwahsingh (2016) argue that all designers attempt to find a design solution (though in different ways even if they share the same design process). Cross (1995; 2006) summarises aspects of what designers need to do and four core features of design ability (Table 2.12).

Table 2.12 Major aspects of work of designers and core features of design ability put forward by Cross (the wording in the table is taken directly from sources here).

Major Aspects of What Designers Do (Cross, 1995, p.107)	Core Features of Design Ability (Cross, 2006, p.20)
Produce novel, unexpected solutions.	Resolve ill-defined problems.
Tolerate uncertainty, working with incomplete information.	Adopt solution-focusing strategies.
Apply imagination and constructive forethought to practical problems.	Employ abductive, productive, and appositional thinking.
Use drawings and other modelling media as means of problem solving.	Use non-verbal, graphic/spatial modelling media.

A more detailed discussion about characteristics of a broad range of designers is now required, as understanding of what abilities (e.g. knowledge and skills) they possess according to their level of experience, and how they use their accumulated knowledge and skills during design work is an essential part of this research. For this reason, the first research sub-question asks what distinctive and differentiating characteristics can be shown between different levels of designers in terms of problem-solving behaviour during design tasks. This is because although a number of design studies deal with the ability of designers by comparing them by level (based on education or years of design experience in the design industry in general), areas of research seem to be scattered across the design discipline. Therefore, a focused assessment of findings is needed.

In the field of engineering design, Christiaans and Dorst (1992) have found that experienced designers adopt a working forward method and knowledge-building approach. These strategies give rise to a detailed grasp of the problematic situation that makes clear the principles at the root of the issue and related approaches for a solution. Ahmed *et al*. (2003) observed two groups of designers in engineering to investigate how novice and expert designers approach a design task. This study shows notable differences between them. The authors discovered that expert design professionals have unique attributes: they consider issues, are aware of limitations, they refer to past designs, keep options open, are aware of trade-offs, and they use intuition in comparison to that of early career (novice) designers. Similar findings were reported by Deininger *et al*. (2017) who examined the use of prototypes by novice designers in engineering design, finding that relatively early career designers may not have gained an in-depth understanding of the importance of prototypes.

Similar characteristics are explored in the area of design education, Human-computer Interaction (HCI) and the other design fields as well. In the field of HCI, Kim and Ryu (2014) show that experienced designers are skilled in grasping design problems and making fast responses while inexperienced designers can less easily identify problems in design. In the area of instructional design, Winer and Vázquez-Abad (1995) claim that highly experienced designers repeatedly trial and improve their designs before achieving an end result in comparison to less experienced designers. In the area of product design, Liikkanen and Perttula (2009) find that experienced designers have the ability/capacity to evaluate and discard their ideas continuously more than inexperienced designers. In information design, Waller (2011) contends that expert design professionals alternate between phases of creativity and evaluation. This author argues that such designers are mentally evaluating what they do even when they are apparently at the solution stage. Table 2.13 summarises some of distinguishing features between experienced and inexperienced designers based on the literature. Despite scholars focussing on different design areas, noticeable distinguishing characteristics among designers based on different levels of education and employment experience can be detected clearly. A range of designer studies prove that more experienced designers are likely to be better problem solvers in any case of design in any domain.

Table 2.13 Distinguishing characteristics among experienced and inexperienced designers in terms of problem-solving behaviour (the wording in the table is taken directly from sources here).

Researcher(s)	Characteristics of designers	
	Experienced (expert)	Inexperienced (non-expert)
Christiaans and Dorst (1992, p.132)	▪ Working-forwards approach. ▪ Knowledge-development strategy. ▪ Utilisation of domain inferences. ▪ Categorising a problem through a preliminary analysis of its features, activating a particular problem category.	▪ Working-backwards approach. ▪ Spending more time to analyse problems. ▪ Quick suggestion of solutions and equations just after reading the problem statement. ▪ Having sparse problem prototypes organised by superficial features from what is known in the problem situation.
Kavakli and Gero (2002, p.39)	▪ The expert seems to have control of his cognitive activity and governs his performance in a more efficient way than the novice.	▪ The novice deals with three times as many concurrent actions as the expert (comparing concurrent cognitive performance).
Ahmed *et al*. (2003, pp.6-8)	▪ Tended to carry out a number of activities (e.g. design strategies) that novice designers did not. ▪ Aware of reasons behind the use of a particular component or process in a particular design. ▪ Refer to past design from various sources including memory, drawing, reports, and colleagues. ▪ Questioned themselves whether a particular approach was worth pursuing and how components were modelled or tested. ▪ Aware of trade-offs and limitations.	▪ Carried out several activities that were classified as a thought or an action rather than a design strategy during the design task. ▪ Often expressed lack of confidence in own decision. ▪ Expressed difficulty in visualising the design while working on the computer. ▪ Expressed difficulty in the task they were undertaking, as they had not done it before. ▪ Follow a pattern of ‘trial and error’.
Cross (2006, pp.26-27)	▪ Often pursue a ‘depth-first’ approach to a problem. ▪ Bottom-up process.	▪ Breadth-first and top-down strategies. ▪ Tend to reject an early solution when it is discovered to be fundamentally flawed.

2.2.2.3.2 Criteria for Designer Classification

Sub-question 2.2 What are the criteria for designers to be called either student, novice, or expert designers?

The second sub-question is about criteria for classifying designers into experience levels. Thus, how other scholarship has divided designer groups in experimental design research will be reviewed. Dreyfus (2003) notes that in order to investigate designers' designing behaviour it is necessary to map out designers by level of experience. Table 2.14 shows the different phases or levels within the design profession put forward by Cross (2011) and Dorst (2015).

As for the criteria for expert and novice designers from the reviewed academic outputs, the following can be seen. Ahmed *et al*. (2003) state that a novice designer refers to a person who is new in the chosen area with a lack of experience, while those with many years of experience are considered expert designers. Mehalik and Schunn (2006) comprehensively review over forty published journal articles in the area of engineering design. These authors describe expert designers as people with more than five years of expertise, while novices have between more than two and less than five years of prior experience. Kim and Ryu (2014) state that expert designers are those who have at least four years expertise. Yao *et al*. (2017) believe that expert designers can be people who hold formal education in professional design, or those with design-related employment experience of more than five years, whereas novice designers include junior or senior design students in a university. Table 2.15 lists conventions used by other researchers for dividing designer groups in designer studies (mainly for investigating problem-solving behaviour).

Table 2.14 The different levels of design expertise (expertise increases from top down).

Cross (2011, p.142)	Dorst (2015, p.57)
Neophyte (introduction)	Naive (result-focused)
Novice (education)	Novice (convention-based)
-	Advanced beginner (situation-based)
-	Competent (strategy-based)
Expert (experience)	Expert (experience-based)
Master (eminence)	Master (developing new schemata)
-	Visionary (redefining the field)

Table 2.15 Levels of design participants taking part in each designer study by experience.

Study No.	Designer Level	Level of Design Expertise (Experience)
1	▪ Novice	▪ 2nd year undergraduate students.
	▪ Intermediate	▪ Final year undergraduate students.
2	▪ Freshman	▪ 1st year undergraduate students.
	▪ Senior student	▪ 4th year undergraduate students.
3	▪ Novice (beginner)	▪ 1st & 2nd year undergraduate students.
	▪ Novice (advanced)	▪ 3rd & 4th year undergraduate students.
	▪ Expert	▪ At least 7 years of working in weaving design.
4	▪ Novice	▪ Graduate student (4-6 years of study in textile) and no employment experience.
	▪ Expert	▪ 5-10 years working in weaving design.
5	▪ Novice	▪ Less than 2-5 years of employment experience.
	▪ Expert	▪ Over 8 years of employment experience.
6	▪ Naïve	▪ No formal training in instructional design and no employment experience.
	▪ Novice	▪ Formal training in instructional design and no employment experience.
	▪ Expert	▪ Formal training in instructional design and at least 2 years of employment experience.
7	▪ Novice	▪ 1st year architecture student.
	▪ Advanced	▪ Final year architecture student.
8	▪ Expert	▪ Over 8 years of employment experience (ave.20.5 years) and master or PhD degree.
9	▪ Novice	▪ No more than one postgraduate Instructional design course with less than 3 years of employment experience.
	▪ Expert	▪ One or more postgraduate Instructional design courses with a minimum of 8 years of employment experience.
10	▪ Advanced beginner	▪ Completion of master's level with some practical design experience (M=0.8 years, SD=0.7 years).
11	▪ Student	▪ Final year university student.
12	▪ Designer	▪ Around 8 years of employment experience (instructional or related design area).
13	▪ Expert	▪ From 1 to 15 years of employment experience in the design area (ave.6.30 years).

(continued)

14	▪ Novice	▪ Between 6 months and 3-years of employment experience (including part time design work).
	▪ Expert	▪ Product design manager or record of design award-winning product development; from 8 to 15 years of employment experience; and at least 13 product development projects completed. (Necessary to meet all three criteria).
15	▪ Novice	▪ 1st, 2nd and 4th year university students.
	▪ Expert	▪ At least 10 years of employment experience.
16	▪ Student	▪ Year 3 of 4 in industrial design course.
	▪ Student	▪ Year 5 of 5 in architecture design course.
	▪ PhD student	▪ Year 1 of 3 at PhD level.
17	▪ Novice	▪ Less than 2 years of employment experience.
	▪ Expert	▪ More than 5 years of employment experience.
18	▪ Designer	▪ Teaching staff in design departments. ▪ Design students. ▪ Professional designers.
19	▪ Novice	▪ 1st year undergraduate student.
	▪ Expert	▪ At least 4 years of employment experience.
20	▪ Advanced beginner	▪ Final year undergraduate student.
	▪ Expert (practitioner)	▪ Over 3 years of employment experience.
21	▪ Expert	▪ Average 21 years of employment experience, and bachelors, masters or doctorate level degrees in design or engineering.
22	▪ Student	▪ 1st year of undergraduate student.
	▪ Student	▪ 3rd year of undergraduate student.
	▪ Expert	▪ At least 2 years of employment experience.
23	▪ Novice ▪ Expert	▪ Practical employment experience at design company.
24	▪ Expert	▪ More than 10 years of employment experience, leading design team in graphic and multimedia area, and award winner of international design competition (necessary to meet these three criteria).
25	▪ Novice	▪ Student in BA information design.
26	▪ Novice	▪ Undergraduate students.
		▪ Master students.
27	▪ Novice	▪ University student majoring in design.
	▪ Expert	▪ More than 5 years of employment experience, education in design, and leading design team in graphic and multimedia design (necessary to meet these three criteria).

Table 2.15 above clearly shows that many researchers divide design participants into two or three groups in their design studies. This generally depends on the number of working years in the design industry or level of design education.

To provide a more visualisable explanation of the classification of design participants, Table 2.16 utilises colour-coded sections which represent levels of designers based on the twenty-seven design research outputs reviewed and the classifications used by those outputs. Naïve, indicating no experience at all, is placed in the light pink area in the table. Only study number 6 invited a naïve group of participants allowing the study to compare non-designers to designers.

Classifications of student designers are coded light yellow in the table. This colour classification covers enrolled design students, including BA, MA, and PhD students, who have no employment experience in the field of design.

On the other hand, a range of novice designers (light green blocks) include design students and those with early career design practitioner experience. It seems that many researchers tend to have a flexible view to designate the novice group as including either persons who do not have practical design experience in the design industry (such as students) or those with such practical experience. The novice designer group also overlaps the expert group of designers (light blue block) as well. The maximum years of employment experience of a novice designer is no more than five years in any study (see study No. 5 in Table 2.16).

For classifications in an expert designer group (colour-coded in light blue), participants needed to have employment experience of at least one year. As can be seen then, the level of employment experience between one year and five years overlaps between the area of the novice and expert designer group. For purposes of this thesis, an expert designer group can be defined as those with more than five years of employment experience to draw a line between it and a novice designer group.

In Table 2.16, the sections coded in grey covering studies 1, 7, 10, 12, 18, and 23 indicate that these studies do not give clear terms or definitions for designer groups. The Arabic number in each coloured block indicates the sample size (number of participants).

Of course, a high level of experience is not a guarantee of a good designer. There does not seem to be a distinct boundary among expert designers, novice, and student designers. However, there is a general view in the studies that expert designers have employment experience of at least five years. Novice designers, on the other hand, are considered to comprise any grade of undergraduate or master's student, or other persons who have less than five years of experience working in the design industry. Student designers are usually those studying at undergraduate level with no or little employment experience. The findings here will be adapted in Chapter Six to distinguish designer groups and compare them in colour experimentations (see section 6.3.2).

Table 2.16 Classification of designers based on twenty-seven scholarly published designer studies.

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<tr><th>Study No.</th><th>Naïve</th><th colspan="4">Student</th><th colspan="5">Novice</th><th colspan="8">Expert</th></tr>
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2.2.2.3.3 Appropriate Research Methods for Design Studies

Sub-question 2.3 What types of research methods do scholars employ to explore distinctive characteristics of designers during problem solving tasks?

According to Cross (1990), there are various ways of investigating the abilities of designers. He orders some of the techniques from the most direct to indirect research methods (Table 2.17).

Table 2.17 Possible research methods for studying design abilities (source: reformatted and adapted from Cross, 1990, p.130 with the wording in the table taken directly from the source).

Direct	Interviews with designers.
	Case studies of particular design projects.
	Observations of designers at work.
	Protocol studies of design activity.
Indirect	Laboratory experiments based on selected features of design ability.
	Theorising.

Table 2.18 Review of twenty-seven design studies focused on research methods used and showing total number of outputs using each method.

Method Used	Total Outputs Using Method
Interview (semi-structured or in-depth interview)	9
Questionnaire	9
Observation (direct or participant observation)	7
Recording video (behaviour recording)	7
Talk-aloud method	5
Survey (attitude or demographic survey)	5
Verbal reporting (self-report, verbal description, write a case response)	4
Think-aloud method	4
Electro-encephalography [EEG] experiment	2
Prototyping workshop	1
Card sorting method	1
Hackathon	1
Delphi method	1

The research methods used in the twenty-seven scholarly published design studies are summarised in Table 2.18. It was expected that frequently used methods would be the most appropriate for investigating designers' characteristics when comparing groups of them during design tasks. This has assisted in selecting the methodological approaches and techniques for the present research project. As can be seen in Table 2.18, qualitative techniques such as a self-report, card sorting, observations, think and talk aloud methods, individual design tasks, recording and describing the design process, the Delphi method, self-reports, interviews, workshops have been used. However, in recent years EEG experiments that are quantitative have been used. This indicates that the articles reviewed from 1992 to 2017 in the present research confirm that Cross's (1990) findings are still accurate (Table 2.17). The findings here suggest what methods need to be used to investigate designers' reflection on design tasks. The research methods applied in this research project will be described in the relevant sections of specific chapters in detail (see sections 4.2.4.3, 5.4.1, and 6.2.4).

2.2.2.3.4 Design Experimentation Setup

Sub-question 2.4 What sample size and duration are needed for experimental designer comparison research?

As shown above, various qualitative research methods have been applied in studies by other scholars. Sample sizes used in qualitative approaches are frequently less large than those used for quantitative studies (Dworkin, 2012). Dworkin (2012, p.1319) notes that this "is because qualitative research methods are often concerned with garnering an in-depth understanding of a phenomenon or are focused on meaning (and heterogeneities in meaning) – which are often centred on the how and why of a particular issue, process, situation, subculture, scene or set of social interactions".

Table 2.19 lists the number of participants, the design experiment duration, and research methods used from each of the twenty-seven reviewed designer studies. As can be seen, the participant numbers and duration for the design experiments vary. There do not seem to be any strict models. For example, Self *et al*. (2014) carry out surveys with over a hundred design participants (study No.20) in each group they establish in order to compare them. On the other hand, other scholars invite relatively small numbers of participants for their research while conducting observations, interviews, self-report, and protocol methods (study Nos. 4, 5, 6, 8, 12, 14, 16, 17, and 19). The duration is likely to depend on the research methods that researchers apply. This all tells us that the sample size and duration for studies is flexible depending on research methods adopted.

Table 2.19 Relationship between sample size, duration, and method applied.

Study No.	Designer level focus	Sample Size	Duration	Methods Used
1	▪ Novice	10	2.5 hours	▪ Think-aloud-method ▪ Card sorting method
	▪ Intermediate	10		
2	▪ Freshman	26	104 min	▪ Think-aloud method ▪ Verbal protocol analysis
	▪ Senior student	24	110 min	
3	▪ Novice (beginner)	21	N/A	▪ Recording + describing the experimental process
	▪ Novice (advanced)	23		
	▪ Expert	17		
4	▪ Novice	2	Between 45 and 67 min	▪ Think-aloud method
	▪ Expert	2		
5	▪ Novice	6	120 min	▪ Observation
	▪ Expert	6		
6	▪ Naïve	4	2 min	▪ Talk-aloud protocol ▪ Attitude survey ▪ Questionnaire ▪ Direct observation
	▪ Novice	4	5.3 min	
	▪ Expert	4	13 min	
7	▪ Novice	30	30 min	▪ Verbal description
	▪ Advanced	30	30 min	
8	▪ Expert	7	120 min	▪ Demographic survey (online) ▪ Think-aloud protocol ▪ Interview
9	▪ Novice	24	120 min	▪ Demographic survey (online) ▪ Write a case response
	▪ Expert	8		
10	▪ Advanced beginners	16	N/A	▪ Observation ▪ Capturing video ▪ Verbal protocol analysis
11	▪ Student	10	50 min	▪ Capturing and examining
12	▪ Designer	7	60 min	▪ Interview
13	▪ Expert	23	90 min	▪ Participant observation

(continued)

14	▪ Novice	7	Ave. 37 min	▪ Verbal reporting (6 open-ended plus generic questions)
	▪ Expert	7	Ave. 47 min	
15	▪ Novice	373	N/A	▪ Delphi method
	▪ Expert	30		
16	▪ Student	4	Ave. 603 min	▪ Self-reports
	▪ Student	4	Ave. 326 min	
	▪ PhD student	4	Ave. 357 min	
17	▪ Novice	3	13 weeks	▪ Observation ▪ Interview ▪ Survey
	▪ Expert	5		
18	▪ Designer	15	N/A	▪ Observation ▪ Interview ▪ Hackathon
19	▪ Novice	8	90 min	▪ Verbal protocol method
	▪ Expert	8		
20	▪ Advanced beginner	116	N/A	▪ Survey
	▪ Expert (practitioner)	106		
21	▪ Expert	13	Ave. 50 min	▪ Semi-structured interview
22	▪ Student	21	55 min	▪ Behaviour recording ▪ Interview
	▪ Student	31		
	▪ Expert	12		
23	▪ Novice	11	Between 90 and 120 min	▪ In-depth individual interview
	▪ Expert			
24	▪ Expert	12	36 min	▪ EEG experiment
25	▪ Novice	160	N/A	▪ Prototyping workshop
26	▪ Novice	14	60 min	▪ Semi-structured interviews
		2		
27	▪ Novice	8	25 min	▪ EEG experiment
	▪ Expert	8		

2.2.2.3.5 Design Activities in Colour Design Context

Sub-question 2.5 Is there any research about characteristics of designers in the area of colour design?

Cross (2011, p.75) argues that there are three key strategic aspects of design thinking regardless of the area of design:

1. Taking a broad *systems approach* to the problem, rather than accepting narrow problem criteria;
2. *Framing* the problem in a distinctive and sometimes rather personal way; and
3. Designing from *first principles*.

Based on Cross's (2011) statement along with scholarly published outputs reviewed in this research project, it is clear that characteristics of more experienced designers revealed in given design tasks are differentiated from those of inexperience designers regardless of design fields. Thus, it can be accepted that although diverse areas of design research were reviewed in this section, the selection of the literature is not a problem because all of the literature reveals similar findings.

Table 2.20 Area of designer-focused research reviewed within this section.

Area of Design (practice-based)	Total output	Study No.
Engineering/industrial design	6	1, 2, 5, 20, 22, 26
Instructional design	5	6, 8, 9, 12, 17
Architectural design	3	3, 7, 15
Product design	3	10, 13, 21
Graphic design	1	11
Visual interface design	1	18
Human-computer interaction design	1	19
Eco design	1	14
Textile design	1	4
Mixed design area (industrial and architecture)	1	16
Non-practice based design Area	**Total output**	**Study No.**
Design education	2	23, 25
Psychology (cognitive science)	2	24, 27

This section (section 2.2.2.3) has reviewed academic resources on the topic of problem-solving during design tasks across a range of design fields, which make comparison between experienced and inexperienced designers. However, there appears to be a lack of experimental design research in terms of use of colour (colour design) under problem solving situations. There may be various reasons. Firstly, colour has a complex nature. For example, in the area of colour design particularly for products, colour designers are required to resolve various conflicting factors such as the relationship of colour with size and volume of the object as well as glossiness and texture of the surface where the new colour will be applied. Moreover, the impact of combinations of different materials (fabric, plastic, or metals) on colours are also considered to discover the most harmonious aesthetic use of colour to make the consumer feel pleasure from such integration. Thus, designers need to mediate diverse factors while working with colours. For designers, obtaining such design skills is time consuming. Because of this, it may be hard to find professional colour designer participants for the research. Plus, there are relatively small numbers of design professionals who focus solely on colours compared to the other areas of design (e.g. graphic, information, web, product, fashion, textile, and so on). These might be reasons for a paucity of designer research in colour design.

Colour designers (commonly called colourists) work intensively on colours compared to designers from other fields. Because of the explanations given above it may be difficult to recruit colour design participants exclusively for this research. However, almost all designers also work with colours in their everyday design life. The same often applies to design students who are enrolled in art and design school. For this reason, inviting design participants from various design fields to participate in colour design tasks exploring how designers deal with colours in the present thesis may not be a problematic issue.

On the basis of the reviewed scholarly outputs in this section, together with the prior colour design experience in the design industry held by the author of this thesis, the following is expected. There will be differences between expert and non-expert designers in terms of their colour use during problem solving design tasks regardless of their area of design. This will be tested experimentally in Chapter Six.

2.3 The Language of Designers

2.3.1 Language Typology for Designer Research

Language is the major tool for communication. People have different views about language based on their disciplines (Twyman, 1985). Figure 2.11 below illustrates perspectives on language from two different areas - linguistic science and graphic design. It shows that linguistic scientists consider language in two forms (spoken and written). Such a traditional linguistic view does not treat the visual form as a language. However, language is seen differently by graphic designers.

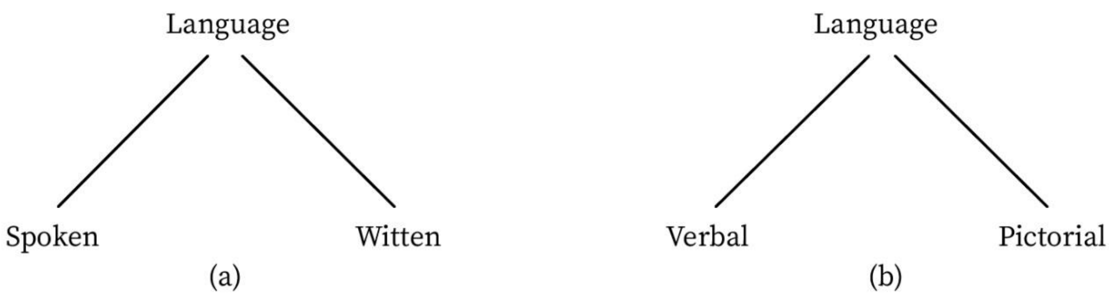

Figure 2.11 Different perspectives on language of (a) linguistic scientists and (b) graphic designers (source: adapted from Twyman, 1985, p.246 and redrawn by the author of this thesis).

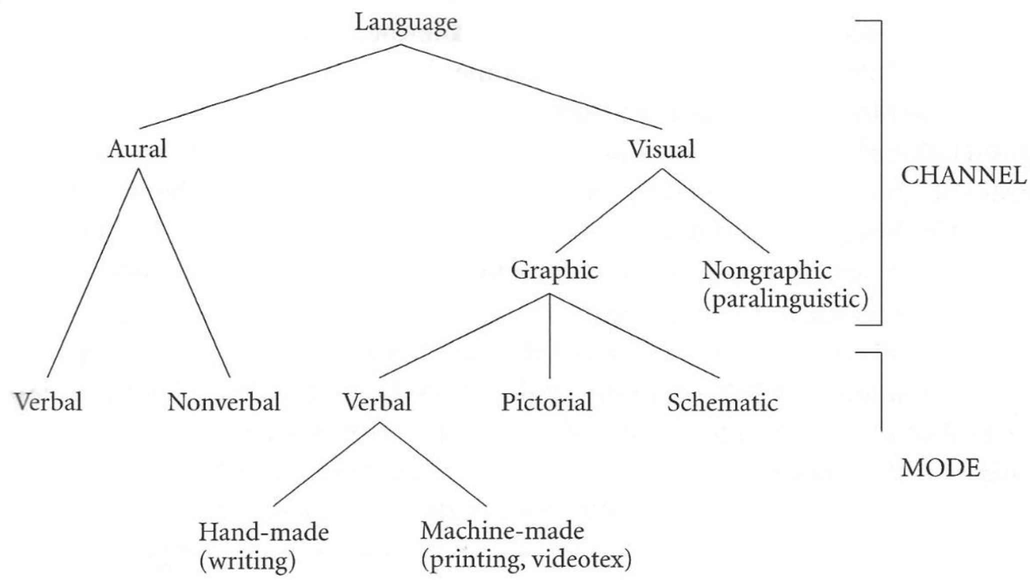

Figure 2.12 Twyman's (1982) language model (source: adopted from Twyman, 1985, p.246).

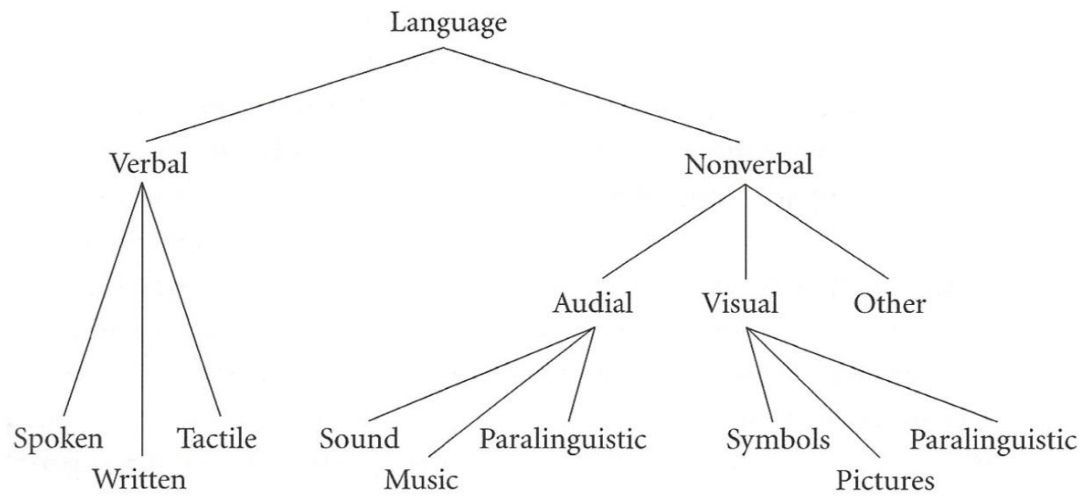

Figure 2.13 Pettersson's (1989) language model (source: adopted from Pettersson, 2002, p.65).

Twyman (1982) establishes a language model which encompasses both linguistic scientists' and graphic designers' perspectives (Figure 2.12). In Twyman's model, ears and eyes are the basic channel where we receive language. Pettersson (1989) later developed his model of language (Figure 2.13) based on Twyman's model. Pettersson's model divides the visual component (non-verbal), adding additional sub-categories in comparison with Twyman's model.

In this thesis, both verbal expression (spoken) and the usage of visual language (colour) by design participants are the main focus. Firstly, in order to illuminate how design participants perceive colours, their verbal behaviour while describing colours will be investigated in Chapter Four. For the analysis of spoken language that design participants use, sociolinguistic theories, such as the linguistic relativity hypothesis and the concept of communities of practice, will be adopted. For brief explanation, definitions of such concepts are addressed here.

The linguistic relativity hypothesis (also known as the Sapir-Whorf hypothesis) is a view of language and thought with a number of interpretations. One expression of the theory refers to "the proposal that the particular language one speaks influences the way one thinks about reality" (Lucy, 2001, p.13486). This is a higher-level concept for the linguistic background for the current doctoral research. More specifically, a concept of the community of practice is applied in the thesis. According to Wenger *et al*. (2002, p.4),

> communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.

Wenger *et al*. (2002) state that despite various forms of communities of practice existing, they are comprised of three fundamental elements: "a *domain* of knowledge, which defines a set of issues; a *community* of people who care about this domain; and the shared *practice* that they are developing to be effective in their domain" (Wenger *et al*., 2002, p.27). These three components are further explained by Wenger *et al*. (2002, pp.27-29) as below:

> The **domain** creates common ground and a sense of common identity. A well-defined domain legitimizes the community by affirming its purpose and value to members and other stakeholders. The domain inspires members to contribute and participate, guides their learning, and gives meaning to their actions.
>
> The **community** creates the social fabric of learning. A strong community fosters interactions and relationships based on mutual respect and trust. It encourages a willingness to share ideas, expose one's ignorance, ask difficult questions, and listen carefully.
>
> The **practice** is a set of frameworks, ideas, tools, information, styles, language, stories, and documents that community members share. Whereas the domain denotes the topic the community focuses on, the practice is the specific knowledge the community develops, shares, and maintains.

Wenger *et al*. (2002, p.29) argue that these three components work well together, "these three elements make a community of practice an ideal knowledge structure – a social structure that can assume responsibility for developing and sharing knowledge". The most crucial point for this thesis is that language, which is part of the practice component, will reflect the common ground and shared identity of members including ideas, styles, and ways of thinking and expressing themselves.

These are the linguistic theories that are used in this thesis to investigate features of designers' verbal language in terms of colour to explore their perceptions about colour (specifically) and design tasks (broadly). They are used in Chapter Four. More detailed theoretical background and some of the important linguistic terms will be described in that chapter where needed (see section 4.2.1).

As for visual language, designing is a central skill in many human tasks. Designers deal with a variety of forms of visual language to convey information. Colour is one of the essential visual language forms that designers use in everyday design tasks regardless of the designers' domain. Thus, in this research, how designers actually handle colours through a colour application and modification task for a real-world product will be explored in Chapter Six. Consideration of effective ways of providing colour information to designers will be studied in Chapter Five. In short, this research focuses on designers' characteristics in terms of their two types of language use (verbal and visual).

2.3.2 Colour as a Visual Language

We now deal with visual language in more detail. For Jacobson (1999, p.2) visual language refers to "the visual characteristics (shape, size, position, orientation, colour, texture, etc.) and of a particular set of elements (point, line, plane, volume, etc.) and the way they are related to one another (balance, rhythm, structure, proposition, etc.) in solving a particular communication problem".

Colour is among the important visual communication tools for designers. Designers work with diverse communication tools, such as colour, shape, tone, texture and others, in creating a visual presentation in order to stimulate intended messages for a particular audience (Poggenpohl, 1993). Kueppers (1982) claims that visual data is primarily comprised of shape and colour data. Arnheim (1967) argues that shape and colour are significantly important but have differences between them. Thus, he writes:

> Both (shape and colour) fulfil the two most characteristic functions of vision: they convey expression, and they allow us to obtain information through the identification of object and happening. Shape, however, is a more efficient means of communication than colour; on the other hand, the expressive impact of colour cannot be obtained by shape (Arnheim, 1967, p.321).

Lester (2013) states that there are three different methods to describe colours: the objective (or scientific) method, the comparative method, and the subjective method. He explains that the objective approach to colour "rests on the assumption that the perception of colour is a result of various light wavelengths stimulating the cones along the back of the eye's retinas" (p.16).

This method is utilised to measure colours accurately and precisely for describing colours objectively (Lester, 2013). Lester (2013) notes also that describing colours through the comparative method is less accurate compare to the objective technique, but more useful. He states that the comparative method conveys colours in their dictionary meanings, which are generally accepted, along with associations, for instance, red and blood, green and healthy plants, and blue and clear and sunny days. However, Lester (2013) says that the comparative technique is unable to describe colours accurately without a universally accepted standard. The third technique for describing colour is the subjective method (Lester, 2013). The author states that this technique is the most symbolic. In this sense, emotional responses to colours are the focus, relevant to the mental state of individuals or the associations they make with objects. Designers and painters feel warm colours such as red and yellow are closer than cooler colours like blue (Lester, 2013). Although such professionals believe bluish colours are the coolest colour, it is one of the hottest colours when we describe it objectively with colour temperatures of around over 5000K (Lester, 2013). Taken together, all of the discussion of colours here indicates that colours are complex but powerful communication tools which can be utilised in diverse ways.

2.3.3 Colour Literacy

The Inter-Society Colour Council [ISCC] and the International Colour Association [AIC] (2019) use the concept of literacy in order to describe and understand colours. They argue that colour literacy [CL] is comprised of scientific literacy [SL] and visual literacy [VL] (Figure 2.14). Their statement can be interpreted as meaning that in order to use and describe colour successfully, two types of literacy are essential, no matter who uses colours.

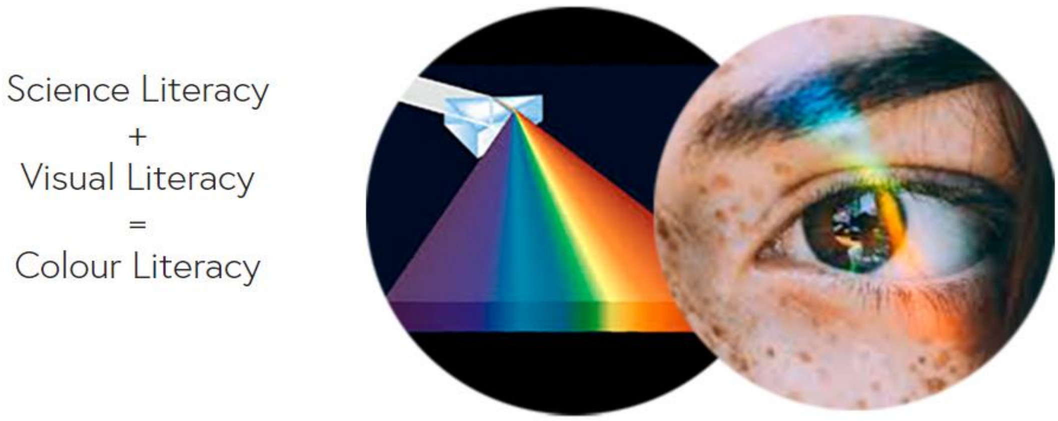

Figure 2.14 Categories of literacy (source: https://colourliteracy.org/, 2020).

Table 2.21 Taxonomy of literacy (source: reformatted and adapted from Pettersson, 2015b, with the wording in the table taken directly from the source).

Main	Literacy	Traditional literacy: Adolescent literacy, critical literacy, print literacy, public literacy, critical literacy.
	Musicacy	Musical literacy is the ability to understand and work with music.
	Numeracy	Ability to understand and work with numbers and other mathematical concepts (e.g. economic literacy, financial literacy, and statistical literacy etc.).
	Visuacy	Ability to understand and work with different kinds of visual representations (e.g. diagrammatic literacy, digital visual literacy, graphicacy, graphical literacy, visual literacy etc.).
	Electracy /Mediacy	Ability to understand digital media (e.g. computer literacy, digital literacy, hypertext literacy, multiliteracy, multimedia literacy etc.).
Additional	Area specific	Belong to more than one of five main literacies (e.g. advertising literacy, aesthetic literacy, cultural literacy, health literacy, media literacy, political literacy, scientific literacy, socio literacy etc.).

The basic meaning of literacy refers to a person's skills of reading and writing language as indicated here:

> The quality, condition, or state of being literate; the ability to read and write. Also: the extent of this in a given community, region, period, etc (OED, 2020d).

On the other hand, the meanings of literacy put forward by the Organisation for Economic Co-operation and Development [OECD] (2000) and the United Nations Educational, Scientific and Cultural Organisation [UNESCO] (2019), could be understood as referring to ability (more than specific skills) and impacting on people's actual lives in a social context.

> The ability to understand and employ printed information in daily activities, at home, at work and in the community – to achieve one's goals, and to develop one's knowledge and potential (OECD, 2000, x).

> Literacy is now understood as a means of identification, understanding, interpretation, creation, and communication in an increasingly digital, text-mediated, information-rich and fast-changing world (UNESCO, 2019).

The meaning of literacy seems to be complex. Pettersson (2009) notes that the term literacy is rather “interdisciplinary” (p.38), is used in various disciplines. Pettersson (2015b, p.22) categorises diverse types of literacies into five main areas: “literacy, musicacy, numeracy, visuacy, and electracy/mediacy”, and provides an additional category labelled “area specific” (p.31), which belongs to more than one of the main five categories (Table 2.21).

As mentioned above, ISCC and AIC (2019) point out that SL and VL is essential to better understanding in relation to colours. Thus, in the next section, SL and VL in the area of colour design will be described in detail.

2.3.3.1 Scientific Literacy for Colour

It can be seen that SL is included in the ‘area specific’ category according to Pettersson’s (2015b) classification (see Table. 2.21). OECD (2006 cited in Bybee *et al*., 2009, p.866) defines SL as combining four inter-related features that individuals’ have:

1. Scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomenon, to draw evidence-based conclusions about science-related issues;

2. Understanding of the characteristic features of science as a form of human knowledge and enquiry;

3. Awareness of how science and technology shape our material, intellectual, and cultural environments; and

4. Willingness to engage in science-related issues, and with the ideas of science, as a constructive, concerned, and reflective citizen.

Language that is used in the area of colour science distinguishes the ability of individuals in this area to articulate their understanding of colour using mathematical formula in comparison with other fields such as design. For them, knowing colour-related scientific terms and standard measurements are important to address colour-related phenomenon accurately but also to conduct colour experiments precisely. Colour scientific subjects are extensive, encompassing elements from a broad range of disciplines: chemistry, physics, mathematics and so on.

Designers need some understanding in this area as we will see. However, for designers, this may be challenging as they may be unfamiliar with understanding colours in a scientific manner. Presumably, this is because designers are trained to use colours to express their creativity sensuously and intuitively without restrictions. However, it is also essential for designers to understand some of the scientific approaches to colour (such as colour-related scientific terminologies, colour theories, illumination and colours, colour perceptions, systems of colour measurement and so on) and to acknowledge their importance in order to allow better use of colours in their design practice. Designers need this knowledge to fulfil successful design projects as well as to communicate with people from different disciplines who work with colours. In the following section some of the scientific terms for understanding colours which it is believed that designers should understand to complete design tasks will be addressed.

2.3.3.1.1 Colour Perception

Since ability to see is primarily a response to light (Dondis, 1973), nothing is visible without the presence of light. Visible light is “electromagnetic radiation ranging approximately from 380 to 780 nm the spectral range of the human eye” (Leo, 2017, p.350). One vital function of the perceptual ability in vision is perceiving colours on the surfaces of objects independent of illumination characteristics (David *et al*., 2019). Figure 2.15 indicates that wavelength of light and hues are correlated: longer wavelengths (red, orange, and yellow) and short wavelengths (blue and purple) (Leo, 2017). This also shows that human eyes show the most sensitivity to green and the least sensitivity to violet (Leo, 2017).

There are two types of light receptors in the human retina at the back of the eyes: rods and cones (Ware, 2008). These function for different environments of lighting (Ware, 2008). Rod cells mainly work at low levels of illumination (night vision) while cone cells function at high levels of illumination (day vision), according to Colour Universal Design Organisation [CUDO] in 2006. Cone cells have three sub-types (Ware, 2008): these are short-wavelength sensitive (S cones - for blue), middle-wavelength sensitive (M cones – for green), and long-wavelength sensitive (L cones – for red) (Figures 2.16 and 2.17).

The three different types of cone mean colour vision is fundamentally three-dimensional (Ware, 2008). People with normal colour vision have all of these three (S, M, and L) cone cells (CUDO, 2006). If any of these cells are limited or are not there at all, people have difficulties in seeing and being able to distinguish colours: they have colour vision deficiency or achromatopia (Figure 2.17) (CUDO, 2006).

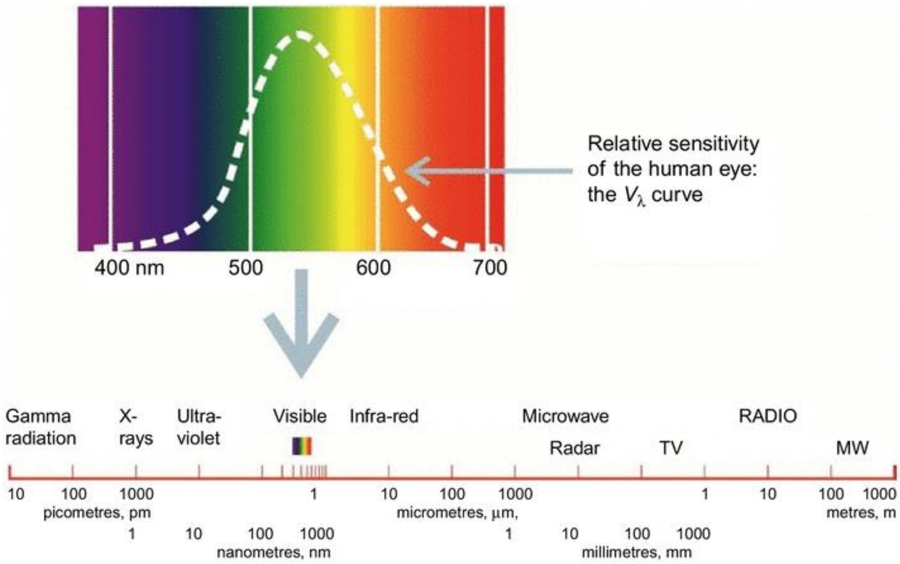

Figure 2.15 Relationship between sensitivity of human eyes and colour wavelength (source: adopted from Peter Tregenza n.d. cited in Leo, 2017, p.350).

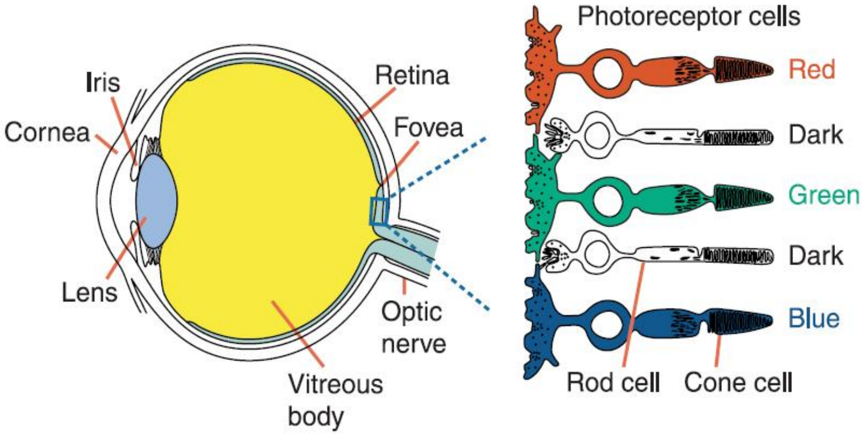

Figure 2.16 Three types of cone cells in human retina which are functionally different (source: adopted from CUDO, 2006, p.9).

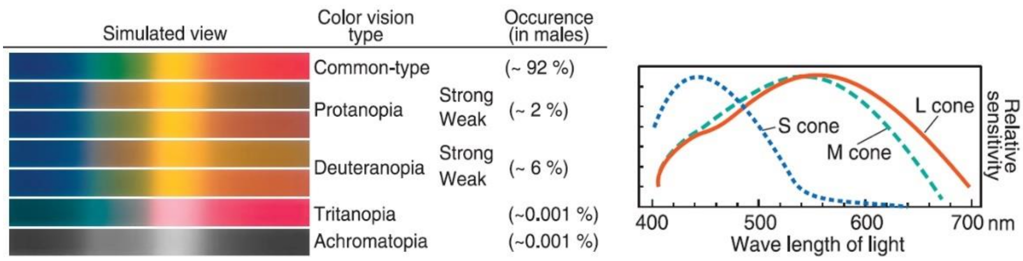

Figure 2.17 Wavelength sensitivity of L, M, and S cone cells (source: adopted from CUDO, 2006, p.9).

2.3.3.1.2 Colour Vision Theories

There are various theories of colour vision to explain how colours are actually perceived. The Young-Helmholtz theory (known also as trichromatic theory) and another theory known as opponent process theory are the major theories which have lead the area of colour vision research (Cherry, 2020). These two major theories are known to oppose each other strongly (Legg, 2018).

Ewald Hering had established process theory in the late nineteenth century (Ware, 2008). The idea of cones was established by this time. In this theory, “neural networks add and subtract the cone signals in different ways, transforming them into what are called the colour-opponent channels” (Ware, 2008, p.68). It is suggested there are three channels (Figure 2.18) in the human retina: red-green, blue-yellow, and black-white opponent processes (Lee, 2008). Hering’s four chromatic colours (red, green, yellow, and blue) and two achromatic colours (black and white) have unique status (Lee, 2008). Also, Hering's opponent process theory has influenced the development of the Natural Colour System [NCS] (Figure 2.19) (Pastilha *et al*., 2019).

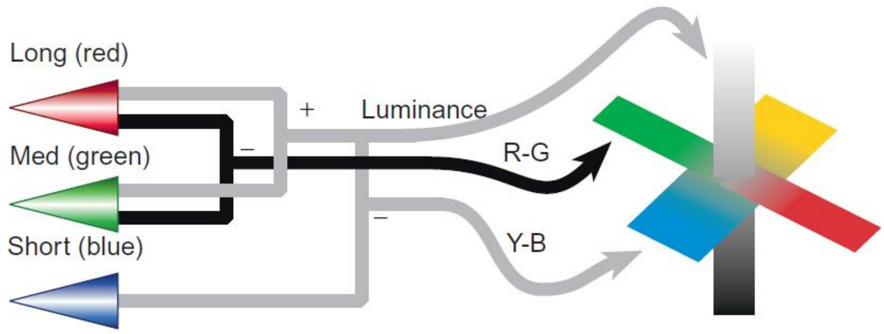

Figure 2.18 Opponent process model: cone signals are transformed into channels for black–white (luminance), red–green, and yellow–blue (source: adopted from Ware, 2012, p.108).

The Trichromatic theory was proposed in the early nineteenth century by Young. It was developed by Helmholtz later. In 1924, Helmholtz proposed that there were “hypothetical excitation curves for three kinds of cones in the retina, sensitive for red, green, and blue” (Pettersson, 1989, p.61). Helmholtz also suggested there were three different cone receptors: short-wavelength (blue), medium-wavelength (green), and long-wavelength (red) (Ware, 2012). Today researchers believe these theoretical positions are useful to describe the operation of colour vision but each of them works at a different level of visual activity (Shevell and Martin, 2017).

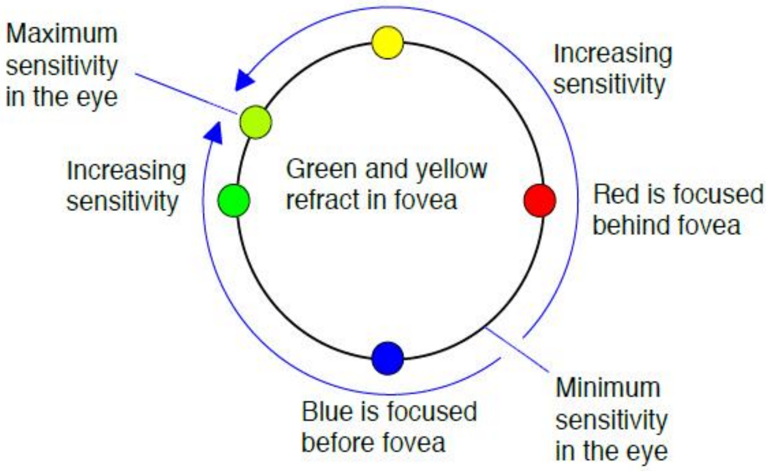

Figure. 2.19 NCS Colour Circle combined with information on the eye's sensitivity developed based on Hering's opponent process theory (source: adopted from Pettersson, 2015c, p.55).

2.3.3.1.3 Colour Description Systems

There are several ways to explain the relationship between hue, saturation, lightness, and blackness. Examples include the Munsell Colour System [MCS], NCS, the Universal Colour Language (Kelly and Judd, 1976), Reichs-Ausschuss für Lieferbedingungen [RAL] Design System, The Deutsche Institut für Normung [DIN] and so on. In this thesis, NCS (the Swedish standard for colour description) is the main one described. This is because colour design samples (collected from thirty designers in Chapter Six) to examine similarities and differences in actual colour use between different levels of designers (see section 6.3.2.2) are all located in the NCS colour circle and triangle (Figure 2.21). Thus, some of the important concepts utilised in the NCS system need to be explained here.

- NCS Elementary Colours and Elementary Attributes

According to Hering's basic concepts (the colour opponency hypothesis), there are six elementary colours which are comprised of four chromatic colours (Yellow-Y, Red-R, Green-G, and Blue-B) and two achromatic colours (White-W and Black-S). These six elementary colours are perceived as pure by human beings (NCS Colour AB, 2020). It means each of the six basic colours do not have resemblance to each other (Figure 2.20).

Hering demonstrates that four bipolar diagrams can be used to represent visually the resemblance between pure chromatic colours and the four chromatic elementary colours (Hård *et al*., 1996). Fridell Anter (2000) states that the elementary attributes of colours are the visual characteristics that can be quantified in terms of the way they resemble elementary colours. Noncapital letters are used to indicate these elementary attributes and thus, *w* represents whiteness, *y* denotes yellowness, and *s* blackness (Fridell Anter, 2000).

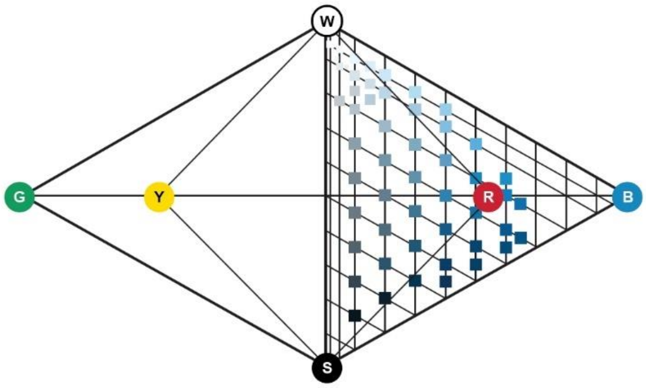

Figure 2.20 Six elementary colours and colour space of NCS (source: adopted from Berns *et al.*, 2019, p.41 - courtesy of NCS Colour AB).

❖ NCS Colour Circle and Colour Triangle

An example of the description of a particular colour is S3050-R30B from the NCS (Figure 2.21). The hue R30B indicates that it has a 70% perceived similarity to red and 30% to blue. The numerical value for hue R30B can be denoted using notation in the NCS colour circle. The nuance of colour is presented on the NCS colour triangle which represents the relationship between whiteness (w), blackness (s), and chromaticness (c). For instance, the nuance 3050 indicates 30% blackness (s) and 50 % chromaticness (c). The whiteness is 20%, according to the equation s+c+w = 100.

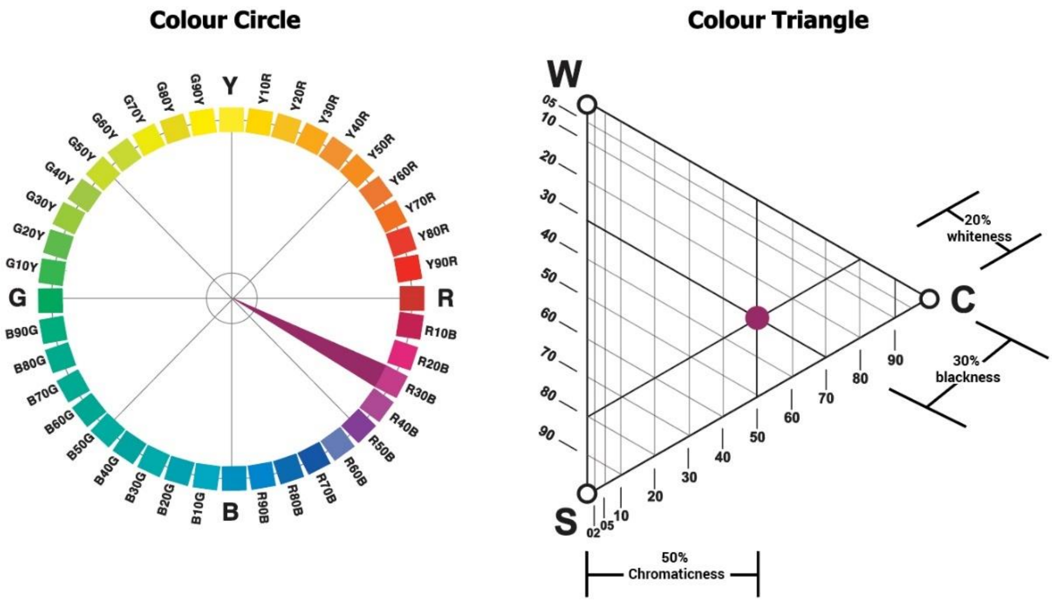

Figure 2.21 S3050-R30B on the NCS colour circle and triangle.

2.3.3.1.4 Colorimetry

- The CIE Standard Illuminant

The term illuminant refers to "a defined spectral power distribution, not necessarily realisable or provided by an artificial source" (BSI, 2008). However, using different illuminants is not only inconvenient but also it makes comparison of results impossible (Hunt, 2011).

According to BSI (2008), the International Commission on Illumination [CIE] recommends either Standard Illuminant A or Standard Illuminant D65 should be used in all colorimetric calculations, unless there are particular reasons to use different illuminants. CIE standard illuminant A is a representation of "typical, domestic, tungsten-filament lighting" whereas D65 is used to represent "average daylight" (CIE, 2020). The CIE (2004, p.5) technical report on colorimetry says of D65, that "at present no artificial source is recommended to realise CIE standard illuminant D65 or any other illuminant D of different correlated colour temperature". Daylight is commonly considered to be a standard light source, allowing an object's true colours to be rendered (McCamy, 1990 cited in Lam and Xin, 2002). CIE standard illuminant D65 is the most widely used for representing typical daylight, with a correlated colour temperature [CCT] of about 6500K (International Organisation for Standardisation [ISO], 2006).

- CIE Geometries

Another important aspect of colour experimentation is CIE geometries. The Helmholtz reciprocity law shows light can be reversed through any optical system (von Helmholtz 1866 cited in Berns *et al.*, 2019). Because of this the CIE (2018 cited in Berns *et al*., 2019) specifies four geometries of reflectance measurements (Figure 2.22).

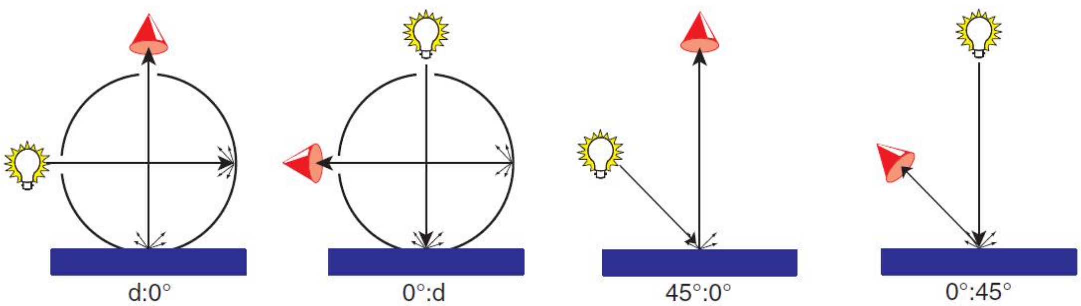

Figure 2.22 Four of the CIE recommended geometries of colour measurement (source: reformatted and adapted from Berns *et al*., 2019, p.117).

Berns *et al*. (2019) explains that the first two of the geometries are labelled as d:0° and 0°:d, known as integrating spheres. The rest of them are labelled as 45°:0° and 0°:45°, referring to the use of bidirectional geometries (Berns *et al*., 2019, p.115).

❖ CIE Standard Colorimetric Observer

As regards a standard observer, the 2° observer is the CIE 1931 standard. However, subsequently, it was established that colour value calculations utilising 2° observation are not always well correlated with visual assessments, because the majority of the latter are carried out with fields of view larger than a 2° field (Hunt, 2005; X-Rite, 2020).

The CIE provided a supplemental observer in 1964 to allow closer correlations with colour matching that was available commercially (X-Rite, 2020, CIE, 2023). A 10° field of view was used in experimental colour matching to provide a basis for the supplemental observer (X-Rite, 2020; CIE 2023). This is commonly called the ‘1964 standard observer’ or ‘the 10°observer’ (Berns *et al*., 2019). The CIE recommendation is that the colour-matching functions of 1964 are utilised whenever colour stimuli exceed 4° of visual angle (Reinhard *et al*., 2008). The 10° observer is most frequently put to use for colour quality control and colour formulation (Hunt, 2005; X-Rite, 2020).

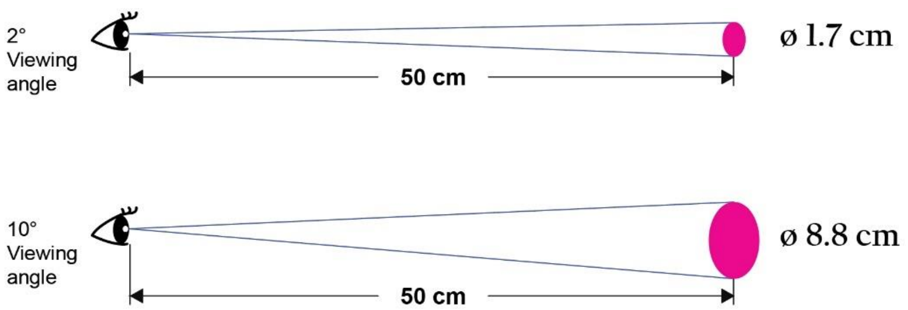

Figure 2.23 The CIE Standard observer for colour measurement (source: adapted from Konica Minolta, 2020 and redrawn by the author of this thesis).

A reason for researchers following the CIE standard is because colour samples on a surface should be seen in an identical way by all participants throughout an experiment to obtain accurate data. For this reason, in the colour description experiment in Chapter Four of this research project, experimentation was performed under a consistent lighting source (CIE illuminant D65). This was achieved by using a lighting box in the lighting laboratory at the University of Leeds to avoid any chance of metamerism. In addition to this, one of the standard geometries 45°:0° illumination/viewing conditions was used using a 45-degree stand in a colour matching light box (see Figure 4.3 in Chapter Four). The size of the samples that were used in the experiment (Figure 4.2 in Chapter Four) was 100x100 (mm) with a viewing distance of approximately 450 mm.

2.3.3.2 Visual Literacy in Colour

Diverse disciplines of knowledge – among them graphic design, visual communication, linguistics and semantics, communication technology, philosophy, art history, information technology, psychology, education - deal with the concept of visual literacy [VL] (Ausburn and Ausburn, 1978; Pettersson, 1994). Thus, the concept has become complex and interpreted differently by scholars depending on their specific areas of research (Avgerinou and Pettersson, 2011; Ervine, 2016). According to Ausburn and Ausburn (1978, p.291), the general meaning of VL describes "a group of skills which enable an individual to understand and use visuals for intentionally communicating with others". These authors claim that one of the basic principles of VL is that "visuals are a language" (p.291) which has its own grammar, vocabularies, and syntax. Ausburn and Ausburn (1978) also argue that colours, shade, lines, light and others are the vocabularies of visual language.

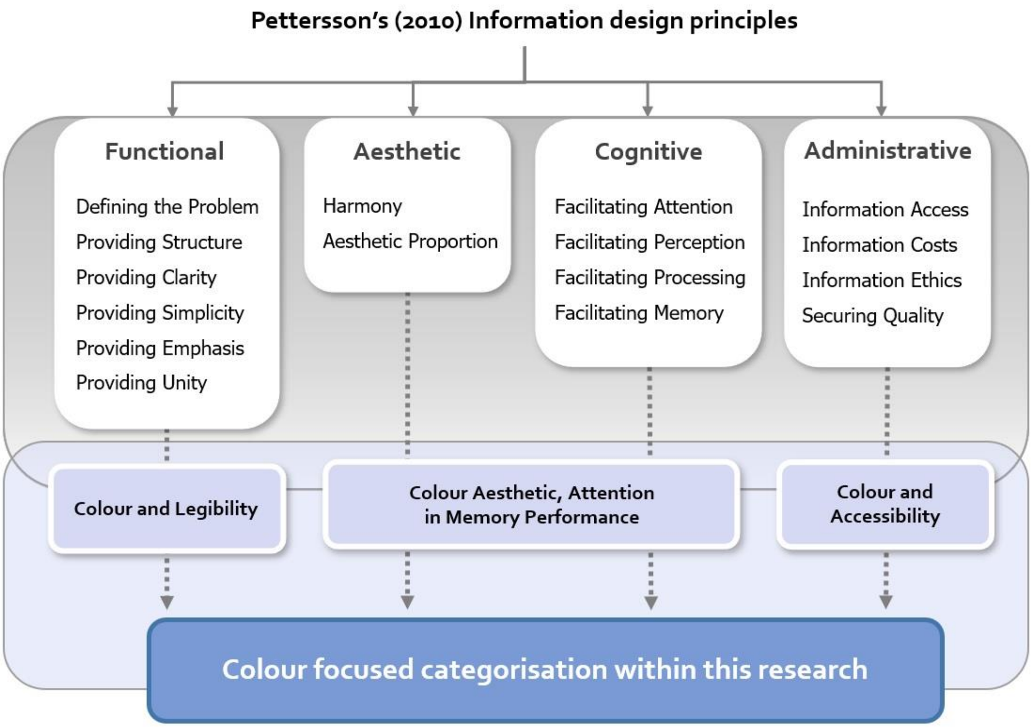

Figure 2.24 Framework for the colour-focused visual communication design section of the present research project based on Pettersson's (2010) information design principles.

In real-world conditions, designers often compose and arrange a range of visual vocabulary in certain ways in order to create visual images to capture people's attention and stimulate desired messages effectively. Designers utilise their design skills and visual thinking abilities to help other people to be visually literate too. Colour is one of the most essential tools of visual literacy that designers use for this. The focus in this section will be how colours play leading roles in improving VL, and what further aspects can be considered from an inclusive design standpoint. This will be framed on the basis of Pettersson's (2010) four components of information design principles (Figure 2.24) but argued from a heavily colour-centred perspective.

2.3.3.2.1 Colour and Legibility

It is apparent that appropriately used colours are beneficial both as a way of enhancing clarity of information and emphasising desired messages in written communication. In the colour context, Nilsson (2006) considers the term legibility in a twofold way: speed of reading and recognition distance, as below:

> Legibility has been defined in terms of reading speed based on the rationale that less legible text requires more processing time to extract enough information for recognition (Nilsson, 2006, p.2).
>
> Legibility has also been defined in terms of distance based on the rationale that a less legible text requires a larger image activating more visual pathways to convey enough information for recognition (Nilsson, 2006, p.2).

The Le Courier legibility table (Figure 2.25) presents thirteen well-established text and background colour combinations as a guide for legibility of printed materials (Grozdanovic *et al*., 2017). However, the suitability of this guideline is not proven for Cathode Ray Tube displays (Humar *et al*., 2008) and Liquid Crystal Display (Hashim *et al*., 2013). Nevertheless, various scholars agree that for optimal legibility an intensive contrast between background and text colours makes reading tasks easier both on the web (Nielsen, 2006; Erdogan, 2008) and in print (Preston *et al*., 1932; Tinker, 1966). An obvious example is black text on a white background (Nilsson, 2006; Erdogan, 2008; Carter *et al*., 2015), and this is labelled “positive text” (Hall and Hanna, 2004, p.183).

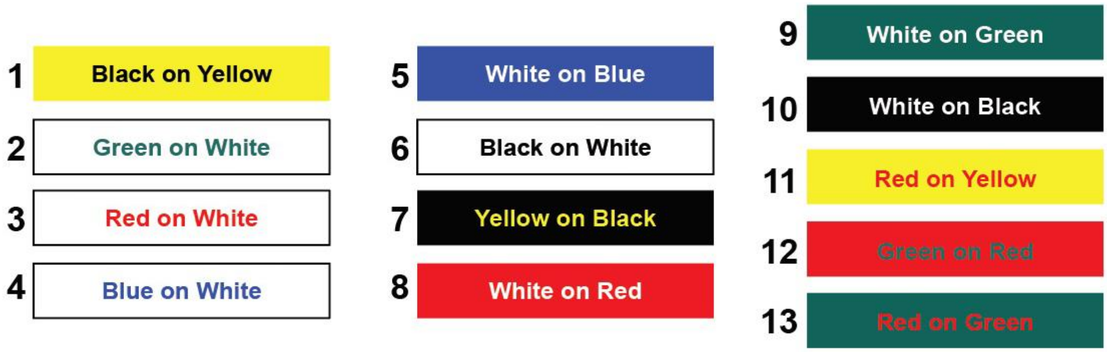

Figure 2.25 The Le Courier legibility table for print (source: adapted from Hashim *et al*., 2013, p.522 and redrawn by the author of this thesis).

2.3.3.2.2 Guidance for Legibility of Colour

Contrast is achieved by ensuring “items such as what stand out by emphasizing differences in size, colour, direction, and other characteristics” (Usability.gov, 2013). Legibility is always affected by colour contrasts between background and text (Pettersson, 2015c). Various kinds of web-based colour contrast analysing tools, or programs to prevent low contrast colour combinations can be used in order to achieve accessibility standards to meet the colour contrast recommendations of the Web Content Accessibility Guidelines [WCAG].

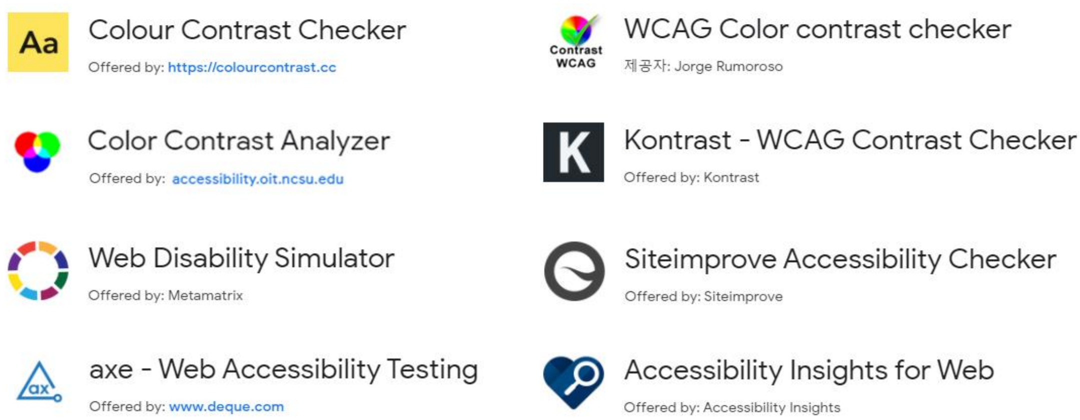

Figure 2.26 Free programs provided at Chrome web store.

Figure 2.26 shows some of the free programs that can be downloaded from Chrome Store, which aim at checking colour contrast between text and background colour in order to improve information accessibility on the web. These can be set up readily on computers by general users. The directions for use are slightly different depending on whether the program is easy to use or a little harder to use.

In terms of accessible printed materials designed for best accessibility, in the UK, the Royal National Institute of Blind People [RNIB] (2015) report - 'how to choose colour and contrast for printed materials that benefits people with sight problems' can be considered. This offers general principles of design, colour related terminologies and theories which increase best practice of use of colour and contrast in printed information for people who have sight problems. In addition to this, UK Association for Accessible Formats [UKAAF] (2012) is active in setting standards and promoting best practice for document accessibility. Colour is included in their work to make information accessible.

The programs and guidelines mentioned so far seem to be targeted at the general public. Designers tend to be skilled using colour compared to others, as designers work with colours in everyday design tasks regardless of their design profession. Thus, designers who study design in higher education or work in the design industry are likely already to have their own ways of utilising colours. The habitual use of colours by designers can cause either positive (aesthetically) or negative (effectively) issues. In other words, although the programs and guidelines discussed above would be useful in some degree, there still needs to be further consideration of how colour information for accessibility can be offered to designers from a designer perspective.

Pettersson (2010, p.173) suggests three basic guiding principles which designers bear in mind for good legibility of colours:

1. Use a light or a dark background colour appropriate to the content, and then use a colour with good contrast for the figure or text;

2. Make sure that differences between colours are clear and obvious; and

3. Combine colours with shape in warning signs.

Figure 2.27 below shows an example of the use of good colour legibility illustrating how Pettersson's (2010) basic guidance can be reflected in use. This figure applies a systematic colour-coded scheme, colour association, and intensive colour contrast aiming at providing critical safety information to members of public to give safety messages in the era of Covid-19 pandemic (see Figure 2.27).

Despite the issues considered above, Lee (2015) found that applying general guidance for giving a high-contrast (often black on white) can hinder vision impaired people's ability to read information. This finding emerged while conducting focus groups to evaluate an accessible printed bus route map for vision impaired information users. In this case, Lee (2015) found that white (or yellow) text on a black background had good legibility for vision impaired information users (rather than black on white because of reflection of light particularly on a clear day). This suggests that while it is wise to follow guidelines to improve legibility of colour, it is also important to consider the needs of particular users and acknowledge that guidelines may need to be questioned.

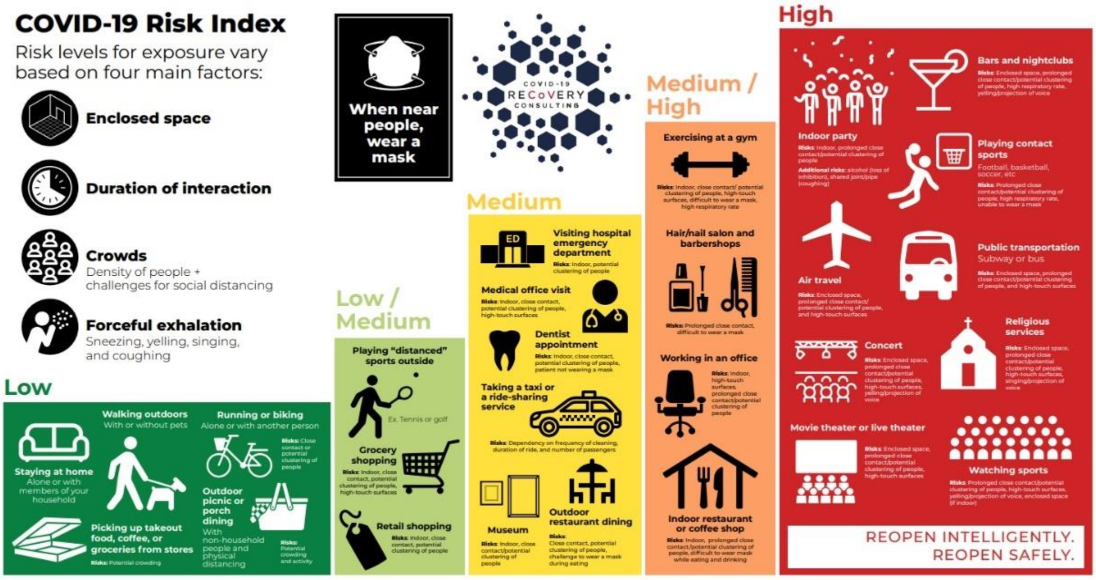

Figure 2.27 Example of good colour legibility for people with normal vision (source: adopted from covid19reopen.com, 2020).

2.3.3.2.3 Colour Aesthetics, Attention in Memory Performance

The understanding of the way colours can affect us is the subject of colour aesthetics (Ball, 1965). Regarding the aesthetics of colours, there are widely known universal and logical laws for obtaining harmonious colour combinations theorised by prior scholars (e.g. Moon and Spencer, 1944; Chevreul, 1967; Birren, 1969; Ostwald, 1969; Itten, 1973; Judd, 1975). The subject of colour harmony has been associated with a number of different disciplines such as design, phycology, education, business, food science, sport along with others.

The use of colour (or colour aesthetics) has been studied with support from the area of cognitive psychology which is concerned with attention, memory, and perception in humans. Atkinson and Shiffrin (1968 cited in Baddeley, 2013) assume that there are three types of memory storage: sensory memory, short-term memory, and long-term memory. The different types of memory storage are important to the process of visual thinking (Ware, 2012). It is therefore worth considering how, according to Baddeley (1999, pp.9-10), the various types of memory work and interact:

> It is assumed that information comes in from the environment through a parallel series of brief sensory memory stores, or registers, and goes into a common short-term store. This is assumed to act as a working memory, capable of manipulating information and relating it to long-term storage. Indeed the short-term store forms a crucial link in this model; without it, neither the learning of new material nor the recollection of old information is possible.

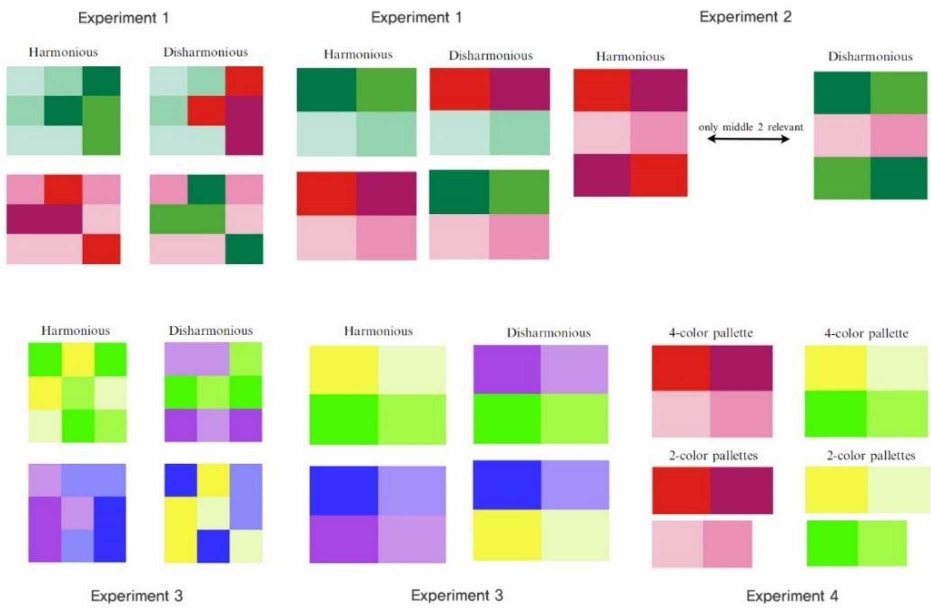

Figure 2.28 Colour pattern used in a colour relation experiment (source: reformatted and adapted from Sanocki and Sulman, 2011, pp.647-648).

Visual short-term memory [VSTM] is a significant part of cognition in human life deteriorating with aging (Mitchell and Cusack, 2018) or diseases (Zokaei *et al*., 2014; Norton *et al*., 2020). Several studies show evidence of how colours work in visual cognition. The effect of harmonious and disharmonious colour on VSTM was proved by Sanocki and Sulman (2011). The authors show that groups of similar colours are associated with harmony and pleasantness. Moreover, people perceive similar (and more aesthetic) colours in high rates which relates to them being held in VSTM. The implication of such colour experiment outcomes for colour design is that colours used in the content and background of communicative material might help focus our attention on the contents itself if colours are used properly and harmoniously (Figure 2.28).

Colour increases attention and arousal and thus influences the way memory performs (Pan, 2010; Dzulkifli and Mustafar, 2013, p.6). Pal *et al.* (2012) investigated the role of warm colours in terms of visual attention. They found that “warm colours with hue relatively closer to red and/or higher saturation are more likely to guide attention” (p.1). Farley and Grant (1976) compared the effect of colour and non-colour (black and white) by using multimedia presentations with over fifty students. The authors found that a coloured presentation is more efficient in facilitating memory in comparison with a non-coloured one.

The visual cognition studies on colour addressed above clearly demonstrate that colour can be a powerful information channel impacting on the human cognitive system. Harmonious colours, particular colours (or combinations of them) play a significant role in improving memorability of information and creating a pleasant feeling. However, due to the fact that designers frequently focus on aesthetics and may not have personal experience of vision and colour vision impairment, the use of colours by designers could be a hinderance for users with such impairments. Therefore, colours might need to be used judiciously.

2.3.3.2.4 Colour and Accessibility

It should be considered that colours can generate discrimination against people with colour vision deficiency (known as colour blindness), vision impairment, and older people. According to the National Health Service [NHS] (2017), around 1 in 12 men and 1 in 200 women are unable to distinguish between shades of red, green, and yellow. However, it is common for red and green colours to be widely used to differentiate symbols and shapes in communicative design artefacts with colour association centred on people with normal vision. Figure 2.29 below simulates how people with red colour vision deficiency would experience the colours and message given in the Covid-19 message in Figure 2.27.

Lee (2015) points out that seeing and distinguishing colours is not just a problem of colour blindness, but also a problem of visual impairment. Using colour blocks, she visualised the challenges faced by vision impaired people in distinguishing colours (Figure 2.30). Lee (2015) asked a focus group of five visually impaired people whether they were able to distinguish colours which are used for a colour-coded bus timetable in the city of Leeds. Although only participant [e] had both vision impairment and red-green colour vision deficiency in the focus group discussion, like this individual, other participants who were not colour blind were unable to distinguish certain colours used. This is illustrated in Figure 2.30.

Figure 2.29 Example of how red-blind information users receive colour-coded information (source: adopted from covid19reopen.com, 2020).

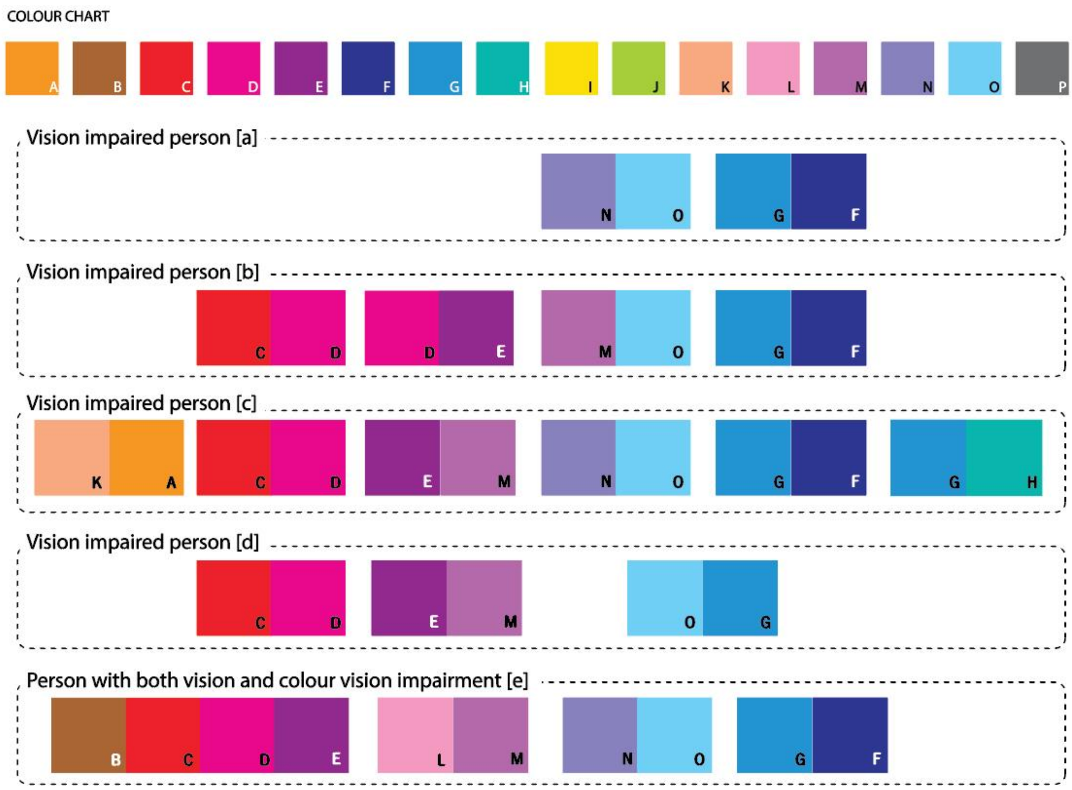

Figure 2.30 Colour testing results for vision impaired people based on colours used on a Leeds network map and handy timetable (source: adapted from Lee, 2015 and redrawn by the author of this thesis).

In Figure 2.30, each block for the separate participants shows the groups of colour types which they could not distinguish. For instance, a visually impaired participant [c] could not distinguish the following colours clearly from a colour chart: K and A, C and D, E and M, N and O, G and F, and G and H. Comparing this to participant [e], we can see that these two individuals had similar problems in terms of groups of colours and being unable to distinguish between them, yet participant [c] is not colour blind. Clearly, vision impairments can be associated with colour vision problems. Seeing and distinguishing colours is not just a problem of colour blindness; rather, it can be a problem of visual impairment too.

The use of colour in designing information is an issue for older people as well. Age UK (2019) states that nearly a quarter of those aged over 65 are affected by sight loss which impacts on their daily lives. Colour vision also tends to worsen as part of the ageing process (NHS, 2017). Medical news reported by Dotinga (2014) shows that older people lose their ability to distinguish a certain range of colours. This starts about age 70 and gets worse as people grow older. Dotinga (2014) reports that the lenses of people's eyes can grow yellowish with aging. This often disturbs blue-yellow vision, affecting forty-five percent of people in their mid-70s, and prevents them from distinguishing between blue and purple, and between yellow and green or yellow-green (Dotinga, 2014). This is not the same as inherited forms of colour vision deficiency.

In order to achieve inclusive design solutions in the colour design context and to make information (messages) more accessible to a wider range of users, designers need to consider who user groups are. They also need to know about their difficulties in order to improve information inclusivity.

2.4 Research Position

Five overarching research questions arise from synthesising the literature review. Firstly, diverse reasons for designers producing disabling artefacts within a communication-oriented design context were discussed at the beginning of this chapter (section 2.1.3). Based on the findings here, the foremost question (RQ 2-1) arises. This underpins the whole research project embracing the four other overarching research questions (RQs 2-2, 2-3, 2-4, and 2-5).

> **RQ 2-1** Why do designers consistently continue to create inaccessible communication materials even though scholars have identified the problems that arise from them doing so?

Secondly, designers deal with a range of elements of visual language to resolve a particular communication challenge. Adequately applied colours can be a part of this. However, inappropriate use of colours in the area of visual communication design is commonplace. In order to understand the reasons for the misuse of colours, first and foremost, how designers communicate about colours from a broader viewpoint needs to be explored. Thus, this research asks:

> **RQ 2-2** How do designers perceive and communicate about colours?

Thirdly, as reviewed in section 2.3.3.2.2, there seems to be a lack of designer-oriented colour information provision which could stimulate designers to think about the concept of inclusion during their design work. The current guidance for improving accessibility identified in this literature review (particularly for colour legibility) seems to be for general use. Designers gain knowledge and information from various sources. Therefore, it can be expected that they receive colour information by a range of means. Without knowing about what designers actually use and assess and what they already know and want to know, it will be difficult to provide appropriate directions for them to change their attitudes and values regarding more inclusive colour design. For this reason, this research asks the following questions:

> **RQ 2-3** What are the features of user-related colour information provision that designers actually access, and how do they talk about the features?

> **RQ 2-4** How should colour information be offered to designers in an effective and efficient way?

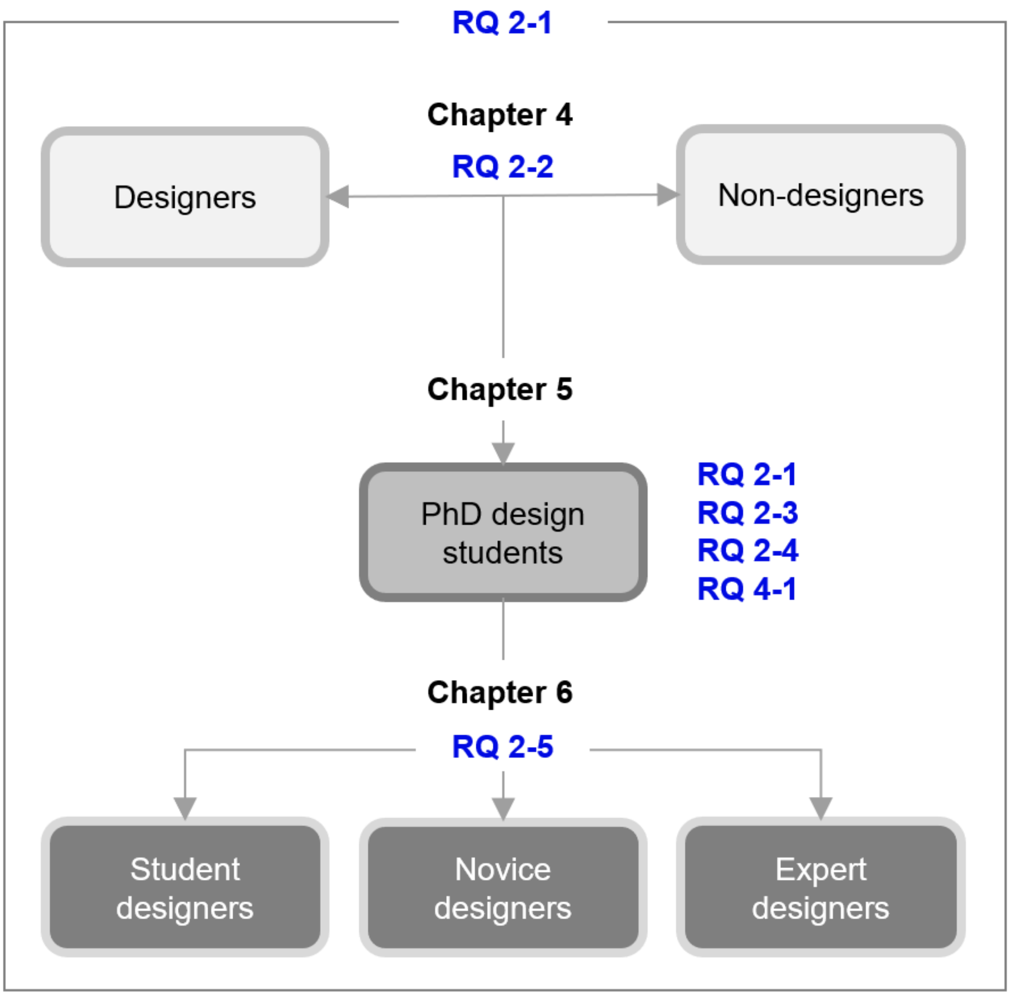

Figure 2.31 The overarching research questions arising from Chapter Two and leading to the main designer studies (Chapters Four, Five, and Six).

Lastly, limits to understanding how designers work with colours within particular design tasks have been identified in this review. Although the empirical designer studies reviewed in this chapter offer the detailed understanding and evidence of what abilities different levels of designers possess, and how these designers use their accumulated knowledge and skills during design work (section 2.2.2.3.1), hardly any research considers this topic within the colour design context. Based on this, this research will answer the research question below through microscopic analysis of a designer-focused colour study.

> **RQ 2-5** Are any distinguishing characteristics between different levels of designers revealed in a problem-solving design task in terms of use of colours and colour information?

Taking into account that there is little research into the roles and behaviour of designers in communication-oriented design from an inclusive design standpoint, for this research project the scope of the investigation was narrowed down to colour inclusiveness, user-related colour design and colour information use by designers.

The five overarching research questions above help to build up the overall structure of the research (Figure 2.31). Each of the overarching questions will be answered in following chapters (Chapter Four, Five, and Six). These answers will allow us to discuss the new research area of designer-centred colour inclusiveness. This considers the following:

> How can we make designers think more inclusively by synthesising their colour perception, colour information use behaviour, and actual colour designing characteristics?

This will be discussed in Chapter Seven.

2.5 Summary

This chapter was comprised of four main parts in order to discuss the topic of design and designers themselves. The first was about the definition of design used within this research project. Design can be defined as problem solving activities conducted by designers, and this represents the perspective of the author of this thesis in terms of how she sees the position of design in our society. This perspective was used to critically review the role of designers in communication-oriented design from an inclusive design viewpoint.

The second part of the chapter reviewed design practice by designers – designers' actual ways of thinking and doing things during problematic design tasks across the diverse area of design. The behaviour of designers was looked at and further explained under the related design paradigm (refection-in-practice) within a constructivist perspective. This will be expounded in the next chapter (section 3.1.2).

The third section was cognitive in nature looking at the verbal and visual language of designers. Two main sociolinguistic theories were introduced in brief in this chapter, but detailed theoretical background for them will be demonstrated in Chapter Four with an analysis of designers' verbal language use in describing colours. Colour is also one of the significantly important visual language forms. Focusing on the term 'language' of colour, the concept of colour literacy was adopted. Colour literacy was explained by two separate conceptions of literacy: scientific literacy and visual literacy.

Finally, based on a comprehensive understanding permitted by the literature review, and by synthesising the findings in it, five overarching research questions emerged which lead to the main designer studies in this thesis (Chapters Four, Five, and Six). An outline also of the overall framework of the research was given.

The next chapter will describe in detail how the current research project is structured and why a particular methodological approach was adopted based on a specific design paradigm in order ultimately to seek to answer the five overarching research questions arising from this literature review.

Chapter 3 RESEARCH METHODOLOGY

This chapter describes the design of the whole research project. It starts with a theoretical background of the research and then outlines methodological approaches through to the selection and application of research strategies, research types, data collection and analysis methods for this research project with justifications given. The issues of the role of the researcher, research trustworthiness, research bias, research reproducibility, and ethical considerations are also addressed in the latter half of this chapter.

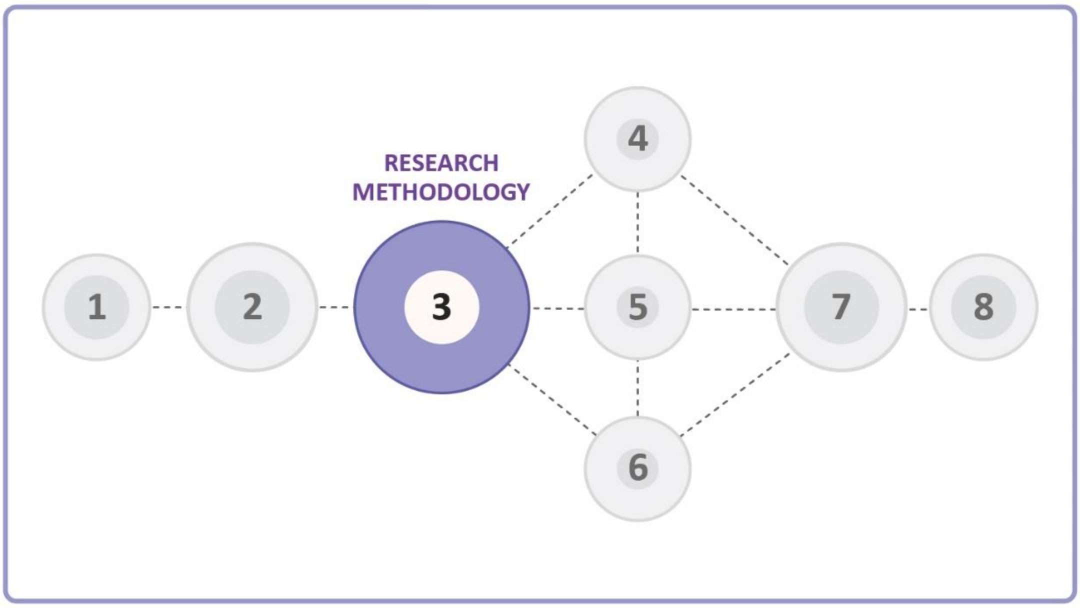

Figure 3.1 Position and context of Chapter Three within the whole research process.

3.1 Theoretical Background

3.1.1 Research Paradigms

Understanding certain philosophical terms permits us to gain more a complex understanding and appreciation of research (Huff, 2009). Creswell (1998) suggests five main assumptions arising from philosophy: ontological, epistemological, axiological, rhetorical, and methodological assumptions. According to Taylor and Medina (2013), ontology, epistemology, and methodology in turn underlie the concept of the paradigm.

> **Ontology** (what is reality?) is about "the theory of social entities and is concerned with what there exists to be investigated" (Walliman, 2006, p.15).

> **Epistemology** (how do we know something?) is concerned with "how we know things and what we can regard as acceptable knowledge in a discipline" (Walliman, 2006, p.15).
>
> **Methodology** (how we go about finding things out?) "as a set of methods and procedures, is shaped by our assumptions about what is *real* and what is *true*, which in turn shapes our perceptions of what is *science* and how we do it" (Henry and Pene, 2001, p.238).

Mills *et al.* (2006, p.26) argue that "to ensure a strong research design, researchers must choose a research paradigm that is congruent with their beliefs about the nature of reality".

According to Punch (2005, p.27), a paradigm is "a set of assumptions about the social world, and about what constitute proper techniques and topics for inquiry". Tolley *et al*. (2016, pp.39-40) state that "paradigmatic assumptions establish boundaries for scientific inquiry; that is, researchers draw on paradigmatic concepts and relationships to construct theoretical frameworks for research design". It is typical for a paradigm to include particular methods related to the assumptions underlying it, and for it to indicate specific pieces of research which are regarded as strong examples of these methodologies and assumptions (Maxwell, 2009). Some paradigms often used in a social research context, are listed in Table 3.1.

Table 3.1 Research Paradigms (source: reformatted and adapted from Birks, 2014, p.20 and the wording in the table is taken directly from the source).

Paradigm	Descriptions
Positivism	Asserts the existence of a single reality that is there to be discovered.
Post-positivism	Rejects the concept of a measurable reality that exists in isolation of the observer.
Postmodernism	Posits that the reality of a phenomenon is subjectively relative to those who experience it.
Critical theory	Seeks to redress perceived societal injustices through research.
Constructivism	Recognizes that reality is constructed by those who experience it and thus research is a process of reconstructing that reality.

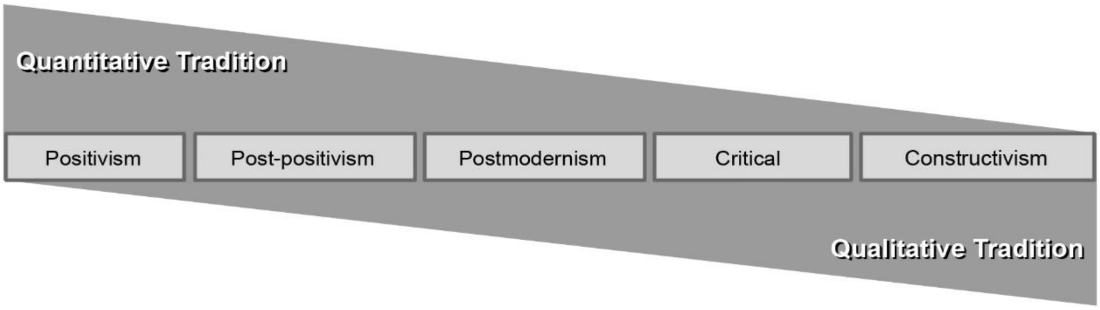

Figure 3.2 Philosophical moments and research paradigms (source: adapted from Birks, 2014, p.21 and redrawn by the author of this thesis).

Scholars (e.g. Taylor and Medina, 2013; Tolley *et al*., 2016) in different disciplines may emphasise certain paradigms that are suitable for their research focus. However, paradigm issues have converged more into positivism and interpretivism in recent years (e.g. Walliman, 2006; Keegan, 2009; Bahari, 2010; Guest *et al*., 2012; Punch, 2014). According to Walliman (2006, p.15), the aim of interpretivism is "to reveal interpretations and meanings" while positivism aims to "establish causes and effects".

As noted above, social research paradigms involve some assumptions about the social world. Adu (2019, p.2) characterises three assumptions of the interpretivist paradigm as below:

1. There are multiple ways of looking at or interpreting an issue (i.e. multiple realities);

2. Individuals' characteristics influence how they see the world or interpret their experience; and

3. All truth or knowledge is linked to a context (i.e. context-bound knowledge).

Due to this thesis focusing heavily on interpretations and meanings of designers' behaviour by analysing how designers respond and behave in certain circumstances, and the meaning of those responses, an interpretivist approach is maintained as an umbrella paradigm throughout the entire research process.

3.1.2 Approach to Design Research

There are two fundamental approaches to design research: 'Rational Problem Solving' (Simon, 1969) and 'Refection in Practice' (Schön, 1983).

As stated in section 2.1.1, within this research project, 'design activity' can be defined as a type of problem solving by designers that improves people's lives and ultimately benefits the world. However, our understanding of the concept of problem solving needs to be considered more closely here.

According to Dorst (2003b), the problem-solving aspect in design is in line with one of the fundamental paradigms established by Simon called rational problem solving, which has a logical positivist framework. Dorst and Dijkhuis (1995) note that a framework for this addition to design studies was set out by Simon, and permitted "the study of designers and design problems within the paradigm of technical rationality" (p.261). Within this approach to understanding design, the design problem is a single unique task expected to be settled and structured and has to be investigated in reaching a design solution (Valkenburg and Dorst, 1998; Dorst, 2003b). This implies adopting scientific methodological tools based in rationalism (Fallman, 2003). Within this positivist view, a good designer is thought of as a person who is enabled to follow the pre-set action rather than emphasising the skills and judgement of each designer (Stolterman, 1994).

Other researchers, however, question the usefulness of such an approach in the area of design. This is because there is no way to map a design problem into a solution in a predictable and understandable manner (Lawson, 2004). Fundamental issues are raised by the nature of design problems that designers face which are complex and are characterised as ill-defined or wicked (Rittel and Webber, 1973; Buchanan, 1992).

A contrary concept of design as a "reflective conversation with the situation" (Schön, 1983, p.76) was proposed based upon constructionist philosophy. Within this paradigm, design means focusing directly on a particular situatedness in the design process within a pragmatic approach (Fallman, 2003). This view supports what professionals actually do in design practice (Roozenburg and Dorst, 1998). Designers "frame" problems in an active manner, and thus they act (perform "moves") to improve existing situations as they see them (Dorst and Dijkhuis, 1995, p.254). This research makes it clear that designers can be viewed as reflective practitioners who solve design problems.

Schön's perspective, which is pragmatic, is part of a wider constructionist philosophy which provides a supporting theory for this research. The constructivist worldview is employed throughout this project to reflect how professionals think through how to deal with the design situations that they confront.

3.1.3 Summary of Philosophical Worldviews

The paradigms that are considered in this research project can be stated as twofold and related. Firstly, in ontological orientation, this research can be viewed within the constructivist paradigm based on the "belief that social phenomena are in a constant state of change because they are totally reliant on social interactions as they take place" (Walliman, 2006, p.15).

Next, in terms of epistemological orientation, this research can be seen from an interpretivist standpoint. This is because the researcher behind this research project believes that "the social world is constructed of symbolic meaning observable in human acts, interactions, and language. Reality is subjective and multiple as seen from different perspectives" (Ulin *et al*., 2005, p.16).

Table 3.2 Summarising two fundamental design paradigms (reformatted and adapted from Dorst and Dijkhuis, 1995, p.263; Fallman, 2003, p.227 and the wording in the table is taken directly from sources here).

	Rational Problem Solving (Conservative Approach)	Refection in Practice (Pragmatic Approach)
Paradigm	Positivism.	Constructivism.
Designer	Information processor (in an objective reality).	Person constructing his or her reality, a reflective, know-how bricoleur.
Problem	Ill-defined, unstructured, to be defined.	Unique to the situation; to be set by the designer.
Process	A rational search process, fully transparent.	A reflective conversation, a dialogue.
Product	A result of the process.	An outcome of the dialogue, integrated in the world.
Design knowledge	Scientific laws, guidelines, design methods.	Artistry of design, how each problem should be tackled, compound seeing, experience.
Role model	Optimisation theory, the natural sciences, engineering.	Social sciences, human science, sociology.

3.2 Research Strategy

Creswell (2008. p.11) states that:

> Strategies of inquiry are types of qualitative, quantitative, and mixed methods designs or models that provide specific direction for procedures in a research design.

The concept of a research strategy is described by Johannesson and Perjons (2014, p.39) as below:

> A research strategy is an overall plan for conducting a research study. A research strategy guides a researcher in planning, executing, and monitoring the study.

The term seems to be closely linked to research methodology based on the definition of this given by Gray (2004, p.405):

> Approaches to systematic inquiry developed within a particular paradigm with associated epistemological assumptions (e.g. experimental research, survey research, grounded theory, action research).

Gray (2004) adds that the choice of methodologies is influenced by the researcher's perspective (positivist, interpretivist, or others). This author also states that the researcher's attitude toward the research (whether positivist or interpretivist) influences the data analysis approaches (whether deductive or inductive).

Creswell (2007 cited in Creswell, 2008, p.11) argues that a strategy of inquiry can be considered an "approach to inquiry". In the same vein, Mertens (1998 cited in Creswell, 2008, p.11) claims that "strategies of inquiry" can be thought of as "research methodologies". In this thesis, the term research strategy is used.

Creswell (2008) divides research strategies into three groups: quantitative strategies, qualitative strategies, and mixed methods strategies (Table 3.3). On the other hand, others (e.g. Johannesson and Perjons, 2014; Palmer, 2019) group research strategies into two - basically quantitative and qualitative.

For this research project, each chapter's main goals, objectives, research questions, along with the overall characteristics of the research project were taken into account to select research strategies that are the most suitable for the project as a whole. Consequently, a sequential mixed methods strategy was adopted involving case studies for exploratory purpose. Qualitative research methods were used in the main, supplemented by a relatively small range of quantitative techniques to support the qualitative findings. Figure 3.3 shows the overall research plan for data collection within this thesis. Individual elements from the figure will be explained as the chapter progresses.

Table 3.3 Strategies of inquiry (source: reformatted and adapted from Creswell, 2008, p.12).

Quantitative	Qualitative	Mixed Methods
▪ Experimental designs ▪ Non-experimental designs, such as surveys	▪ Ethnographies ▪ Grounded theory studies ▪ Case study ▪ Phenomenology ▪ Narrative research	▪ Sequential mixed methods ▪ Concurrent mixed methods ▪ Transformative mixed methods

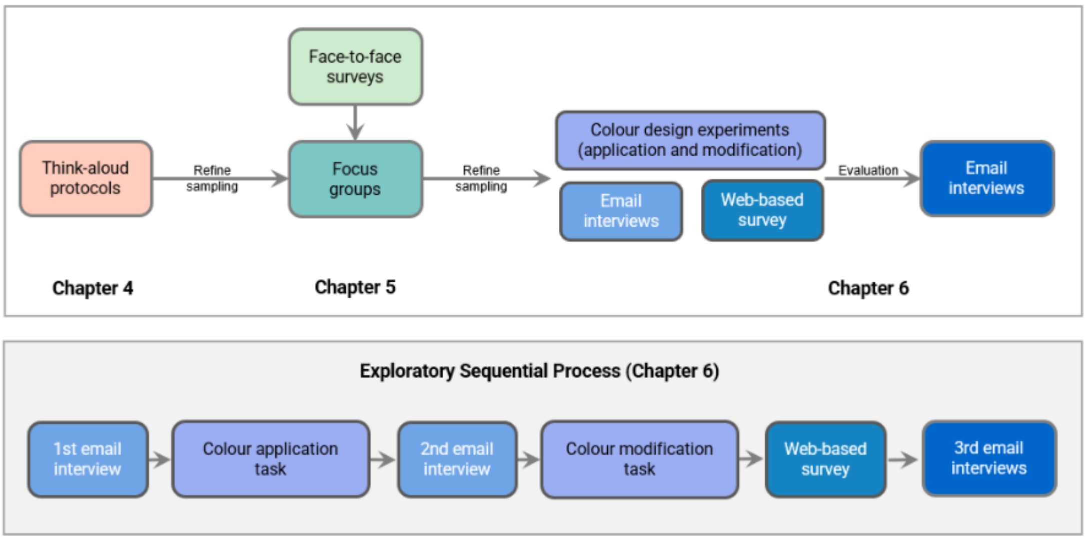

Figure 3.3 Sequential mixed-methods case study research process in exploratory nature.

3.2.1 Case Study Research

A case study focuses on a single example of phenomena under investigation, and allows detailed descriptions and insights into that example (Johannesson and Perjons, 2014). The case study can vary between qualitative, quantitative, or a mixture of qualitative and quantitative approaches (Norander and Brandhorst, 2017). With respect to appropriate methodological approaches within case study research, there are different opinions among scholars.

Palmer (2019) claims that a case study is frequently regarded as a core example of qualitative research which studies phenomena in context, brings interpretation to data, and takes into account the subjectivity which makes situations meaningful for individuals. Stake (2010) argues that qualitative case study research appeals to subjective ways of knowing and to a primarily qualitative methodology, that captures experiential understanding. However, Kitchenham (2010) maintains that approaches drawing on case studies are especially helpful in research using mixed methodology as they allow the possibility of designing, analysing and interpreting research and data in many ways. This scholar adds that mixed method approaches are of particular help because the in-depth data revealed by a case study is offered to the researcher who can then subject it to either qualitative and quantitative approaches together, or use just one of these (Kitchenham, 2010). Table 3.4 outlines detailed characteristics of case study research from a range of researchers.

Based on arguments from other scholars (e.g. Stake, 2010; Kitchenham, 2010; Palmer; 2019) as well as considering the methodological approaches of the present research, this research could be characterised as qualitatively driven mixed methods case study research. This is because the analysis of particular phenomenon (in this research, the situation that designers confront) was aided by multiple collection methods which will be explained in section 3.4.1.

Table 3.4 Some characteristics of case study research (source: reformatted and adapted from various researchers and the wording in the table is taken directly from sources here).

Researcher	Characteristics
Yin, 1984 cited in Zainal (2007, pp.4-5)	▪ **Advantages of case study** - The examination of the data is most often conducted within the context of its use. - Variations in terms of intrinsic, instrumental and collective approaches to case studies allow for both quantitative and qualitative analyses of the data. - The detailed qualitative accounts often produced in case studies not only help to explore or describe the data in real-life environment, but also help to explain the complexities of real-life situations. ▪ **Disadvantages of case study** - Often accused of lack of rigour. - Provide very little basis for scientific generalisation. - Often labelled as being too long, difficult to conduct and producing a massive amount of documentation.
Johannesson and Perjons (2014, p.53)	▪ **Purpose**: investigate in depth a phenomenon with a well-defined boundary. ▪ **Key Concepts**: case/instance, natural setting, holistic view. ▪ **Key Activities**: multisource data collection and triangulation. ▪ **Major Concerns**: weak generalisability.
Taylor and Thomas-Gregory (2015, p.40)	▪ **Attributes of 'good' case study research** - The context is clearly articulated. - The boundaries of the research are well defined and are evident to the reader. - The methods are suitable to achieve the aims of the research and are used rigorously. - The ethical issues are clearly and appropriately addressed.
Norander and Brandhorst (2017, pp.117-119)	▪ **Focus on gathering in-depth data** on a single or sometimes a small number of cases (unlike experiments or survey research study). ▪ **Procedures** - Developing research questions. - Choice of types: a single-case research design or a multiple-case design. - Data collection: interviews, direct or participant observations, and artefacts such as documents or records. - Data analysis: depending on the purpose of the research. - Case study write-up.

3.3 Research Types

Kumar (2011, p.9) classifies research types into three groups in accordance with different standpoints: “application of the findings of the research study, objectives of the study, and mode of enquiry used in conducting the study”. The main types of research used in this thesis from Kumar's (2018) typology (Figure 3.4) are explained and discussed below.

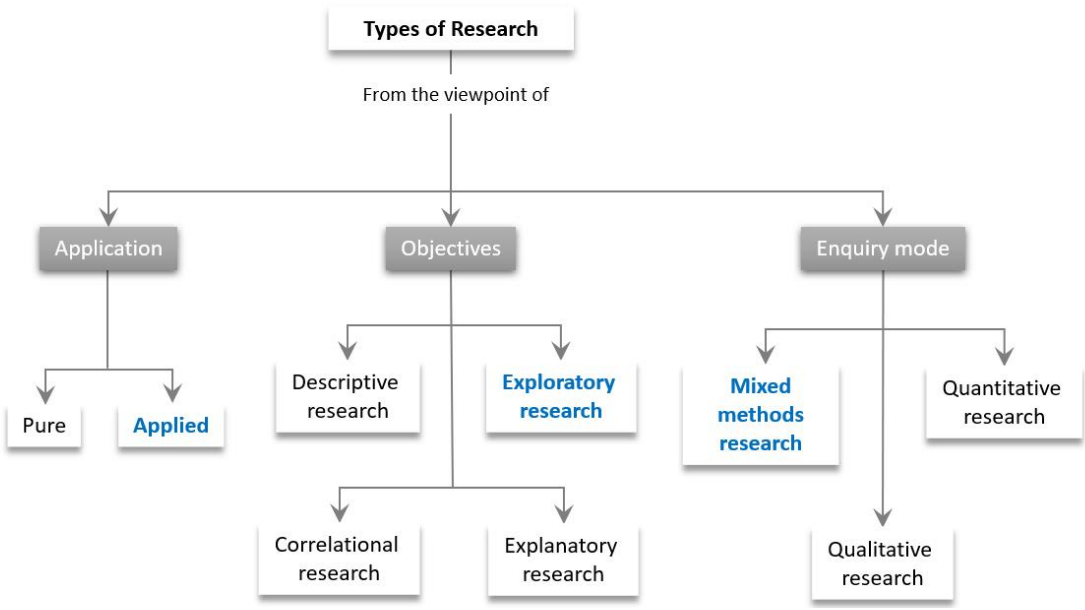

Figure 3.4 Types of research: the types of research adopted in this thesis highlighted blue in bold (source: adapted from Kumar, 2018 and redrawn by the author of this thesis).

3.3.1 Applied Research

In general, applied research is regarded as an opposite side of basic research (or pure research) (Phua, 2004; Guest *et al.*, 2012). However, applied and basic research can be complementary in some ways (Baimyrzaeva, 2018).

Applied research is an overarching term that encompasses a number of types of systematic, empirical research which is aimed at solving particular problems (McEneaney, 2018). To find solutions to particular problems, applied researchers may use exploratory approaches or they may try to understand a pattern (frequently to allow them to predict things accurately) (McEneaney, 2018). In addition, they may seek confirmation of previous findings or results they intend or would expect (McEneaney, 2018).

When methodological approaches are considered in applied research, purely qualitative, quantitative, or mixed methods can be used (McEneaney, 2018; Baimyrzaeva, 2018). Numerous data collection methods including document reviews, surveys, focus groups, observation, and different types of interviews can be employed for the applied research (Baimyrzaeva, 2018).

The present research project is a form of applied research. This is because the researcher in this thesis ultimately aims to discover how to change designers' behaviour in a particular context by seeking evidence-based findings from data collected from designers. To fulfil the main goals of the research, focus group interviews and email interviews, web-based and face-to-face surveys, and colour design experiments (application and modification) were utilised (see Figure 3.3).

3.3.2 Exploratory Research

Scholars put forward varying numbers of types of research in social science. Scholars (e.g. De Vaus, 2001; Palmer, 2019) point out that there are two fundamental research types according to research questions: descriptive (what is going on) and explanatory (why is it going on). Other scholars (e.g. Gray, 2004, Kumar, 2011, Kumar, 2018) classify types of research based on its purpose but numbers vary (Table 3.5). Characteristics of some of the established research types are outlined in Table 3.6.

According to Singleton and Straits (2005, cited in Richey and Klein, 2009, p.43), "exploratory research relates to topics about which very little is known. Because of this, there are few guidelines to follow and the research designs are less structured than in descriptive research". Those using exploratory approaches assume that the greater their knowledge of data, the greater will be their ability to use data in developing, testing, and refining theories (Hartwig and Dearling, 1979).

Much exploratory research collects both qualitative and quantitative data (Stebbins, 2001). As shown in Table 3.7, exploratory research can be conducted by employing a number of research methods. The benefit of exploratory research is that this allows the researcher to discover new findings readily due to methodological flexibility (less-rigorous restriction) (Palmer, 2019).

Table 3.5 Types of research categorised on the basis of purpose.

Forms of Research	Scholar(s)
Exploratory, descriptive, explanatory	Robson, 2002 cited in Gray, 2014; Richey and Klein, 2009.
Exploratory, descriptive, explanatory, and correlational	Kumar (2011)
Exploratory, descriptive, explanatory, and interpretive	Maxwell (2009)
Exploratory, descriptive, explanatory, and emancipatory	Marshall and Rossman (1999)

Table 3.6 Distinctions of research types based on research purposes (source: reformatted and adapted from Marshall and Rossman,1999 cited in Tang, 2010, p.47; Kumar, 2011, pp.10-11; Gray, 2014, pp.36-37).

Type of Research	Purpose and Characteristics
Exploratory	▪ Purpose: seek to explore what is happening and to ask questions about it (e.g. what do *x* people think about *y*?). ▪ Also called a feasibility study or a pilot study. ▪ Exploratory research can be conducted by (1) A search of the literature; (2) Talking to experts in the field; and (3) Conducting focus group interviews.
Descriptive	▪ Purpose: provide a picture of a phenomenon as it naturally occurs (Hedrick *et al*., 1993 cited in Gray, 2014) as well as comprise a normative study, comparing the data against some standard. ▪ Weaknesses: lack of explanation of why an event has occurred. ▪ Focus on 'what' question. ▪ Good descriptive studies provoke 'why' question.
Explanatory	▪ Purpose: to clarify why and how there is a relationship between two aspects of a situation or phenomenon. ▪ Focus on 'why' question.
Emancipatory	▪ Purpose: to create opportunities and the will to engage in social action. ▪ Almost exclusively of flexible design.
Interpretive	▪ Purpose: seek to explore peoples' experiences and their views or perspectives of these experiences. ▪ Typically Inductive in nature and often associated with qualitative approaches to data gathering and analysis.
Correlational	▪ Purpose: to discover or establish the existence of a relationship/ association/ interdependence between two or more aspects of a situation.

Regarding types of research based on its purpose, the present research shows principally exploratory but also interpretive characteristics. This is because, a small range of data collection and analysis was conducted in Chapter Four before concrete research questions and hypotheses were generated which were tested in Chapters Five and Six. In this research, the interpretations of the researcher about certain phenomenon were presented in detail (thickly) based on patterns and themes from the data in order to develop conceptual categories rather than establishing theories. This is the main reason for the adoption of exploratory case studies in this thesis.

Table 3.7 Commonly used research methods matched to research purpose (source: reformatted and adapted from Richey and Klein, 2009, p.44).

Purpose of research	Common Research Methods
Exploratory	Case study, content analysis, field observation, in-depth interview, mixed methods, multiple methods, literature review and analysis, think-aloud methods.
Descriptive	Content analysis, in-depth interview, survey, mixed methods, multiple methods, case study, evaluation, expert review.
Explanatory	Delphi, experimental, evaluation, survey.

3.3.3 Mixed Methods Research

Kothari (2004) classifies two basic approaches in research (quantitative and qualitative), while Creswell (2008, p.4) suggests three types as below:

> **Qualitative research** is a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures, data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data.
>
> **Quantitative research** is a means for testing objective theories by examining the relationship among variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analysed using statistical procedures.
>
> **Mixed methods research** is an approach to inquiry that combines or associates both qualitative and quantitative forms. It involves philosophical assumptions, the use of qualitative and quantitative approaches, and the mixing both approaches in a study.

Scholars assert that both qualitative and quantitative approaches should not be viewed in opposition (e.g. Newman and Benz, 1998, Bryman, 2006; Saldaña, 2011, Hesse-Biber, 2016). Saldaña (2011) argues that the epistemology and methodology of both approaches (qualitative and quantitative) can be used together to give weight to results or show outcomes that complement or even contradict each other. This view is supported by Hesse-Biber (2016) who mentions that mixed methodology in research has a "synergistic potential" (p.649) which offers flexible and powerful ways to handle complex factors of analysis and interpretation. This is due to its breadth of practical methodologies and wide-ranging uses (Hesse-Biber, 2016). In practice, mixed methods research utilises a syntagmatic way to gain a research goal (Choo *et al*., 2015).

There is debate about the position of mixed methods research. Creswell *et al.* (2006) emphasise that mixed methods research prioritises qualitative research, while Giddings (2006) reverses this emphasis. In this research, although both approaches were integrated, qualitative research methods were employed predominantly throughout the research project. The reason for adopting a small amount of quantitative methodology (through a survey) was to test research hypotheses which were generated after qualitative data analysis and a review of literature both of which made comparison between designers and non-designers and different levels of designers by their years of experience. This quantitative technique played a secondary role to strengthen the results of the qualitative approach and eventually achieve the aim of the research. This research was also conducted under the interpretivist paradigm, in which subjectivity plays a vital role in deep understanding about a particular phenomenon, and the constructivist paradigm, which believes that reality is constructed and "multiple realities" (Levers, 2013, p.2) exist. For these reasons, the present project can be stipulated as qualitatively driven mixed methods research.

3.4 Research Planning

The methods of data collection and analysis in research are the main elements along with methodological approaches which characterise a research paradigm (Daniel, 2016). This section provides justifications for data collection and analysis methods selected and applied throughout this thesis.

3.4.1 Methods of Data Collection

As stated above, two different research approaches were mixed in this research project. This means that different data collection and analysis methods were used.

In social science "research methods are the practical means to carry out research" (Walliman, 2006, p.29). Specifically focusing on the area of visual communication design, Noble and Bestley (2011, p.60) state that this is generally understood as: "ways of approaching design problems or investigating contexts within which to work".

Cross (2011) states that various research methods have been utilised by previous scholars to research designers' abilities and include: "interviews with designers, observations and case studies, experimental studies, simulation, and reflection and theorising" (p.5). All these methods give the researcher insights into the "natural intelligence of design – or the *designerly* way of thinking" (Cross, 1999, p.27). The data collection methods used for studies of designers' abilities in design research are reviewed and listed in the literature review (see section 2.2.2.3.3 and Table 2.18).

Qualitative data collection methods (such as think-aloud protocols, focus groups, and email interviews) were chosen as the main techniques for gathering data from design participants. It was expected that such qualitative research methods would help the researcher to illuminate designers way of acting, their values and thoughts, in a holistic understanding within particular circumstances (design tasks set by the researcher). At the same time, a relatively small amount of quantitative research (through a survey) was used to support the qualitative findings.

Table 3.8 summarises the research methods used throughout this thesis, along with justifications for selecting these research methods. Selected methods are further described in each chapter in detail.

Table 3.8 Summary of selected research methods for data collection.

Section	Method Used	Description of Methods and Rationale
Chapter 4	Think-aloud protocol	▪ As there is little information available about how designers perceive colours in current literature, the think-aloud method was considered as an appropriate method to explore this topic. ▪ This technique was used especially for language-based activities for comparison of design participants with non-design participants (based on sociolinguistic theory).
Chapter 5	Survey (face-to-face)	▪ A mini study was conducted with two participants (aged over 65) by using face-to-face surveys. ▪ Open-ended questionnaires were used to generate contents which were used on a second design prototype (with 16 older people).
	Focus group interviews	▪ The focus group method is suitable for exploring design participants' attitudes, values, and knowledge about particular situations. ▪ Asking designers what they do is the simplest way to investigate design abilities according to Cross (2011). Therefore, focus group interviews (open-ended style) were used as effective methods to conduct a designer study. ▪ Quantitative measures (a five-point Likert-type scale) were also adopted unobtrusively during the first focus group session to evaluate a second design prototype with verbalised feedback.
Chapter 6	Email interviews	▪ A considerable amount of data gained from thirty designers from all over the world (Britain, China, Hong Kong, and South Korea) was without geographic and time constraints using email interviews with thirty individual designers. ▪ Rich data were collected from design education experts in Higher Education [HE] in the UK to evaluate the AII formats, and obtain additional ideas for developing designer friendly user-information formats based on their experience. ▪ There was no concern about transcription errors as each participant typed answers in person in their own words.
	Surveys (web-based)	▪ Designers were sent questionnaires that included five questions that were closed-ended, two five-point Likert-type scales, and an open-ended item. ▪ The closed-ended items addressed two issues: 'perception of information' and 'useful source of information for designers'. ▪ The open-ended items asked about the following topic: overall feeling and emotional experience. ▪ Therefore, two types of data can be collected and analysed simultaneously.
	Colour design tasks	▪ A colour application and modification experiment was conducted with each of thirty designers using Adobe Illustrator software (design formats were made by the researcher then offered to each design participant by email). ▪ This was conducted to investigate differences in terms of colour and colour information use by different levels of designers (by comparing three groups).

3.4.2 Approach to Data Analysis

The data collected in this research has different forms: non-numerical (qualitative) and numerical (quantitative). Prior to conducting data analysis, it is necessary to understand which data analytic approaches are most suitable based upon the nature of data.

According to Pascale (2011, p.39), "all forms of research rely upon the logics of induction, deduction, and abduction to varying degree". These are ways of reasoning and lead to analytical approaches. The distinctions between these three ways of reasoning are outlined in Table 3.9.

Table 3.9 Distinctions between three ways of reasoning (source: reformatted and adapted from Brewer, 2003; Walliman, 2006; Tomlinson, 2010a; Yin, 2010; Gray, 2014; Kennedy, 2018 and the wording in the table is taken directly from sources).

Reasoning and Data analysis approach	Characteristics
Induction	▪ The empiricist's approach. ▪ Going from the specific to the general. ▪ Induction is associated with qualitative research and naturalism. ▪ Inductive thinking: developing concepts, categories, and relations from the text.
Deduction	▪ The rationalist's approach. ▪ Going from the general to the specific. ▪ The analytical process on the basis of which a general proposition leads to the facts, or a hypothesis (derived from previous evidence and theory) provides the foundation for the exploration of particular cases or facts. ▪ Deductive thinking: testing the concepts, categories, and relations against the text, especially against passages or cases that are different from those from which they were developed.
Abduction	▪ The third type of data processing. ▪ It can be understood as selecting or inventing a provisional hypothesis to explain a particular empirical case or data set better than any other candidate hypotheses, and pursuing this hypothesis through further investigation.

Inductive and deductive approaches are opposites (Jupp, 2006; Yin, 2010) because each represents alternative means of moving between data on one hand and concepts on the other (Yin, 2010). Deductive approaches start by taking universal views of situations and work back to specifics (Gray, 2014). On the other hand, inductive approaches consider 'facts' or 'raw data' to identify possible patterning (Boyatzis, 1998). This permits themes that could arise unexpectedly to feed into the data analysis while the data is being coded (Roberts *et al*., 2019).

Although most qualitative research within social science follows an inductive orientation (Jupp, 2006), deduction is also used in qualitative research (Yin, 2010; Gray, 2014; Kennedy, 2018). In other words, the approaches do not exclude each other. For example, Kennedy (2018, p.50) claims that “one advantage of deducing from theory in qualitative research is that the theory helps researchers attend to details and nuances in the data that otherwise might be overlooked”. Abduction may be incorporated with others too. Thus, the qualitative researcher uses abduction in a process which selectively and creatively examines how hypotheses or theories that already exist are supported by data, but also how data potentially calls for current understanding to be modified (Thornberg, 2012).

The present research chooses to make use of inductive discovery. Thus, data analysis within the inductive (bottom-up) approach guides the researcher of this thesis in dealing with a dataset of responses by design participants confronted with a design situation. At the same time, deductive proof was also used. After conducting the literature review and the two main designer studies (Chapters Four and Five), a set of research questions and hypotheses were formulated inductively. These were tested and analysed through quantitative techniques (deductive) using a survey. Figure 3.5 is adopted from Gray (2014, p.18) and illustrates how the inductive and deductive approaches can be used together.

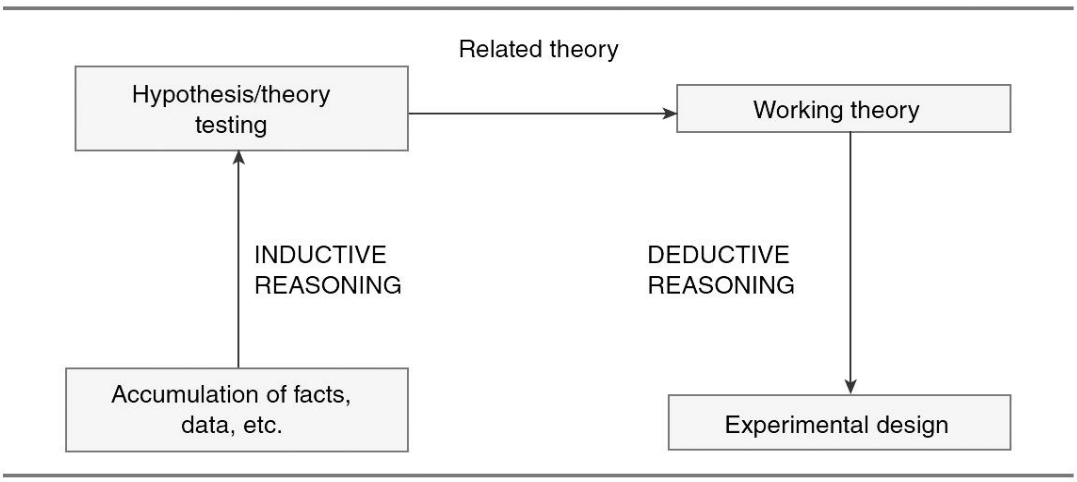

Figure 3.5 Illustration of how inductive and deductive reasoning work together in research (source: adopted from Gray, 2014, p.18).

3.4.3 Data Analysis Methods

There are two approaches to data analysis in this thesis on the basis of the research objectives and the nature of data. The majority of data in this research project is non-numerical and narrative collected from think-aloud protocols, focus groups, and email interviews. For this qualitative data, thematic analysis [TA] and qualitative content analysis [QCA] were applied. NVivo12 Plus (computer-assisted qualitative data analysis software) was utilised together with manual coding on Microsoft Excel spreadsheets and Microsoft Word documents. Also, for the analysis of visual elements (groups of colours obtained from colour design tasks in Chapter Six), visual content analysis [VCA] was adopted in a qualitative form. However, there is a small amount of numerical data gained from a web-based survey. For this, descriptive analysis was used by using Jamovi statistical software. Table 3.10 lists the approaches to data analysis, data analytic methods, and computer software applied in this research project.

Table 3.10 Summary of the approaches to data analysis, analysis methods, and software used in this thesis.

Data Analytic Approach	Data Analytic Method(s)	Software used
Qualitative	▪ Thematic analysis ▪ Qualitative content analysis (a conventional approach)	QSR NVivo12 Plus
	Visual content analysis	Adobe Illustrator
Quantitative	Descriptive statistics	Jamovi

3.4.3.1 Thematic Analysis

The thematic analysis method is widely used in qualitative data analysis (Braun and Clarke, 2019), and is defined as “a method for identifying, analysing and reporting patterns (themes) within data” (Braun and Clarke, 2006, p.79). The term theme is critical in TA as meaning “explicit words or phrases and focus on identifying and describing both implicit and explicit ideas within the data” (Guest *et al*., 2012, p.10). Braun and Clarke (2006) theorise that TA can be used within a constructivist approach. These authors argue that the TA method allows us to consider how “events, realities, meanings, and experiences” (p.81) are brought about by “a range of discourses operating in society” (p.81). Braun and Clarke (2006) suggest a six-phase reflexive TA method to conduct qualitative analysis (Table 3.11).

There are also several ways of conducting a step-by-step data coding process in qualitative research which can be applied for an inductive approach. Table 3.11 summarises processes of data analysis suggested by other researchers. These include the inductive coding process (Creswell, 2002 cited in Thomas, 2006, p.242), the inductive analysis of qualitative data with five key features (Thomas, 2006), and the five-phase cycle (Yin, 2016).

As can be seen in Table 3.11, despite scholars using different terms and slightly different numbers of steps, there is a common factor. For example, Thomas's first two steps are covered in the first step of the process offered by other scholars. Regardless of coding processes used by different scholars, in the first stage, it is anticipated that researchers or interpreters will transcribe raw data, and obtain initial ideas and impressions while reading and re-reading transcripts.

Highly descriptive and non-numeric data obtained from focus groups was analysed and described thematically and inductively using NVivo within a five-step framework after analysing the slightly different processes of four scholars (see Table 3.11). The use of NVivo facilitates the researcher to generate codes (nodes) and cluster them, and allows effective visualisation of the data presentation from a large amount of textual data. Each step of the process will be described thoroughly in Chapter Five.

Table 3.11 Summary of step-by-step data coding processes proposed by various scholars (the wording in the table is taken directly from sources here).

Creswell (2002, cited in Thomas, 2006, p.242)	Braun and Clarke (2006, p.87)	Thomas (2006, pp.241-242)	Yin (2016, p.185)	This thesis
Inductive coding process	Six-phase reflexive TA method	Inductive analysis of qualitative data	Five-phase cycle	Five-stage TA method
Initial reading of text data	Familiarising yourself with your data	Preparation of raw data files (data cleaning)	Compiling	Immersion in dataset
Identify specific text segments related to objectives	Generating initial codes	Close reading of text	Disassembling	Identifying codes
Label the segments of text to create categories	Searching for themes	Creation of categories	Reassembling (and arraying)	Developing thematic categories
Reduce overlap and redundancy among the categories	Reviewing themes	Overlapping coding and uncoded text	Interpreting	Constructing themes (reviewing, refining, and defining)
Create a model incorporating most important categories	Defining and naming themes Producing the report	Continuing revision and refinement of category system	Concluding	Presenting findings

3.4.3.2 Content Analysis

For the analysis of data collected from thirty designers in Chapter Six, content analysis [CA] was utilised in two ways: (1) CA for narrative data analysis obtained from email interviews and (2) CA for visual data (colours) analysis collected from colour design experiments. Both textual and visual data were analysed in a qualitative form. The justification for the approach to the analysis will be demonstrated in the section below.

3.4.3.2.1 Content Analysis for the Textual Data

For the analysis of qualitative data collected from email interviews in Chapter Six, CA was considered. Bloor and Wood (2006, p.59) state that “the purpose of content analysis is to describe the characteristics of the document's content by examining who says what, to whom and with what effect”. In CA, although there is no strictly established criteria for the size of the unit of analysis (Bengtsson, 2016), “words, sentences, grammatical structures, tenses, clauses, ratios (of say, nouns to verbs), or even themes” (Prior, 2014, p.361) can be the unit of analysis which can be focused upon.

As described on the previous page, TA is used for qualitative data analysis in Chapter Five. The common ground between the TA and CA methods is both facilitate qualitative data analysis. In addition, like TA there are no straight forward guidelines for doing CA (Kondracki *et al*., 2002). However, there are several differences between TA and CA as explained below.

Unlike TA, CA can be utilised in both qualitative and quantitative approaches. The goal of CA as a quantitative method is to “produce counts of key categories and measurements of the amounts of other variables” (Fink, 2009 cited in Neuendorf, 2017, p.21). One of the main goals of quantitative CA is to investigate the frequency of specifically identified terms in the dataset (Columbia University Irving Medical Centre, 2019).

Qualitative content analysis [QCA] is also one of the various methods for textual data analysis (Hsieh and Shannon, 2005). Data can be collected through numerous qualitative research methods such as open-ended survey questionnaires, interviews, focus groups, videography, and so forth (Kondracki *et al*., 2002). QCA looks at “relational aspects, involving interpretation of the underlying meaning of the text” (Erlingsson and Brysiewicz, 2017, p.96). This can be dealt with by either inductive or deductive reasoning (Elo and Kyngäs, 2008; Bengtsson, 2016). In short, the CA method allows the researcher to analyse data either within the quantitative or qualitative paradigms (Kondracki *et al*., 2002; Gray, 2004; Elo and Kyngäs, 2008; Grbich, 2013; Krippendorff, 2018).

On the other hand, TA permits the researcher to identify “a more detailed and nuanced account of one particular theme, or group of themes, within the data” (Braun and Clarke, 2006, p.83). As noted, TA is a purely qualitative approach (Vaismoradi *et al*., 2013).

There are three separate approaches in QCA: conventional, directed, or summative, according to Hsieh and Shannon (2005). In the current research, the conventional type was used for analysis of textual data. It is often wise to use a conventional approach when limited scholarship or theory exists on phenomena (Hsieh and Shannon, 2005). This type of approach avoids pre-imposing the categories to be used, and instead new insights emerge from the raw dataset (Hsieh and Shannon, 2005). Several authors argue the weakness of the conventional approach in QCA. Hsieh and Shannon (2005) point out that such a method shares similarities in terms of its analytical approach with other qualitative methods (e.g. grounded theory method or phenomenology) and this can cause confusion. Lindkvist (1981, cited in Hsieh and Shannon, 2005, p.1281) makes the criticism that at best, “concept development or model building” is the result of a conventional QCA. Nevertheless, conventional QCA permits researchers to build up findings and theoretical cohesion which could guide the potential direction of further research and corroborate future findings (Fox *et al*., 2015).

Table 3.12 outlines the procedure for QCA offered by four scholars. These scholars suggest different numbers of steps for QCA. However, an important common point is that all involve reducing the amount of data by formulating codes and categorising (organising) them gradually over time. In the present research, the researcher understood the requirement of each stage then set up four phases of QCA. These were (1) selection of meaning unit and condensation, (2) identification of codes, (3) inductive category development, and (4) thematic exploration.

The collected data was analysed manually on a Microsoft Word document in the first place. This involved close reading combined with initial manual coding. Doing this permits the researcher to develop valuable initial insights. However, to support this approach, NVivo 12 Plus program was also used at some points to help the researcher to manage a large amount of data, locate codes and group them together into categories in a time saving manner. The detailed data analysis process will be presented step by step in order to confirm reliability standards for qualitative research throughout Chapter Six.

Table 3.12 Qualitative content analysis procedure (the wording in the table is taken directly from sources here).

Elo and Kyngäs (2008, p.110)	Flick (2014, p.174)	Bengtsson (2016, p.9)	Erlingsson and Brysiewicz (2017, p.95)	This thesis
Inductive content analysis process	Steps in qualitative content analysis	Process of a qualitative content analysis	Qualitative content analysis process	Four-stages qualitative content analysis
Preparation	Deciding on a research question	Decontextualisation	Familiarising oneself with the data and the hermeneutic spiral	Selection of meaning unit and condensation
	Selecting material			
Organising	Building a coding frame	Recontextualisation	Dividing up the text into meaning units and subsequently condensing these meaning units	Identification of codes
	Segmentation			
Resulting	Trial coding	Categorisation	Formulating codes	Inductive category development
	Evaluating and modifying the coding frame			
	Main analysis	Compilation	Developing categories and themes	Thematic exploration
	Presenting and interpreting the findings			

3.4.3.2.2 Content Analysis for the Visual Data

According to Bell (2001, p.15), “any kind of meaningful visual/verbal information” can be used for analysis in the CA method. Byrne (2016) states that visual analysis [VA] is qualitative in form in the area of social science research dealing with “the content of images, the arrangement of elements within them, the nature of the processes of production of the images, and the social context surrounding their production”.

In this research, particularly Chapter Six, colours (the major visual element) gathered from designers by undertaking colour design experiments (colour application and modification tasks to the product package cases) will be analysed by using the Natural Colour System [NCS]. The relevant theories and terms have been addressed already in section 2.3.3.1.3. Thus, in Chapter Six, each colour that designers use is transferred to NCS code using Adobe Illustrator (CMYK mode). In order to obtain NCS colour codes, the NCS colour palette swatch was imported on Adobe Illustrator (Figure 3.6). This lists all colours on the NCS Atlas digitally with the NCS code for each colour (Figures 3.6 and 3.7).

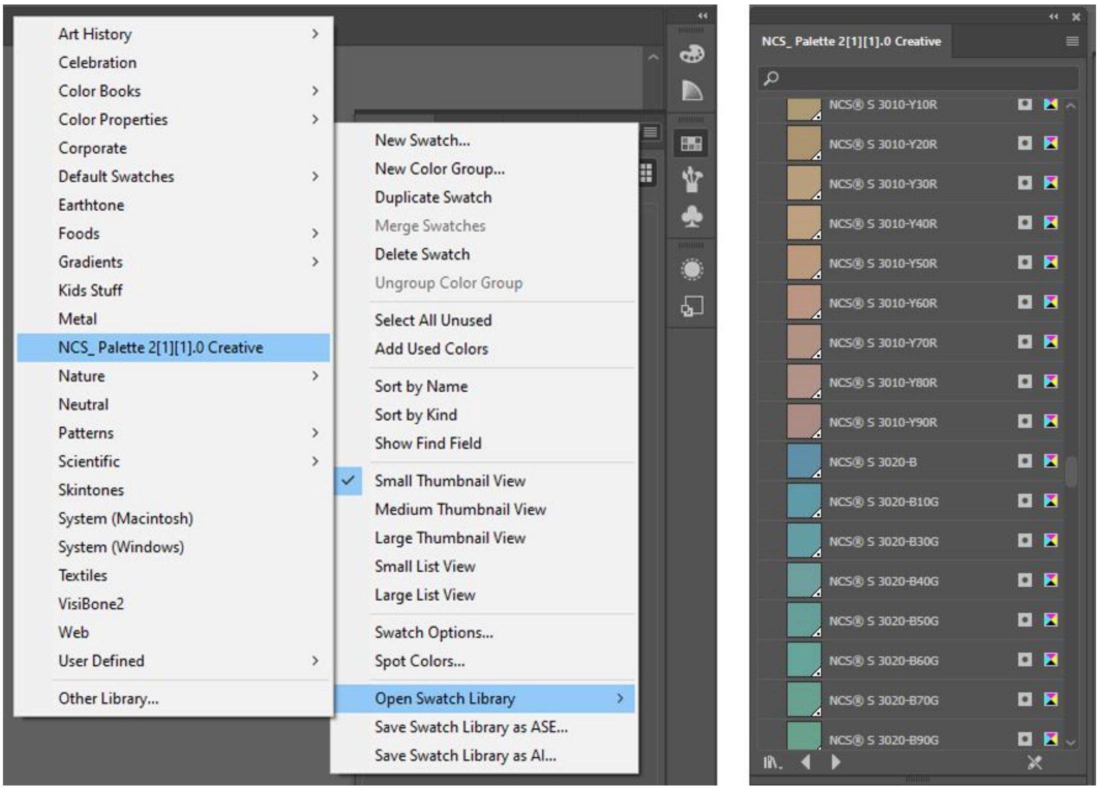

Figure 3.6 NCS colour palette swatch added to Adobe Illustrator (left) and list of NCS colour with code (right).

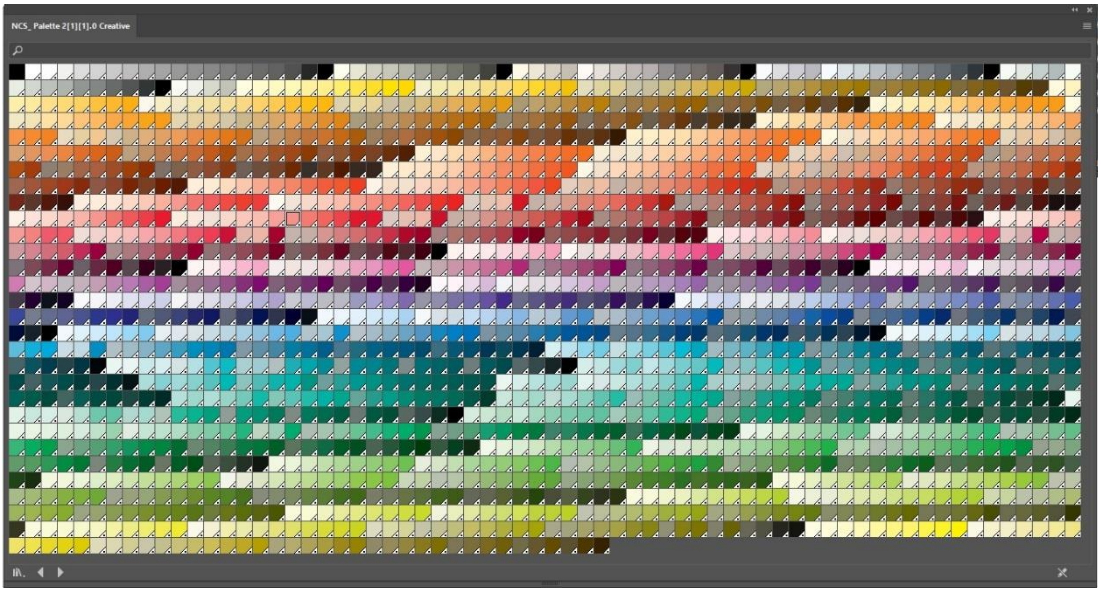

Figure 3.7 Colours from NCS Atlas digitally listed on Adobe Illustrator.

The colours selected by designers on Adobe Illustrator are converted into the nearest colours on NCS to gain NCS colour code in order to be located in NCS colour circle and triangle to investigate the general tendency of colour use by designer groups. Figure 3.8 indicates one of the colour selections by a student designer and the nearest colours on NCS chart. The two colours look almost identical but are not actually the same. In this way, a total of 300 colours were manually coded by the researcher. All colours selected from thirty designers during the colour design tasks will be listed with NCS codes in section 6.3.2.2.

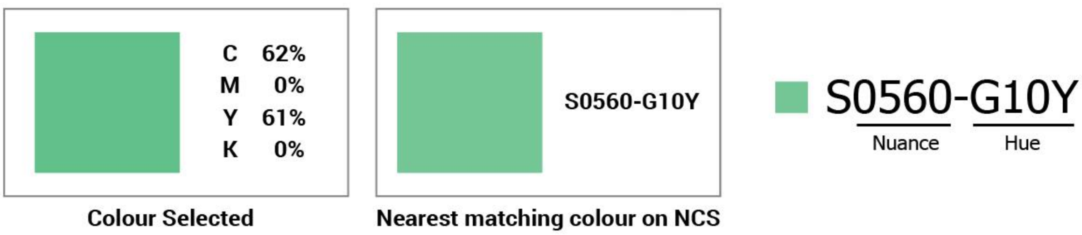

Figure 3.8 Colour selected by one of the student designers (left) along with the nearest NCS colour (middle), and NCS colour code (right).

As the colour data were collected digitally, the issue of colour fidelity of digital colour needs to be discussed here. Fidelity refers to “the ability of an image to faithfully reproduce colour” (Ahmad, 2019 cited in Hodson and Donnell, 2020, p.547). However, due to all imaging devices differing and all of them having their own particular operating qualities (Sharma, 2018), reproducing colour across imaging devices is an issue in the area of colour management. Sharma

(2018, p.2) defines the term colour management as the use of “a digital technology framework that can be used to compute device-specific instructions and thereby control colour among different devices in an imaging system”.

In the present research, around three-hundred colours were elicited from thirty individual designers based in different countries through colour design tasks using their own computers. Thus, “device variability” (Sharma, 2018, p.8) and whether it is an issue in this study are considered below.

When researchers need very high colour fidelity, bespoke colour management is almost always preferred. This calls for careful calibration and characterisation of a device. An example of an application where this sort of fidelity to colour might be needed would be in the area of colour difference or colour threshold research. If researchers want to show colour stimuli on screen and estimate the threshold change in colour, for example, that is just noticeable to an observer, then bespoke colour management is crucial, because otherwise, the variation in colour may be too large to allow the threshold to be detected. One other important use of colour management is that it potentially allows another researcher to copy the experiments in a way that just giving the RGB values used, for example, would not.

However, that type of precise and specific colour management is not always possible or even something the researcher will want. A colour naming experiment ran by Moroney (2009) from Hewlett-Packard, for example, distributes a colour-naming experiment over the internet. It sets aside high colour fidelity in return for being able to collect data from a large number of people that are widely spread out geographically.

Moroney (2003) argues that this compromise is possible because the automatic International Color Consortium (ICC) processes are now widely used by devices and have a sufficient level of colour fidelity. Several papers (e.g. MacDonald, 1996; Green and Luo, 2018) have been published that deal with colour that do not use bespoke colour management but rely on ICC profiling instead. Whether it is reasonable to do this is down to the relative cost of bespoke colour management (the cost goes up considerably if researchers want to run the experiment in different geographical locations or over the internet) and also on the level of colour fidelity that is needed in the experiment. High colour fidelity might be needed for a threshold-detection experiment, for example, but that much fidelity might not be needed for a simple colour naming experiment.

In this thesis, bespoke colour management has not been used for two reasons: (1) the experiments were carried out in different places, and (2) the degree of colour fidelity that could be provided by bespoke colour management was not needed for very general and broad colour distinctions that were used in this work. Thus, exact replication of colours or accurate viewing of colours across devices was not a requirement in this study. The current study merely sought to determine whether designers changed their colour decisions after being provided with user information. Furthermore, it sought simply to ascertain overall trends in the use of ranges of colours rather than making exact comparisons of colour use.

3.4.3.3 Statistical Analysis

Descriptive analysis will be used for the data analysis collected from an online survey in Chapter Six. This will be done by using Jamovi statistical software. Based on the responses of designers (n=30), the response rate for each of seven closed-ended questions and percentages will be calculated. The results will be listed and discussed in 6.3.3.

3.4.4 Sampling

As explained in section 3.3.3, this research uses both qualitative (main) and quantitative (less prominent) approaches. In qualitative research, typically small numbers of participants are selected, and it uses purposive sampling to enable an in-depth focus, unlike random sampling (Crouch and Pearce, 2012). The main goal of purposive sampling is to “select cases that are *information-rich* to develop an understanding of the situation being studied” (Patton, 2001 cited in Richey and Klein, 2009, p.89). Thus, it is more important to think about ‘who’ is involved for the research rather than ‘how many’ participants when considering the appropriate numbers of participants for the research here.

Since the present research project focuses on the behaviour of designers, their attitudes, and values in certain design circumstances, design participants were purposively recruited from the researcher’s professional network. The term ‘design participant’ in this thesis refers to individuals who hold a design degree at least at bachelor’s level from a University (mandatory) or practical experiences in the design industry (optional).

To investigate the distinctive characteristics of designers, in Chapter Four non-design participants also were included in this research, to enable comparison with the designers. Moreover, professional design educators were involved in Chapter Six to evaluate a set of AII formats and gain ideas for future directions. Figure 3.9 gives information about all participants who took part in this doctoral research project.

Figure 3.9 Brief information about participants in each of main designer study.

Table 3.13 further presents a detailed description of data collection: who was involved (participants), when (period), where (venue), and how (methods) in the research conducted. In some parts of Chapter Six, quantitative research techniques (surveys and descriptive analysis) were used, and relatively large numbers of participants (*n*=30) participated in that part of the research in comparison with the numbers of participants for the qualitative research in Chapters Four (*n*=16), Five (*n*=10), and Six (*n*=6). Detailed participant information will be given for every participant in each chapter.

Table 3.13 Information on purposively recruited participants by data collection method.

Research Method Employed (period)	Target Population	Sample Size	Venue(s)
Think-aloud protocols (2018)	Design and non-design postgraduate students (aged between 23 and 42)	**16 in total** ▪ 8 design participants ▪ 8 non-design participants	Lighting laboratory at the University of Leeds
Face-to-face surveys (2017)	Older people (68 and 70 years old)	**2 in total** ▪ 2 females	Home of each respondent
Face-to-face surveys (2019)	Older people (aged between 61 and 89)	**16 in total** ▪ 11 females ▪ 5 males	▪ Older People's Action in Locality in Horsforth ▪ Belle Isle Senior Action in Leeds
Focus group interviews (2019)	▪ Doctoral design students (aged between 24 and 36) ▪ Divided into two focus groups - major in information design - major in various design areas ▪ In each group a mixture of participants - Having employment experience in research or practical design areas (prior to PhD course) - Having no employment experience in design area	**10 in total** ▪ 4 information design PhD students for a mini focus group ▪ 6 information, colour, and fashion design PhD students for a classic focus group	Seminar room at the University of Leeds
▪ Email interviews ▪ Web-based survey ▪ Colour design experiments (2018-2019)	▪ Student designer (ave.23): none or less than one year of employment experience ▪ Novice designer (ave.28): between 2 and less than 5 years of employment experience ▪ Expert designer (ave.33): over 5 years of employment experience	**30 in total** ▪ 10 student designers ▪ 10 novice designers ▪ 10 expert designers	N/A (conducted via online)
Email interviews (2022)	▪ Professional design educators in HE in the UK. ▪ Experience of teaching (ave.10.5 years) ▪ Experience of work in design industry (ave.16.5 years)	**6 in total** ▪ 3 females ▪ 3 males	N/A (conducted via online)

3.5 Researcher Roles

Qualitative and quantitative research significantly differs in terms of the role of the researcher (Sciarra, 1999). As the present research project was characterised as qualitatively driven mixed methods research, the role of the researcher in qualitative research is mainly discussed for two issues here: researcher subjectivity and researcher sensitivity.

Subjectivity refers to an "individual's feelings, opinions, or preferences" (Siegesmund, 2008, p.843). Traditionally, subjectivity has been believed to be the contrary to objectivity, which suggests unbiased analysis and impartial reasoning (Siegesmund, 2008). Although subjectivity is often deemed a requisite of qualitative methodology (Ratner, 2002), this is an issue that is argued about among scholars. For example, some scholars (e.g. Mruck and Breuer, 2003; Rinsum and Verbeeten, 2012) mention several ways of eliminating researcher's subjectivity or its negative impact on research in some cases, whereas others (e.g. Peshkin, 1988; Ratner, 2002; Clarke and Braun, 2018) champion the positive role of subjectivity for research.

The present researcher's subjective lens as a designer (having several years of employment experience in the practical design area along with a design education) intimately shapes this entire PhD research project, starting from the selection of the topic, through the planning of the research, application of methodological approaches, recruitment of participants, and to the interpretation of the data. In this sense, the present researcher can be considered a manager of the research project who makes important judgements, constantly, based on her subjectivity. However, due to the researcher's worldview inevitably impacting on the entire research process, there could be concern about potential bias which relates to reduction reliability (trustworthiness) of the research. Endeavours were made to reduce this in order to make objectivity and subjectivity mutually complementary by applying various techniques (see Table 3.14). This will be described in section 3.6 in detail.

The term 'researcher sensitivity' is put forward by Low (2008) as something required for successful use of qualitative research methods. It means "a host of skills that the qualitative researcher employs throughout all phases of the research cycle in qualitative research" (Low, 2008, p.780). In comparison with the issue of 'research subjectivity' discussed above, this issue seems to be closer to the researcher's attitude toward research informants in a certain sense.

Low (2008, p.780) considers five types of required sensitivity as below:

1. Sensitive to issues of cultural and language differences;
2. Sensitivity to nonverbal cues;
3. Theoretical sensitivity;
4. Sensitivity to be prepared for possible communication problems; and
5. Sensitive to the meaning of silences in interviewing.

Researcher sensitivity may link to social sensitivity. Based on a review of prior research literature, Bender *et al.* (2012) state that the meaning of social sensitivity in social science is "the personal ability to perceive the mind and mood of others" (p.39). The concept of social sensitivity could be related to some of the required researcher sensitivities by Low (2008). The researcher took these issues into consideration.

Table 3.14 Summary of efforts made in this research to improve research trustworthiness.

Research stage	Applied Techniques for Research Trustworthiness	Related Criteria in this Research
Data collection	▪ Purposeful sampling	Transferability
	▪ Voluntary participation	Credibility
	▪ Methodological triangulation	Credibility
	▪ Use of two types of questionnaire styles	Credibility
Data analysis	▪ Transcription accuracy	Credibility
	▪ Test-retest reliability	Credibility
	▪ Use of a software program for qualitative data analysis (QSR NVivo 12 Plus)	Transparency
Reporting	▪ Thick description	Transferability
	▪ Direct quotation with interpretation	Confirmability

3.6 Trustworthy Research

Research paradigms were described according to two major categories at the beginning of this chapter: positivism and interpretivism. Although theoretical and methodological approaches differ in each paradigm, no matter what paradigm any researchers follow, research veracity should be held in mind during the collection and analysis of data, and presentation of the findings.

Andres (2015) notes that the issue of research veracity is traditionally discussed in twofold terms: reliability/validity and trustworthiness. Scholars (e.g. Elliott, 2018; Saldaña, 2011) point out that the term 'reliability' is a rather positivist quantitative paradigm. To translate such a quantitative term into a qualitative concept that is more appropriate, Julien (2008, p.122) suggests the terms "credibility" and "trustworthiness". When discussing the issue of veracity, some of the important terms of both qualitative and quantitative research in social science are listed in Table 3.15.

As demonstrated so far in this chapter, the present research can be characterised as a 'qualitatively driven mixed methods case study' with a highly exploratory nature. For this reason, the most appropriate term would be 'trustworthiness' for probing veracity in this research project.

> Trustworthiness is a term used within interpretivist and constructivist paradigms that is the approximate equivalent of validity (Mathison, 2005).
>
> Credibility, dependability, confirmability, and transferability are the standards for evaluating the rigor of qualitative studies that are consistent with the worldview, information sources, and methods of the interpretivist paradigm (Ulin *et al*., 2005, p.27).

Ten techniques (listed in Table 3.14) aimed at proving research trustworthiness of the present research project will be demonstrated within description of three stages of the research procedure outlined in the following section. In particular, qualitative related terms (credibility, dependability, confirmability, and transferability) are highlighted with the rationales for selecting and applying the ten techniques.

Table 3.15 Definition of terms for research trustworthiness (source: reformatted and adapted from various scholars and the wording in the table is taken directly from sources here).

Quantitative Terms and meaning		Qualitative Terms and meaning	
Validity	Validity of research is about the degree to which the research findings are true (Walliman, 2006, p.34).	Credibility	Credibility can be defined as the methodological procedures and sources used to establish a high level of harmony between the participants' expressions and the researcher's interpretations of them (Jensen, 2008a, p.138).
Generalisability	Research results are generalisable when the findings are true generally speaking in most contexts with most people most of the time (Frey, 2018, p.724).	Transferability	▪ Transferability refers to the extent to which the findings can be transferred to other settings or groups (Polit and Beck, 2012 cited in Elo *et al*, 2014, p.6). ▪ Equivalent to the terms generalizability and external validity (Dick, 2014, p.785).
Reliability	▪ Reliability is the extent to which research produces the same results when replicated (Bloor and Wood, 2006, p.148). ▪ Validity, reliability and generalisability is the key concept of quantitative research (Muijs, 2004).	Dependability	▪ Dependability refers to the stability of data over time and under different conditions (Elo *et al*., 2014, p.4). ▪ If the data are dependable, we will find logically consistent patterns of response that remain reasonable stable over time (Ulin *et al*., 2005, p.26). ▪ Equivalent to the terms reliability (Ulin *et al*., 2005; Jensen, 2008b).
Objectivity	Objectivity is a traditional standard of quality in quantitative data. The term generally implies maintaining distance between the observer and the observed and minimizing any possible influence of the researcher's values on the process of inquiry (Ulin *et al*., 2005, p.26).	Confirmability	▪ Confirmability can be expressed as the degree to which the results of the study are based on the research purpose and not altered due to researcher bias. Confirmability is often equated with reliability and objectivity in quantitative research (Jensen, 2008c). ▪ Applying reflexivity contributes to the confirmability of the results (Ulin *et al*., 2005, p.26).

3.6.1 Data Collection Section

3.6.1.1 Purposeful Sampling

The use of a purposive sampling technique is one way of increasing transferability in qualitative research (Jensen, 2008d; Palinkas *et al*., 2015). Jensen (2008d) argues that having participants who are most suitable for the way research has been designed will increase the possibility that other researchers can see whether an approach can be transferred to their own work. To improve transferability in this research, close attention was paid to questions of who needed to be participants, and why they were linked to the research. The majority of participants were from a design background. These were mostly recruited considering their level of design education and years of practical employment experience in the design industry. This is because the common goal of each of the main designer studies (Chapters Four, Five, and Six) was to shed light on phenomenon occurring in the design community (microscopic) and their effect on society (macroscopic).

3.6.1.2 Voluntary Participation

This research was undertaken on a voluntary participation basis. Prior to commencing data collection, each participant was informed of the purpose of the research by email. It was projected also that they would be strongly willing and have interest in the topics and issues in the research being carried out. For the foregoing reasons, it could be expected that participation engagement would be more active and dynamic than in random sampling. Such dynamic attitudes among participants gives opportunities to the researcher to gather rich data which is expected to have a positive influence on data analysis and the final outcome of the research. This enhances the credibility of the research.

3.6.1.3 Use of Two Types of Questionnaire Styles

Jensen (2008a) argues that one of the disadvantages of close-ended questions is lack of credibility, as the researcher offers pre-set options about the research context through the survey questions rather than permitting the respondent to define them. Arguably, the data collection in a less-structured and inductive approach improves validity compared with fixed and structured instruments (Guest *et al*., 2012). Jensen (2008a) maintains that use of closed and open-ended style together can be more credible. In the present research, both closed and open-ended questioning techniques were used in surveys and focus groups for data collection. In Table 3.8 (section 3.4.1), the rationale for selection of two styles of questioning for each research method were explained in brief. The actual questions used while gathering data will be shown in Tables 5.6 and 6.5 in detail.

3.6.1.4 Methodological Triangulation

A methodological triangulated approach was considered by adopting multiple data collection methods (Figure 3.10). Such an approach is particularly useful in mixed methods research (Pinto, 2010). Mixing various research methods that balance each other is the key point of triangulation (Kennedy, 2009), which can be undertaken either in a sequential or simultaneous fashion in a study (Murray, 1999).

The advantage of triangulation of analytic techniques is variable subject to the researcher's perspective (Hastings, 2010). In this thesis, the main purpose of adoption of methodological triangulation was the complementary effect. For instance, in Chapter Six, email interviews were carried out with thirty individual designers, but there were also quantitative questions in a web-based survey in which participants ranked information sources. It can generally be accepted that application of triangulation increases validity (Modell, 2005; Bloor and Wood, 2006; Yeasmin and Rahman, 2012; Carter *et al*., 2014) and credibility (Jensen, 2008a) of evaluation and research findings. Such approaches help to diminish intrinsic biases that come from single-method studies (Guest *et al*., 2012).

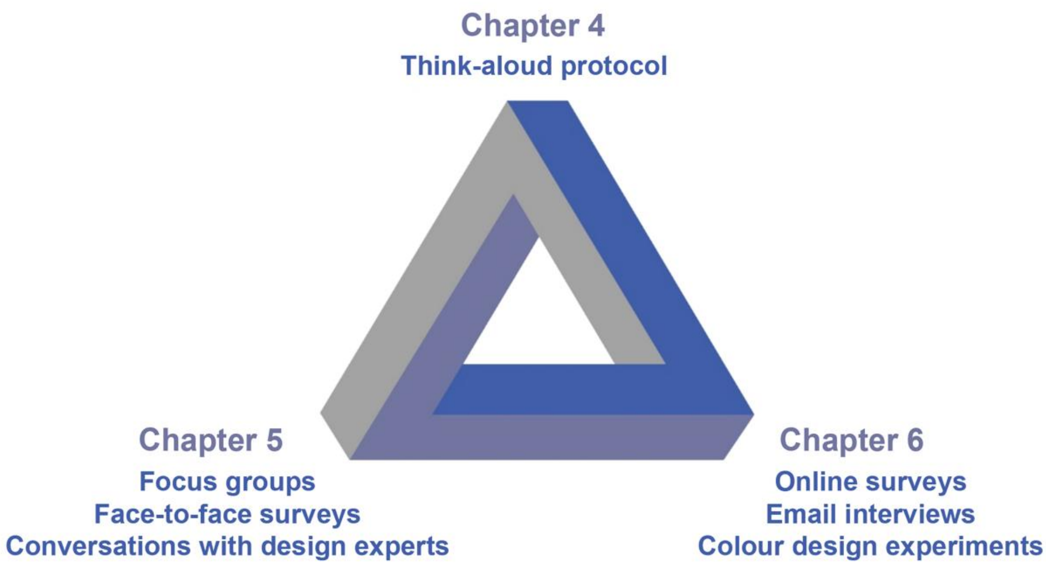

Figure 3.10 Methodological triangulation showing multiple data methods used in this research project.

3.6.2 Data Analysis Section

3.6.2.1 Transcription Accuracy

The way that a transcriber hears and perceives interview content (and the accuracy of the transcription) can have an impact on decisions about what data to analyse and how reliable it is (MacLean *et al*., 2016). Although transcribing has become standard practice in qualitative research, it is almost impossible to capture flawless transcription and the full complexity of the interaction (Sandelowski, 1994). Where sections of recordings were illegible, individual participants were contacted and the sections were played back to them to be clear what they had said during the session in order to reduce risk of transcription error. Finally, the completed transcriptions were examined twice by a native English speaker to improve its accuracy. The efforts made for transcription accuracy here enhance credibility of data analysis in the research.

3.6.2.2 Test-retest Reliability

There are two types of reliability strengthening factors in qualitative research which can be kept in mind. These are "consistency between researchers (or inter-rater reliability) and consistency over time with the same researcher" (Elliott, 2018, p.2858). While inter-rater reliability can aid reliability, this project is not a team endeavour. However, several scholars discuss the importance of "consistency over time with the same researcher" (Elliott, 2018, p.2858) which is also called "test-retest reliability" (Roberts *et al*., 2019, p.71). For example, King (2004) suggests that thematic decisions cannot be finalised until all data is read and codes are checked a minimum of two times. Findings are more likely to have credibility if enough time is given to establishing themes (Lincoln and Guba, 1985). In this research, test-retest reliability was implemented. Because the data coding process is reflexive and iterative, many hours were taken in order to generate final central themes and identify hierarchical relationships between them throughout the data analysis process. This long-term engagement for the data analysis enhanced the credibility of the research findings in this research.

3.6.2.3 Use of Software Program for Qualitative Data Analysis

There is an agreement that using computer-assisted software can aid in improving the reliability of research (e.g. Bringer *et al.,* 2004; Marshall *et al*., 2014). Bringer *et al.* (2004) argue that the way software is used needs to be transparent to make research accountable, and is vital in demonstrating that methodologies, analysis of data, and what is discovered match together. As Bringer *et al*. (2004) state, accountability and transparency have a close relationship. Accountability refers to “a state of, or a process for, holding someone to account to someone else for something - that is, being required to justify or explain what has been done” (Rogers, 2005, p.3). In this research, QSR NVivo12 Plus was used, handling a considerable amount of narrative data collected from focus groups (Chapter Five) and email interviews (Chapter Six). All procedures (how the researcher of this thesis generated codes, categories, and themes from raw data by using NVivo) will be presented thoroughly and clearly in Chapters Five and Six with relevant figures. This enhances transparency for the research project.

3.6.3 Result Section

3.6.3.1 Thick Description

Thick description can enhance transferability (Lincoln and Guba, 1985) and validity (Creswell, 2008) in qualitative research. The concept of thick description is particularly related to case study research (Dawson, 2010) and observation (Tomlinson, 2010b). Thickly describing statements also helps in making thick interpretation possible (Denzin, 2017). The efforts that are made by the researcher, such as an account of rich descriptive data and clear description of the research design process allow readers to assess the transferability of the research. This is known as “transferability judgement“ (Korstjens and Moser, 2018, p.122).

3.6.3.2 Direct Quotation with Interpretation

For Jensen (2008c), confirmability involves demonstrating that the way a researcher interprets the “constructions” of those participating actually has its basis in what participants say. It also involves showing that the analytical process and any findings or conclusions arising from it do reflect the way those participating actually perceive things (Jensen, 2008c). Providing direct quotation is a greatly important aspect in qualitative research (Guest *et al*., 2012) which permits readers to see how the raw data was interpreted by the researcher (Duranti, 2006; Guest and MacQueen, 2008). In order to improve the confirmability of research findings, verbatim quotes were extracted from transcription to show how interpretations were made. Presenting excerpts (what participants actually said) along with the researcher’s interpretation is evidence which can improve trustworthiness for this research.

3.7 Research Bias

The word bias is described with noun and verb forms in English dictionaries as below:

> (*noun*) the action of supporting or opposing a particular person or thing in an unfair way, because of allowing personal opinions to influence your judgment (Cambridge English dictionary, 2020b).
>
> (*verb*) to give a bias or one-sided tendency or direction to; to incline to one side; to influence, affect (often unduly or unfairly) (OED, 2020e).

Bias in research suggest various things. It suggests that researchers may not be objective (Payne and Payne, 2004). It also suggests that participants may demonstrate bias. There are various types of biases in the social science area. These include interviewer bias, observer bias, sampling bias participant bias, conformity bias, confirmation bias, and so on.

While Polit and Beck (2004) argue that it is obvious that the participants' voices from an inquiry should be mirrored in research findings, it remains necessary to reduce biases arising from participants. Clearly the biases, motivations, or viewpoint of researchers should also be avoided (Polit and Beck, 2004). However, the latter takes place at any stage of a research procedure from research design to publication (Pannucci and Wilkins, 2010). Although it is almost impossible to eliminate different types of biases, researchers need to control biases to some degree. In this section, efforts that were applied to minimise such biases throughout the whole research process are described and discussed. Participant bias, conformity bias, and sampling biases are discussed here.

In terms of biases expressed by participants, participant bias (known as subject bias) is explained by Duignan (2016) as "the phenomenon sometimes observed during a research undertaking whereby respondents to a survey give answers that they think the researcher wants, or answers that might benefit themselves". As described earlier in this chapter, the research adopted a variety of methods for qualitative data collection including focus groups, email interviews and think-aloud protocols to minimise participant bias. Less-structured instruments (open-ended questions) were also used in order to gain truthful and honest answers from participants, instead of simply gathering 'yes' or 'no' responses during the data collection stage. In addition to this, a five-point Likert-type scale was utilised during the first focus group to evaluate a set of second design prototypes. Participants were required to rate their opinions on a scale rather than providing two options (agree or disagree) and to avoid implying there is a right answer.

Conformity refers to “the act of changing one’s behaviour to match the responses of others” (Cialdini and Goldstein, 2004, p.606). Genuine social issues may be overlooked if researchers fail to recognise conformity bias and do not put it behind them (Padalia, 2014). There are two types of conformity distinguished by Deutsch and Gerard (1955): informational (behaving as if a group is better than individuals) and normative (the want to fit in the group) and these motivate conformity. Thus, group pressures on individuals need to be carefully considered while carrying out research projects. Padalia (2014, p.223) argues that “conformity is not a unitary concept and has various facets to it”. In fact, there are variables that affect conformity which include size of groups, gender, age, culture (racial diversity), education, unanimity, cohesion, task difficulty, lack of group unanimity, presence of an ally, type of responses, and so on. The relationship between such factors has been a concern within scholarship in the areas of socio psychological and behavioural studies. A classic piece of experimental conformity research was conducted by Asch (1956). Although his research has limitations in terms of lack of cultural, gender, and topic considerations, one of Asch’s findings shows that conformity becomes weaker in a smaller group (McLeod, 2018).

In this present research, two focus group interviews were conducted with small numbers of participants in each (see section 5.4.2). The first focus group had four participants and the second had six. It is believed that this will have helped to reduce conformity bias in comparison to having a single focus group with large numbers of participants. Such a small group technique also offers a great deal of opportunities for focusing on questions (Scioli, 1971). Overall, focus groups with small numbers of participants reduce conformity bias and can help to produce high-quality data, which in turn leads to a more successful research project.

I now turn to a type of bias that can be introduced by the actions of a researcher. Sampling problems can become an issue during selection of a sample that is adequate in a particular piece of research (Oppong, 2013). When discussing sampling bias, it is necessary to know about three key terms: population, sample, and sampling. The definitions of these terms are given in Table 3.16.

Table 3.16 Definition of terms for sampling bias.

Term	Definition
Population	"A population is the entire collection of entities one seeks to understand or, more formally, about which one seeks to draw an inference" (Litt, 2010, p.1053).
Sample	"A group of people, objects, or items that are taken from a larger population for measurement" (National Health Service, 2006).
Sampling	"Sampling is a technique (procedure or device) employed by a researcher to systematically select a relatively smaller number of representative items or individuals (a subset) from a pre-defined population to serve as subjects (data source) for observation or experimentation as per objectives of his or her study" (Sharma, 2017, p.749).

Due to the impossibility of data collection from an entire population for research, it is imperative to select adequate samples for research purposes. It is obvious that a sample is supposed to reflect the population from which it comes (National Health Service, 2006). In order to choose appropriate samples, although there are various sampling techniques, Sharma (2017) broadly classifies techniques into two: probability and non-probability sampling. Each of these techniques can be split into four sub-categories respectively, as is shown in Table 3.17.

Table 3.17 Categorisation of sampling techniques (source: reformatted and adapted from Sharma, 2017, p.750 with the wording in the table taken directly from the source).

Probability Sampling	Non-probability Sampling
Simple Random Sampling	Quota Sampling
Systematic Sampling	Purposive Sampling
Stratified Sampling	Self-Selection Sampling
Cluster Sampling	Snowball Sampling

As demonstrated in section 3.4.4, in this research, purposive sampling (one of the non-probability sampling techniques) was utilised to reach the main goals of the research. Purposive sampling may be prone to bias because of the inevitable judgement of the researcher about where to find participants, who will be involved, and how many informants will be consulted. It may arise also in collection of data from certain individuals, groups, or conditions. However, efforts have been made to minimise the risks of sampling bias in this research with the use of a wise, logical, reasonable sampling procedure. This is explained in Figure 3.11, there are three stages to the sampling process used in this research.

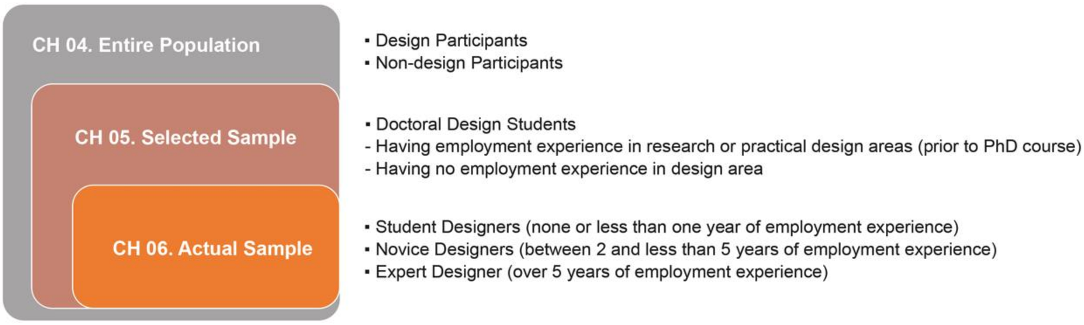

Figure 3.11 Sampling procedure used in this research to meet the overall aims of the research.

Firstly, an entire (target or theoretical) population was identified based on the research interests of the researcher. In this research, the target population is a group of people who work in the design industry or study design as a subject. At this stage, people who have employment experience in design without having obtained a design education at a higher educational level are included. This is because, in reality, there is a group of people who work in the design industry without prior design education.

However, at the second stage, to specify participants, people with no design education in higher education were removed from the entire population. The reason why experience of design education is a factor in defining different groups in this stage is because (a) in Chapter Four, a comparison study was conducted with participants who study design and those studying other subjects, and (b) in Chapter Five, PhD design students were divided into two groups based on their specialisms: information design and other design areas. Thus, how designers think about (perceive) design tasks was examined in Chapter Four along with the information design students have in comparison to others (non-information design PhD students) in Chapter Five.

Lastly, the selected samples were further categorised in terms of design experience in the design industry. In order to investigate the use of user-related colour information and actual colour use on product packages across different groups, designer participants were divided into three groups: student, novice, and expert. All these groups of designer participants hold a design degree in higher education. Detailed explanation about categorisation of participants for sampling is described in sections 3.4.4, 4.2.3, 5.4.2, and 6.2.3.

All of these systematic efforts based on a clear rationale are intended to reduce the risks of sampling bias in this research.

3.8 Research Reproducibility

Scientific research is defined as "research conducted for the purpose of contributing towards science by the systematic collection, interpretation and evaluation of data and that, too, in a planned manner" (Çaparlar and Dönmez, 2016, p.212). The issue of reproducibility has been a concern in various scientific fields (Feger *et al*., 2019). However, the definition of reproducibility varies among a range of disciplines and is ill-defined (Feitelson, 2015). Feitelson (2015) notes some related terminology (e.g. repetition, replication, variation, reproduction, corroboration) when discussing the term reproducibility. This author also argues that in social science the term replication is preferred, and is defined as a process whereby the social scientist will "precisely replicate exactly what someone else has done, recreating their artifacts" (Feitelson, 2015 p.3). In the present research project, while replication is a known term, reproducibility is a sufficiently familiar concept and adopted to explain the possibility of research reproducibility throughout the research process.

In this research, thematic analysis [TA] and qualitative content analysis [QCA] methods are adopted for qualitative data analysis, in Chapters Five and Six to analyse non-numerical data collected from focus group discussions and email interviews. In qualitative research, reproducibility is still necessary or desirable. Verification of reproducibility enhances research reliability and rigour. Reliability can be tested in two ways: test-retest reliability and inter-coder reliability. The latter can be described as "consistency of judgement across various viewers" (Roberts *et al*., 2019, p.6) or, in other words, researchers and is closely related to research reproducibility. Nevertheless, Roberts *et al*. (2019, p.1) argue that research replication for the TA method can be challenging in qualitative research due to detailed overviews of research processes often being omitted by researchers in their publications. To ensure that this is not the case in the present research project, the whole research process was described in detail throughout and included details of data coding, categorisation, development of themes, and interpretation (sections 5.5 and 5.6). In order to finalise creation of themes the processes of data coding and categorisation were conducted by utilising the NVivo12 software program. The NVivo provides a function called 'coding comparison query' which facilitates an inter-rater reliability measurement between different coders. Thus, although this research is not a team endeavour and test-retest reliability was emphasised (see section 3.6.2.2), rather than what if other researchers (inter-rater or inter-coders) conduct this data analysis again using the NVivo12 software, it will be possible to measure the consistency of judgement between different researchers.

Regarding reproducibility in content analysis [CA], Wombacher (2017) suggests three ways to increase this: namely by providing details of the data set, codebook, and coders. Firstly, this author argues that one of the most vital points for reproducibility in terms of CA is to describe "what data one is analysing" (p.731) very clearly and accurately. Secondly, the author points out the significance of "providing a detailed description of the codebook" (p.731). This shows researchers developed to analyse their data. Lastly, Wombacher (2017) emphasises the importance of providing detailed information about coders themselves in relation to the coding process.

Based on Wombacher's (2017) suggestions, I now explain how this research is reproducible. In terms of the need to describe the data set and codebook, the coding processes were clearly demonstrated within four stages from coded data to theme generation in section 6.3.1.2.2. The codebooks were provided in Tables 6.10, 6.11, and 6.12 and included examples of data excerpts from actual answers by design participants. This also meets the requirement of describing "what data one is analysing" (Wombacher, 2017, p.731). It was also seen how the codes (in Tables 6.10, 6.11, and 6.12) were utilised to generate categories and themes in Table 6.13. The use of clear and detailed description supports research credibility further.

With regard to coder information, the coder is a design researcher having master's degrees in colour and graphic design and several years of practical experience in the colour and graphic design industry. This research project investigates the designerly way of perceiving tasks (Chapter Four), finding colour and user information (Chapter Five), and working with actual colour for design artefacts (Chapter Six). Therefore, the design and educational background of the researcher is beneficial for understanding/analysing the behaviour of design participants in terms of information seeking, using and actual designing. As stated above, this research is not team-based. However, the CA also was conducted using NVivo 12, which enhances the potential for inter-coder reliability in a measurable manner. All these processes improve the possibilities for research reproducibility.

3.9 Ethical Considerations

Many scholars state that research ethics should be taken as a given. According to Saldaña (2011, p.24), “there are moral and legal codes in place regarding the ethical treatment and care of people involved with research studies”. It is essential for researchers to behave morally to make sure their work and what they find are trusted and seen as reliable (Palmer, 2019). When discussing ethical issues, some factors should be carefully considered in advance. A University of Cambridge (2020) guides five basic principles that need to be considered for research integrity. These are “respecting autonomy, maximising benefit, minimising harm, being fair, behaving with integrity” (University of Cambridge, 2020).

In order to minimise any harmful effects of the research to individuals who were engaged in it, the question of sensitive topics was considered. The concept of sensitive topics in research is concerned with the possibility that researchers or participants may be threatened in various ways including the economic, political, social or physical (Brewer, 2012). Powell *et al*. (2018) review literature and state that sensitive research could deal with particular contexts such as “sexuality, drug and alcohol use, family violence, parental incarceration, parental intellectual disability and the like” (p.648). It also includes the issues of “death and dying” (Robinson, 2020, p.4). The present research does not deal with such issues. Participants were only asked to provide their age, gender, detailed educational background, and years of employment experience in the design industry. Nevertheless, any possible risks were examined and appropriate ethical forms were approved by the ethics committee of the University of Leeds before gathering data for the research project. Such processes show researcher’s committed effort toward research sensitivity.

Ethical issues were considered in all stages of the research process. The following documents were used for each stage of data collection:

- Participant information sheets: providing information for participants before they gave consent (e.g. purpose and procedures of research process, duration, what they would be asked/how they would be asked questions, and so on).
- Consent forms: obtaining consent to participate.
- Risk assessments: considering any potential physical, psychological, and social risks related to participation and actions to prevent such possible hazards before conducting research.

The participant information sheet was read out and explained for the group of older people participating in the research in Chapter Five. The staff at the venues - Older People's Action in Locality in Horsforth and Belle Isle Senior Action in Leeds (see Table 3.13) where the research took place helped to facilitate explanation of the purpose of the research and obtain individual's informed consent. Other participants read the information given themselves and signed the document consent form.

It was explained that the research would be confidential, and their personal information would not be identified during and after the research. All of the participants understood and agreed to the recording of their responses during the research and that this would be transcribed for later analysis for the research.

3.10 Summary

This chapter has expatiated the overall structure of the present research which takes the form of three designer studies (Chapters Four, Five, and Six). To recapitulate, the chapter began at the stage of philosophical conceptualisation (theoretical background). At this point, interpretivism and constructivism were set as overarching paradigms. After this, justification of selection and application of methodological approaches were explained on the basis of a critical review of literature in social science research. The qualitatively driven mixed methods form of case study research was described to show how the overall research goal would be achieved through employing multiple data collection and analysis methods. The issues of the role of researcher were looked at carefully. Finally, the chapter discussed research trustworthiness, research bias, research reproducibility, and ethical issues. Table 3.18 summarises the overall research framework. The next chapter will present the first designer study featuring design and non-design participants and allow comparison of each group.

Table 3.18 Research frameworks in this research project.

	Designer Study 1 (chapter 4)	Designer Study 2 (chapter 5)	Designer Study 3 (chapter 6)
Ontological orientation	Constructivism	Constructivism	Pragmatism
Epistemological orientation	Interpretivism	Interpretivism	Pragmatism
Research strategy	Sequential mixed methods 'case study' research		
Research type	Applied research (application perspective)		
	Exploratory research (objectives perspective)		
	Qualitatively driven 'mixed methods' research (inquiry perspective)		
	Qualitative research	Qualitative research	Mixed methods research
Data collection method	Think-aloud protocols	▪ Face-to-face surveys ▪ Focus group interviews	▪ Colour design experiments ▪ Web-based survey ▪ Email interviews
Data analytic method	Linguistic analysis	Thematic analysis (qualitative)	▪ Descriptive analysis (quantitative) ▪ Content analysis (qualitative)
Data analysis approach	Inductive	Inductive	Inductive + deductive
Unit of analysis (number)	▪ Design participants (8) ▪ Non-design participants (8)	▪ PhD design students (10) ▪ Older people (16) ▪ Older people (2)	▪ Student designers (10) ▪ Novice designers (10) ▪ Expert designers (10) ▪ Expert design educators (6)

*** Note.** Related Publications to Chapter 3.

Book review

Lee, G. 2021. Clarifying the complexities of qualitative research: a book review of Philip Adu’s a step-by-step guide to qualitative data coding. *The Qualitative Report*, **26**(7). pp.2168-2170.

Chapter 4 DESIGNER STUDY 1

4.1 Introduction

The first priority of this chapter is to discover how designers communicate about colours. This will help to understand how designers react to colours. More broadly, this could also be interpreted as showing how design tasks are perceived by designers. To achieve this, a consideration of the characteristics of designers, in terms of their description of colour samples, is the starting point to shed light on the question of how they communicate about colours.

The overarching perspective of this chapter draws from the constructivist standpoint, where an individual's identity is the result of a process of construction (see Eckert, 2005; Eckert, 2008; Bucholtz, 2009). Constructivism relates to social practice, and such social practice includes a repeated performance of actions in design. It also includes processes of communication in sociolinguistic interaction. This communication would also include ways of speaking about design topics. The results of this chapter generate new research questions and hypotheses which allow the research to move forward to the next steps in the thesis.

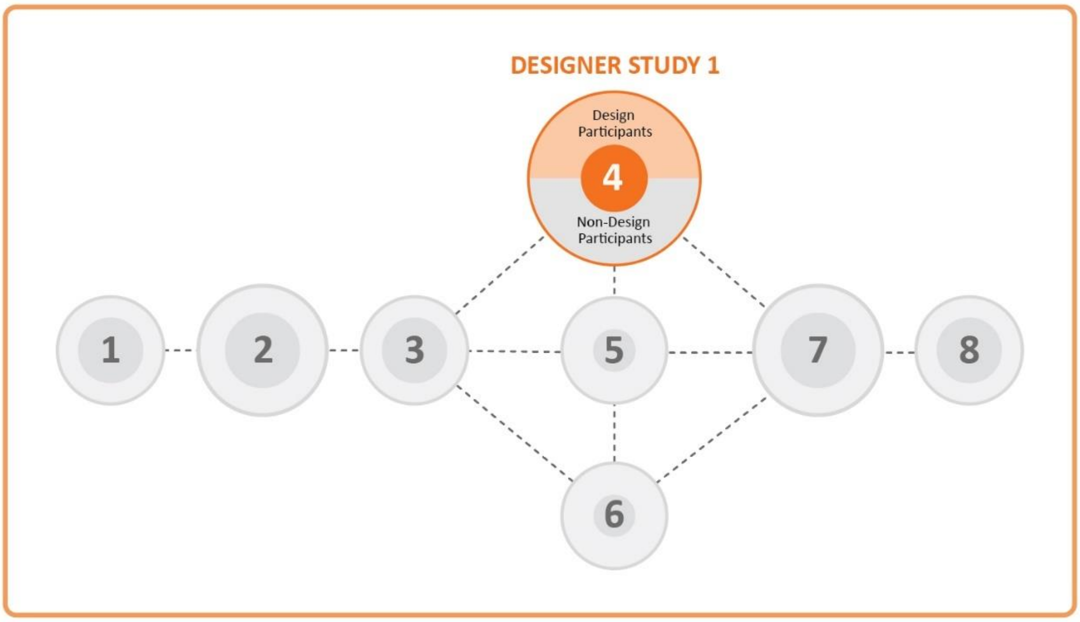

Figure 4.1 Position and context of Chapter Four within the whole research process.

4.2 Research Design

4.2.1 Background Linguistic Theory

Two linguistic theories (providing backing for the idea that language relates to the way people think and contributes to identity) can be described. First, the linguistic relativity hypothesis, often known as the Sapir-Whorf hypothesis, implies that “the structure of our language in large measure affects the way we perceive the world” (Trask, 1999, p.63).

A more central theory to this chapter comes from sociolinguistics. Individuals use language to shape their identity, and that includes shaping personality because associations build up between features of language and personality (Hall, 2012). Bucholtz and Hall (2005, p.594) argue that “identities may be linguistically indexed through labels, implicatures, stances, styles, or linguistic structures and systems”. People build up linguistic styles as part of personality construction and as part of participation in communities of practice (Eckert, 2005; Bucholtz, 2009).

The Concise Oxford Dictionary of Linguistics defines the term ‘style’ in the “ordinary sense” as “a style appropriate e.g. to a specific genre of writing or one characteristic of an individual” (Matthews, 2014). Wales (2011, p.398) describes style as “in essence, the set or sum of linguistic features that seem to be characteristic: whether of register, genre or period”. We have seen that style can relate to groups, and this can relate to the term register. According to Ballard (2013), register is a type of style of language and language variation which varies according to situation and content. It can be associated with groups including professional groups. Ballard (2013) explains that it is comprised of three elements: mode, tenor, and semantic field. First, mode often means the form of the communication (both written and spoken). Next, tenor relates to the relationship between sender and receiver of the message and determines whether it is formal; it may reflect the level of intimacy, familiarity, and formality. Finally, semantic field relates to the way the topic influences word choice and sentence length. Among these, this part of the study focuses more upon the semantic fields.

We now return to the concept of the community of practice and can think of designers using particular semantic fields as a community of practice. By creating a style of speech (repeatedly choosing similar types of language from the same semantic field) people express a certain personality and through this, they express membership of certain communities of practice (Eckert, 2005;

Bucholtz, 2009). This can link choices in language with personality types that are shared by designers.

For instance, one distinctive finding within this chapter is that design participants use emotional language that suggests they create emotional personalities and character types for themselves. This creates their identity as designers within social or professional groups comprised of designers. This is another justification for communication with designers in ways that they personally and, as members of a community of practice of designers, would find helpful and useful.

4.2.2 Hypotheses, Aim, and Research Questions

Aim and research questions

This chapter aims to explore characteristics distinguishing a designer group and a non-designer group, with the interest in how designers perceive tasks from a colour description experiment through their language choices. The argument is that language choice relates in some way to ways of thinking and understanding. If we investigate and analyse designers' ways of describing colours, then the findings here are likely to provide justification for proposals about how to provide colour information in a designer-driven way. In line with this aim, the following research questions were adopted:

> **RQ 2-2** How do designers perceive and communicate about colours?
>
> **RQ sub-2.2.1** What differences can be shown between people from design and non-design backgrounds in terms of colour description and response to colour?

Hypothesis 1

Based on the linguistic background illustrated above, it is expected that if language relates to thoughts and identity, and if different groups of people use different semantic fields as part of register and style consistently in describing colours, then the way in which these groups express themselves about colour relates to their way of thinking.

Hypothesis 2

Particularly, in regard to colours, it will be possible to classify how designers communicate, understand, and express themselves by analysing their language choice. Although each individual might apply their own associations or connotations to colours, there will be distinctive differences between groups of people from design and non-design backgrounds.

4.2.3 Description of Participants

In order to seek to answer the research questions, sixteen postgraduate students took part in an experiment to describe the appearance of twelve samples. These students were divided into two groups comprised of eight from a design background and eight from a chemistry/engineering background.

There are several reasons why these two different disciplines were selected. Firstly, in the field of professional colour design, two groups of colourists (either based in design or chemistry/engineering) often need to collaborate with each other (Lee *et al*., 2019). Secondly, education has been claimed to affect not just people's development of domain knowledge but also their way of thinking and acting (Cross, 2011). In the case of designers, academic learning is claimed to be one of the main factors that build up their identities (Dong, 2010).

While professional design colourists who are currently working in the colour design industry may reduce their distinctive language use because they collaborate with non-design based (chemistry and engineering) colourists, there remain problems in communication between these two groups (Lee *et al.*, 2019).

For the reasons outlined above, it is considered that these two groups (design and engineering/chemistry based) are suitable as participants. Their language use provides insights into the building of deep-seated ways of thinking and understanding based on the experience of education in the absence of professional colour design experience.

The demographics of participants are seen in Table 4.1, which summarises the composition of the two groups of participants by gender, age, and ethnicity. In each of the two groups, three-quarters (75%) were female and a quarter of them were male (25%). The age of the participants ranged from 23 to 42 years old.

Among the design participants, three were at the time of the study taking masters programmes, and the rest of them were enrolled on PhD degrees in design. All of these design students already held a degree either at undergraduate or master's level in areas such as graphic design, information design, visual communication design, brand design, product design, and fashion design. Of the engineering and chemistry students, all were enrolled in PhD programmes. Tables 4.2 and 4.3 give details of each participant's education history.

In terms of national/ethnic background, design participants were mainly Asians (Chinese and Korean) and one was from Botswana (Motswana). This compared to chemistry/engineering participants who had a wider range of ethnic backgrounds including British, Irish, Chinese, Malaysian, and American. This variation in national background may not be a serious weakness in the study. This is because design is an international discipline regarded as one of the most creative and widespread human pursuits (Lawson, 2006).

In addition, although English was not the first language of all design participants, they all possessed a minimum level of English needed for study at the University of Leeds in the United Kingdom on either masters or doctoral programmes. Therefore, this all reduces the limitations of the study. Nevertheless, it should be taken into account that English is the second language for most of the participants and this is evident in some lack of fluency in the quotations given below.

Table 4.1 Demographic data for participant groups.

Demographic Details		Design Participants	Chemistry/Engineering Participants
Gender	Male	25%	25%
	Female	75%	75%
Age	29 years or younger	75%	62.50%
	30 years or older	25%	37.50%
Ethnicity	British/European	0%	25%
	Asian	87.50%	62.50%
	Other	12.50%	12.50%

Table 4.2 Disciplinary background of design participants.

Participant	Undergraduate	Masters	PhD
D1	Design technology	Product design innovation management	Luxury brand design
D2	Graphic design	Graphic design	Information design
D3	Product design	Product design	Colour design
D4	Graphic design and advertising	Graphic design	-
D5	Visual communication design	Visual communication design	-
D6	Visual communication design	Visual communication design	-
D7	Fashion design	Women's wear fashion design	Fashion design and textile
D8	Oil painting	Graphic design	Information design

Table 4.3 Disciplinary background of chemistry/engineering participants.

Participant	Undergraduate	Masters	PhD
C1	Analytical forensic chemistry	-	Pigment addictive interactions for modern and contemporary works of art
C2	Package design (BEng)	Chemistry	Colour science
C3	Biomedical material science	-	Textile processing
C4	Textile technology	Clothing management with textile	Textile (Functional fibre)
C5	Chemistry	Chemistry	Organic chemistry
C6	Chemistry	-	Chemistry
C7	Electronic engineering	Image and video communication and signal processing	Colour science
C8	Chemistry	Colorants, polymers, and fine chemicals	Perceptual and instrumental measurement of translucent materials

4.2.4 Materials and Method

4.2.4.1 Colour Samples

Six alphabetically coded pairs of colour samples were used for the experiment described in this chapter, in which samples were shown to participants. Each sample within a pair, differed from the other as follows. Pairs A, B, and C differed in colour; pairs D, E, and F differed in gloss, texture, and colour (Figure 4.2). With every pair, each sample was shown individually and then both samples in the pair were shown together.

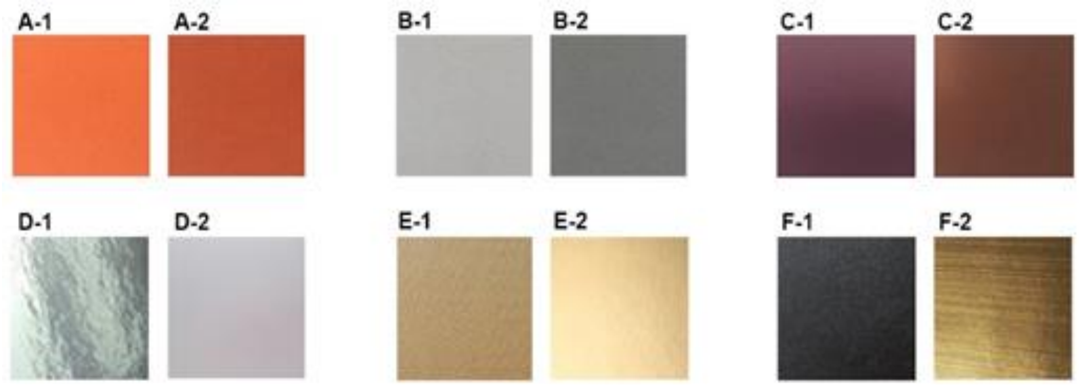

Figure 4.2 Pairs of samples used for the experiment.

4.2.4.2 Procedure

Participants were asked to describe each sample and then describe the process of adjusting the first sample from each pair to make it look like the second in the pair. The word ‘colour’ was not mentioned by the researcher during this process as it might influence participants to describe and talk about colour only. They were simply asked:

- How would you describe sample X?
- How to change sample X1 to make it look like sample X2?

The order in which each sample was presented to each participant was randomised. There are two reasons for this. Firstly, this was to ensure that all samples had the same chance of being the first to be described and to counter the effect of apathy as the test progressed. Secondly, and related to this, it was to avoid the issue of attentional bias which refers to how the perception of a person is affected by selected factors in their attention (Bar-Haim *et al.*, 2007). For example, attention bias could cause participants to fail to consider alternative possibilities when they are occupied with an existing thought, such as a thought about a prior sample (Baron, 2008).

4.2.4.3 Think-aloud Method

Qualitative data were collected with a think-aloud protocol. This technique is a method in which “participants speak loud any words in their mind as they complete a task” (Charters, 2003, p.68). All verbal data was transcribed verbatim by the researcher of this study closely looking at differences between the two groups before being double-checked by a native English-speaking person for accuracy of the transcription. The data has been qualitatively analysed for themes and quantitatively analysed for occurrence of particular words to reinforce qualitative analysis. The data was manually analysed using a Microsoft Word document and Excel sheet. Participants’ non-verbal communication such as their body movements were observed and hand-written on paper during the experiment by the researcher.

4.2.4.4 Experimental Setup

The experiment was implemented in the lighting laboratory at the University of Leeds where was dark, quiet, and windowless. Colour samples were placed on a grey background using a 45-degree stand in a colour matching light box with identical lightness (illuminated by a light that approximated CIE D65 illuminant).

Figure 4.3 Experimental setup (left) and actual experimental environment during the colour description experiments (right).

4.3 Data Analysis and Interpretation

In the following sections, it is mainly the characteristics of design participants that are focused upon, apart from one part (section 4.3.1.9). However, non-design participants’ characteristics are also presented as a counterpart.

4.3.1 Linguistic Characteristics

4.3.1.1 Use of Evocative, Emotional, and Associative Terms

It was observed that design participants tend to respond to samples emotionally in terms of evocation and association. Design participants used evocative, emotional, and associative terms such as “reminds me”, “it makes me think”, “feel”, “it look(s) like”, and “it’s saying to me” more often in comparison with participants from chemistry/engineering. They were approximately twice more likely to use these terms associated with feeling/memory than chemistry/engineering participants (Table 4.4). Although participants from chemistry/engineering used emotional, evocative, and associative terms, they were still likely to describe what they were looking at objectively. There are several examples which allow comparison between the two groups.

Table 4.4 Frequency of emotional/evocative/associative terms.

Disciplinary/Educational Background	Design	Chemistry/Engineering
Emotional/Evocative/ Associative terms	Frequency	
Feel	88	77
Reminds me	5	8
Makes me think about	46	0
Look(s) like	35	14
It’s saying to me	11	0
Total	**185**	**99**

Participant D1 and C4 show distinctive descriptions describing sample D-1 as follows:

> To me it’s saying hey I’m bling-bling, I attract attention, I am shiny, I am expensive, don’t touch me just look at me, but I am going to touch it, and again when I look closely at it, it has got a glossy, surface, also has a texture (Participant D1, describing sample D-1).

> It looks like an aluminium foil, it has shiny, but it has just a smooth surface. I can see it has some mirror image (Participant C4, describing sample D-1).

Contrasting approaches were clearly shown by participants D8 and C3 describing sample E-1 as follows:

> Dirty, warm, well, uncomfortable, and this colour make me think about poor places, not well organised places, like in the very dirty, dirty underground or dirty village. Yeah, that kind of feeling. And it makes me think about the autumn, especially leaves down, so it makes me feel uncomfortable. And dirty basically (Participant D8, describing sample E-1).

> It looks like paper pulp with a beige pigment to it. This one looks quite rigid. And yeah, don't know what more to say about it (Participant C3, describing sample E-1).

Participants D2 and C3 also showed this contrasting approach to the colours as follows:

> Classic, traditional, food. you know the warm colour always reminds me of food. Tomato, can I say like McDonald, can I say the brand like McDonald. Hot I mean like chilli. Blood. Like an old traditional, like Chinese culture. Positive as well, like passion (Participant D2, describing sample A-2).

> Similar to sample A1 in size and dimension. A little bit more hint of red. Again, made from pulp, I do not really know, some paper pulp or something like that? I would imagine. And yeah, a duller colour (Participant C3, describing sample A-2).

4.3.1.2 Associations of Sample Colour with Images and Memories

Bartlett (1932) notes that "evocativeness of words is a function of our long-term memory which is conceptual and schemata based" (cited in Lawson, 2004, p.93). Lawson (2004) states that designers acquire higher levels of sophistication and elaboration in schemata for concepts they deal with. Design participants closely connected with evocative and emotional language uses that are mentioned above. They also tended to associate samples with a range of images. There has been a crucial place for imagination in considerations of creative behaviour and the formation of ideas (Ainsworth-Land, 1982). For designers, what they were feeling at the time appears to have been very important during the whole process. It seems that for this reason, some of the design participants did not mention the names of colours at all. Interestingly, for sample C-2, none of the design participants mentioned the name of the colour while all chemistry/engineering participants did (Tables 4.5 and 4.6).

Table 4.5 Language use in response to sample C2 by design participants.

D1	natural, earthy, blend with environment, calmness, smooth, made of card, wood paper pulp
D2	chocolate, coffee, forest, feel Africa, cosmetic, foundation, hair
D3	wood, fence, good for clothes
D4	out of fashion, elder people like, earth
D5	wall, building in the Lisbon, Lisbon city
D6	same as C1 just colour different
D7	buildings, house wall
D8	boring, autumn, sadness, old style, old building, rough, very cheap

Table 4.6 Language use in response to sample C2 by chemistry/engineering participants.

C1	burnt umber
C2	brown, soil, leather, bricks
C3	similar to C1, robust, rigid, matte black finish
C4	brownish, smooth
C5	matte, brownish red, earthy, pottery, smooth looking, browny beige
C6	brown, tan, between brown and orange, more brown side, not reflect, quite opaque
C7	wood, natural, soft, brown, matte
C8	cognac, rust, orange, slight orange, mostly brown, shoes

Similar contrasts between the two groups are clearly shown with sample D-2 (Tables 4.7 and 4.8). Only two design participants mentioned colour whereas all chemistry/engineering participants described the sample with a colour focus in terms of its surface.

Differences can be seen when comparing participants D5 and C1 describing sample D-2.

> Ah, I think it is more like a foggy than sample D-1. And um, peaceful, I don't know it makes me feel like I am going to die, if I see this colour everywhere I feel die, yes, I mean I am just dying naturally (Participant D5, describing sample D-2).

> So, this is a lighter silver, so it's not pewter, it's lighter so a light silver. It's matte in finish. It's very opaque so it's changed in opaqueness the other one [D-1] was almost transparent, like mirror like. This one isn't this is completely matte, complete opaque and a light silver. The paper probably looks the same thickness as sample D-1 (Participant C1, describing sample D-2).

Table 4.7 Language use in response to sample D2 by design participants.

D1	wet, matte, smooth, calm, not bling-bling
D2	frosted, blurry, aeronautic, plastic, materials, texture
D3	a bit bright silver, more brighter, not very reflective
D4	similar feeling as D-1, reflect less light, warm, more expensive
D5	foggy, peaceful, going to die, feel die, dying naturally
D6	metal, harder than D1, metal for kitchen stuff, pot
D7	silver, not bright, not reflect
D8	bright, modern, cutting-edge, technology, business, business website, efficient, good

Table 4.8 Language use in response to sample D2 by chemistry/engineering participants.

C1	lighter silver, not pewter, matte, opaque, almost transparent, mirror, same thickness as D1
C2	very smooth, white, not reflective, very even
C3	more of an even pigment, a lot brighter, brighter silver, more matte
C4	glossy, white mixed with grey, not shiny, mirror
C5	reflective, silver, matte, less clear
C6	silver, metallic, matte, opaque, fogginess
C7	velvet coat, nail polish effect, mirror, matte, metallic silver paint, car
C8	reflective, doesn't have a mirror effect, matte, gradient light grey, jewellery, kitchen stainless steel

4.3.1.3 Range of Semantic Fields

As mentioned above, design participants express their feelings and emotions more than chemistry/engineering participants. The concept of the semantic field borrowed from linguistics is helpful here.

Semantic fields are defined by Crystal (1997, p.104) who says “one way of imposing some order on vocabulary is to organise it into ‘fields’ of meaning. Within each field, the lexemes interrelate, and define each other in specific ways”. Design participants used a wide range of semantic fields creatively and imaginatively in their description. They used semantic fields of natural and artificial features, feelings, emotions, food, cities, country, nature, products, and temperature (Tables 4.5 and 4.7).

In contrast, participants from a chemistry/engineering background used a more limited range of semantic fields focusing heavily on colour and surface (Tables 4.6 and 4.8). It was observed that chemistry/engineering participants tended to make an objective observation when describing colours, actually looking at them from physical different directions and positions. They described the names of colours repeatedly. This may also relate to semantic fields. Although participants from chemistry/engineering used a limited range of semantic fields, they used vocabulary that showed fine-grained colour terminology within those semantic fields. These characteristics were clearly revealed by participants C1, C6 and C8 (Table 4.9). However, none of the design participants showed this verbal behaviour. Traditionally, scientists tend to value objectivity and methodological precision, whereas designers and artists tend to value creativity and might express their ideas more subjectively. The language used by design and chemistry/engineering students probably reflects the emphasis and values within their different disciplines.

Table 4.9 Examples of fine-grained colour terminology by chemistry/engineering participants.

Participant	Sample	Description
C1	A-2	So A2 has a slightly more red tinge. So, I would say it's still an orange, but it's a slightly redder orange.
	B-1	I would say it's an off white colour. It's more, it has a blue tinge.
	C-1	It's a maroon purple colour. I'd say purple, a lot more purple.
C6	C-2	It is a matte sort of brown tan colour. So in-between brown and orange, bit more to the brown side. It doesn't seem to reflect a lot of light and it's quite opaque.
C8	B-1	It's, off white or white. It's a kind of white with a grey tint to it. Or really grey if you're talking general terms. Relative to the stand though it appears a lot closer to white but not white, if that makes sense. Or not a perfect white.
	C-2	I would describe this as like a kind of a rust colour. Kind of orange, well slight orange but mostly brown.
	F-2	It's like a mix between gold and bronze. Because I wouldn't say that it's like. It's not a yellow gold but it's more of a like bronzy gold or maybe, not quite rose gold either. It's got striations going horizontal, so you kind of see like little lines, and the various lines kind of show different vibrancy or saturation of that gold. So, some parts of it look a bit, almost darker gold, almost brown. Whereas the places where it's highlighted appear more gold brown.

4.3.1.4 Overlooking Tasks

In terms of describing how to change the first sample in a pair to look like the second, design participants often ignored this question. Some of them focussed on differences between samples and their own feelings instead of a practical method of making samples the same.

> Wow, I like both, I like both, I wouldn't change. Umm changes from here to there, can I touch? I will still do same thing, I would get a spray which is glossy and of a goldish (spray to F2) yes, yes, it's a very smooth one, that will bring the same like texture, yes, wow this is my favourite colour (Participant D1, describing how to change sample F-1 to F-2).

> Actually, A1 is more brighter than this A2, So I like A1. And When I choose one colour, I want to choose this one A1, yes (Participant D7, describing how to change sample A-1 to A-2).

4.3.1.5 Longer Time Period for Activities

Design participants often imagined specific situations or recalled their previous experiences while seeing colours samples. For this reason, design participants took longer periods of time to describe the whole range of samples with an average of 22 minutes. However, the average time taken by chemistry/engineering participants was relatively short at 13 minutes. They described samples concisely and precisely.

4.3.1.6 Suggestions for Possible Application of Samples

Participants from a design background described samples in terms of possible application (Table 4.10). This characteristic of design participants may be related to their creative role and behaviour in real life. According to Hamel and Prahalad (1991), professional designers, for instance, can aid consumers in finding the direction that they wish to follow, when customers do not actually realise what is achievable. In contrast, none of the participants from chemistry/engineering suggested applications.

Table 4.10 Possible applications suggested by design students.

Participant	Sample	Possible Application
D2	E-2	Packaging design especially the luxury brand.
D3	C-2	Maybe this is good for clothes.
D6	F-2	It makes me feel like the package for the wine kind of.
D7	B-1 & B-2	When I design for … sophisticated design, I will use that kinds of grey colours, um, yes.

4.3.1.7 Sobbing Voice

It was observed that two out of the eight design participants (D1 and D5) seemed to be about to sob and had shaky voices when they describe colours. This may demonstrate a tendency to be emotional among designers.

4.3.1.8 Expression of Personal Preferences

Five out of eight design participants expressed their personal preferences toward samples (Tables 4.11 and 4.12). It was observed that they tended to express their personal preference after they described their feelings and emotions. Design participants also linked colour samples to their personal belongings. Conversely, only one person (participant C3) from chemistry/engineering showed a preference for a sample. However, his response was relatively short in comparison with design participants.

Table 4.11 Examples of extended preference expressions.

Participant	Sample	Participants Responses
D1	F-1 and F-2	Wow, I like both, I like both, my favourite colours.
D3	F-2	I want to use this colour to decorate my home.
D4	A-1	I like the previous one more.
D7	E-2	I don’t like this colour for jewellery.
D8	A-2	It makes me something fail or something unfortunate thing. I don’t like this
C3	F-1	It’s a nice colour. I like this.

Table 4.12 Frequency of preference terms.

Terms used	Disciplinary Background	
	Design	Chemistry or Engineering
	Frequency	
I like	10	1
I do not like	10	0
Total	**20**	**1**

4.3.1.9 Fine-grained Terms

All of the chemistry/engineering participants explained how to make the sample in each pair match. The terms used by them to answer this question contrasted with the responses of design participants. The chemistry/engineering participants used technical terms and explained the process systematically using fine-grained terms to distinguish between colours and materials. Example sentences of colour changes by non-design participants (participants C3, C4, C6, and C7) are as follows:

> Adding a pigment perhaps maybe. I don't know… sanding it down or polishing it down but you will get more if a gloss on it. Leave it out in the sun for a while. Yeah, I think so (Participant C3, describing how to change sample C-1 to C-2).

> I think it is very different. You need to do coating on the paper to remove the glossy (Participant C4, describing how to change sample D-1 to D-2).

> They're very different samples. So, I would say F1 would need to be made a golden colour first and it would also need to be more metallic. So, I would say the golden colour is lighter than the darker which F1 is (Participant C6, describing how to change sample F-1 to F-2).

> Um, first I need to have something like a sandpaper to scratch from in the surface one side to another side, so I can make this kind of structure. And then I am probably going to spray off the like a gold paint on the top of it. Um or I can, ok there is a very scientific way of it. Because I can see this one is probably copper, so this one probably another kind of iron base metallic, so there is one of the ways that you put in a different sign of the power like plus (+) sign and minus (-) sign, and you put the metal inside, because there is an aluminium, like a copper aluminium inside that solution so they will cover the top of it like that (Participant C7, describing how to change sample F-1 to F-2).

4.3.2 Behavioural Characteristics

4.3.2.1 Trying to Touch Versus Scrutinising Samples

Various scholars claim that moving the body in natural ways and touching things can help the way participants engage emotionally with tasks and affects how what is being evaluated is perceived (Wu *et al.*, 2011; Bianchi-Berthouze, 2013; Petreca *et al.*, 2015). It was observed that three out of eight design participants tried to touch or asked to touch samples although they were asked not to (Table 4.13). In any case, most design participants described samples as if they had touched them.

In contrast, it was observed that chemistry/engineering participants moved their body in order to scrutinise samples from different angles while describing colours. However, none of those from chemistry/engineering asked to touch samples. It may be that designers display a greater emotional response than chemistry/engineering participants signalled by their desire to touch samples rather than simply move their bodies. This would be an interesting matter for future research.

Table 4.13 Design participants' behavioural characteristics.

Participant	Sample	Participants Responses
D1	F-1 & F-2,	Can I touch? It's saying to me touch me.
	B-1	I want to even touch and feel that texture
D5	B-1 & B2	I don't know I can touch it, because this textile, horizontal it makes me peaceful.
D6	E2	If I touch, the feeling like, I look at it, I feel something in my hand.

4.4 Conclusions

4.4.1 Communication Style about Colours among Designers

This chapter has revealed some major findings about design participants by comparing them to non-design participants with the aid of hypotheses based on linguistic theories, and it has sought to address core research questions. It has introduced nine key issues:

- **Emotional, evocative, associative, and descriptive terms** were often used by design participants to describe colours.

- **Association of colours** with feelings, images and memories were revealed by designers to express themselves which is also linked to evocative and emotional language use.

- **A variety of semantic fields** of natural and artificial features, feelings, emotions, food, cities, country, nature, products, and temperature were used by design participants**.**

- **Designers ignored tasks**, often in comparison with non-design participants. Rather, they were focused upon their feeling, preference and emotions while being asked to perform the second task of transforming colours.

- **Longer periods of time** were taken by designers while describing colours with use of descriptive detailed and senses.

- **Focus on the expression of personal preferences** is characteristic of design participants.

- **Suggestion of possible application** while describing colours.
- **Sobbing and shaky voice** while describing colours.
- **Designers wanted to touch colour samples.** This may help them to build up their creativity and enhance their emotional expression.

4.4.2 Assumption of the Approach

The findings above indicated that design participants tended to ignore a current task focusing instead upon their emotion, feelings, experiences, and preferences. Because of this, all designers may show emotional, evocative, associative, and descriptive terms to describe colour samples to express themselves during the experiment.

Design participants also tried to touch colour samples during the tasks which may help them to enhance their creativity or emotional responses. This can be interpreted as suggesting that designers seem to want to communicate and express themselves emotionally, imaginatively, or artistically with less reference to specific terminology and measurable quantities such as percentages. Designers may gain a holistic impression by looking at colours subjectively instead of considering other properties of colours.

An implication of this is the possibility that designers' subjective reaction toward colours may cause greater effectiveness and more appropriate colour application in their daily design activities where they receive emotion-based instruction and guidance. They may be less effective where such instruction and guidance is lacking. Therefore, the following research question and hypothesis have been generated on the basis of findings from this chapter (Table.4.14).

Table 4.14 Overarching research question and associated hypothesis generated by Chapter Four.

Research Questions and Hypotheses	
RQ 4-1	How can designers' emotional characteristics be utilised/reflected in providing colour information to them?
H4-1	Design participants will want to touch and feel formats while they are searching for information. There is likely to be a need also for tactile information forms to motivate designers. However, in the current era it is inevitable also that designers would use technology-based tools and forms of information.

4.5 Summary

In sum, eight distinct patterns of verbalisation and a behavioural issue (tactile behaviour) have been revealed as a result of this descriptive and qualitative study of responses to colour. It has been based on sociolinguistic theories, analysing verbal data, and observing body reaction while colour samples were described by design and non-design participants. On the basis of nine key findings here, the new associated overarching research question (RQ 4-1) and hypothesis (H4-1) emerged, shown in Table 4.14. The next chapter will test the hypothesis generated in this chapter, adopting focus group interviews with different design participants.

*** Note.** Related Publications to Chapter 4.

Journal article

Lee, G., Westland, S., Cheung, V. 2019. Colour communication challenges: exploring disciplinary Divides. *Journal of the International Colour Association*, **23**, pp.25-35. (Invited paper)

Conference paper

Lee, G., Westland, S., Cheung, V. 2018. Effective colour communication. In: *Proceedings of the International Colour Association. Interim Meeting of the International Colour Association 2018, 25-28 Sep 2018, Lisbon, Portugal*. International Colour Association (AIC), pp. 517-522. (Award-winning)

The journal article was developed from a prize-winning conference paper "Effective Colour Communication", presented at the Interim Meeting of the International Colour Association (AIC) in 2018.

Chapter 5 DESIGNER STUDY 2

5.1 Introduction

In Chapter Four, the distinctive verbal and behavioural characteristics of design participants were explored. It was discovered that design participants tend to express their emotions, try to touch colour samples, or talk as if they have touched them while describing colour samples. These characteristics may be valuable assets of design participants which should not be disregarded. This chapter starts with the question generated from the findings from Chapter Four as below:

- **RQ 4-1** How can designers' emotional characteristics be utilised/reflected in providing colour information to them?

In addition to this, some of the overarching research questions which emerged from Chapter Two (see sections 2.4 and 4.4.2) guide this chapter. All of the overarching research questions are broad. Therefore, they are broken down into five research sub-questions (listed in Table 5.2) in order to seek to provide answers to the overarching questions. Therefore, this chapter is designed to answer the five research sub-questions and is structured into four broad phases: (1) background, (2) setting two design prototypes, (3) data collection, and (4) data analysis and interpretation of the findings.

Firstly, in terms of background, a strong relationship between emotion and design is reviewed briefly from prior studies to provide a rationale behind this chapter. Subsequently, the reasons for the adoption of the first design prototype are explained. Also, the process of the creation of the second design prototype is described. Thirdly, focus group interviews with PhD design students are used for the main data collection. Lastly, the data collected from design participants are analysed thematically and interpreted. Each of the research sub-questions are addressed in turn with answers provided.

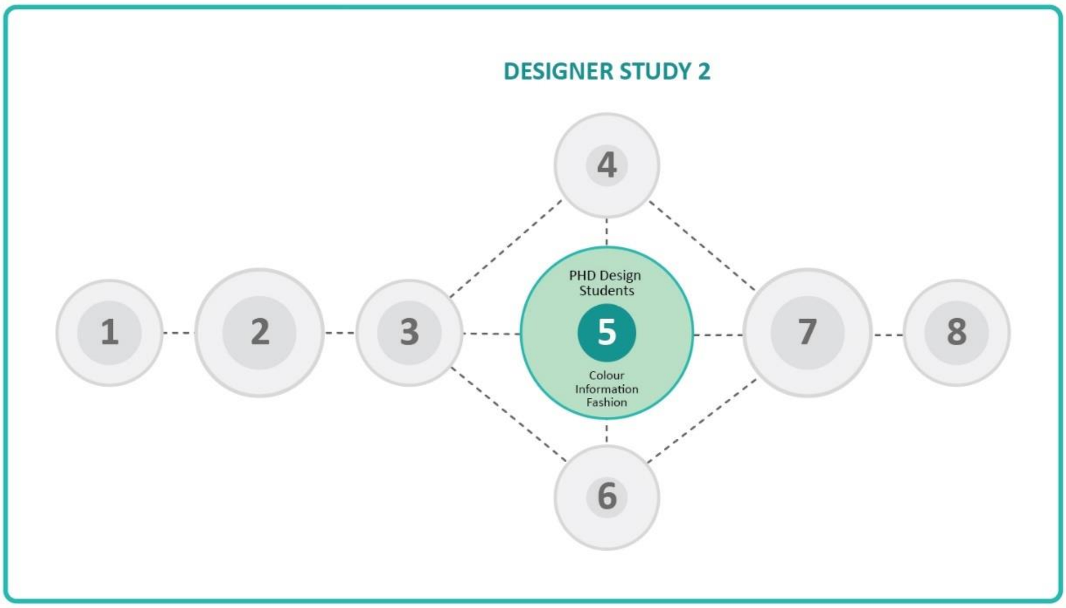

Figure 5.1 Position and context of Chapter Five within the whole research process.

5.2 Rationale behind the Research

5.2.1 Emotion and Empathy in Design

One of the essential abilities (or responsibilities) of designers is to reach out to users at the emotional level, in order to understand them, and ultimately to accomplish a design project successfully. This could be approached by asking users how they feel and the reasons. In a theoretical approach to design which offers a framework for the emotional response of users, Norman and Ortony (2006) translate these responses into three levels (visceral, behavioural, and reflective), (Table 5.1 and Figure 5.2). Norman (2002) claims that these different levels of experiences can be derived from or caused by different design styles. In reality, however, there is a huge gap between the view of designers and users about design artefacts. Norman and Ortony (2006) state that in terms of the part played by emotion there is clear evidence users and designers differ in their perspective toward the same product (Figure 5.3).

Our behaviour and motivation is influenced by emotions. Emotion is influenced in turn by our experience. However, designers generally may not have experience of visual difficulties. For this reason, it may be challenging for designers to understand and empathise with various types of users of design artefacts when those users have different physical and cognitive levels. It may prevent designers from producing thoughtful design outcomes.

Table 5.1 Characteristics of three levels of affective processing proposed by Norman (source: adapted from Norman, 2002; Norman and Ortony, 2006 and the wording in the table is taken directly from sources).

Three levels of processing	Characteristics
Visceral level	▪ Visceral level is innate and biological (perceptually-induced). ▪ The visceral level is fast: it makes rapid judgments of what is good or bad, safe or dangerous, and sends appropriate signals to the muscles (the motor system) and alerts the rest of the brain.
Behavioural level	▪ Behavioural-level design includes the general concepts of usability but goes beyond this to include the physical feel of the object as well as the subjective 'feeling of control'. ▪ Sub-conscious and automatic (expectation-induced).
Reflective level	▪ Conscious and self-aware (intellectually induced). ▪ The reflective level is influenced by experience and culture as well as by one's social group and by the whims of fashion.

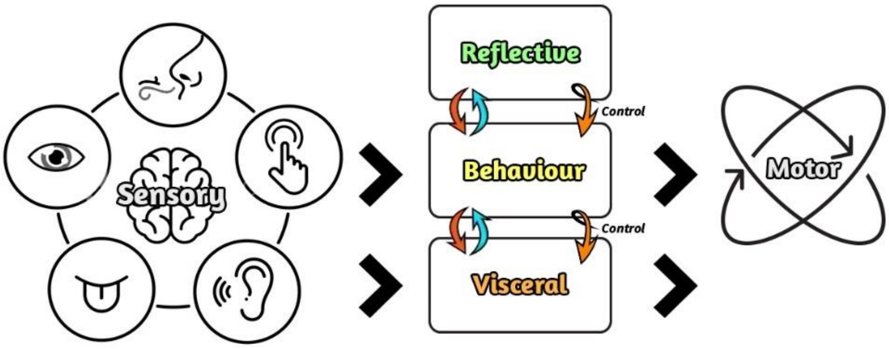

Figure 5.2 Three levels of affective processing (source: adapted from Norman, 2002 and redrawn by the author of this thesis).

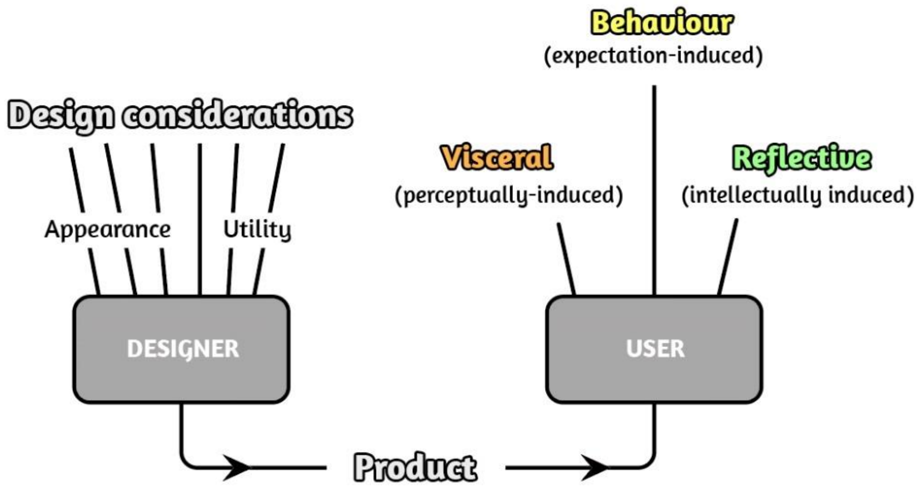

Figure 5.3 Different views of design products expressed and experienced by designers and users (source: adapted from Norman and Ortony, 2006 and redrawn by the author of this thesis).

In order to fill the gap between the emotional responses and experiences of designers and users, the concept of ‘empathy’ can be utilised. The English word ‘empathy’ arises originally from the field of psychology and is defined as “the ability to understand and appreciate another person's feelings, experience, etc” (OED, 2020f). Empathy sometimes is used alongside the psychological term “affective and empathic forecasting” (Hall *et al*., 2018, p.37) meaning “the predictions of another person’s emotional state about an event in the future” (Tracey and Hutchinson, 2019, p.1262).

The concepts of emotion and empathy have been used in a variety of disciplines not just psychology, such as design and many others. It has been utilised, for example, by the author of this thesis in an earlier MA design project by meeting users (Lee, 2015), and its importance and interrelation with emotion in design has been shown (e.g. Köppen *et al*., 2011; Köppen and Meinel, 2012; Tracey and Hutchinson, 2019; Zingoni, 2019).

As demonstrated in Chapter Four, designers tend to be emotional and imagination driven in situations where being objective would be considered an advantage. However, it is possible that such distinctive features of designers in relation to design tasks could be utilised effectively if they were applied in the right place in an appropriate manner. Therefore, this characteristic of designers may be a two-edged sword.

From a consideration of findings in the previous chapter (Chapter Four) and the review of literature (Chapter Two), it is expected that designers’ emotional responses (as a main characteristic) could be used to enhance their performance in design tasks. In other words, by triggering imaginative and empathetic responses, designers could be stimulated and motivated to behave with a more user-centred mindset. Based on this idea, in this chapter, a set of Affective Imaginary Information [AII] formats was designed and tested with the aim of bridging the emotional gap (arising from different cognitive and physical experiences) in specific situations between designers and information users. This will be explored throughout this chapter.

Figure 5.4 Diverse factors that influence production of better design outcomes.

5.3 Background to Development of Research Questions

This chapter answers overarching research questions generated at the end of Chapters Two and Four. There are two parts to this chapter, each answering two of these four overarching questions.

Part 1. WHY and WHAT

- **RQ 2-1** Why do designers consistently continue to create inaccessible communication materials even though scholars have identified the problems that arise from them doing so?
- **RQ 2-3** What are the features of user-related colour information provision that designers actually access, and how do they talk about the features?

The questions addressed in Part 1 arise from Chapter Two (see section 2.4). The findings in this part will allow us to provide answers regarding 'what' designers already know or need to know, and the difficulties they face in accessing information themselves about the needs of a range of information users. This part will focus on user-centred colour application (colour inclusivity) by designers, and their colour information use for various information users (colour and vision impaired people in this part). A rich body of data has been gathered to provide deeper understanding of design participants' perception, knowledge, and values related to colour information use and colour design inclusivity in this part of the chapter.

Part 2. HOW

- **RQ 2-4** How should colour information be offered to designers in an effective and efficient way?
- **RQ 4-1** How can designers' emotional characteristics be utilised/reflected in providing colour information to them?

The questions in Part 2 arise from Chapters Two and Four. In this part, designers' reaction and responses toward Affective Imaginary Information formats (facial representation of emotion) will be examined by looking into descriptive data from design participants. This element was planned based on the findings from Chapter Four reflecting the emotional characteristics of the perception of colours by design participants. These findings will give support for the claim that there is a need for further development of information sources and formats and to consider 'how' colour information should be provided to designers effectively to inspire and motivate them.

5.3.1 Research Questions

There are two main topics throughout Chapter Five. These cover colour information and inclusion (Part 1) and consideration of effective information presentation (Part 2). Each part answers two central (overarching) research questions incorporating related research sub-questions (Table 5.2).

The research sub-questions were then reformulated so that they could be put to design participant during the focus group interviews. The actual focus group questions are listed in Table 5.6. The focus group questions were designed in an open-ended style to allow for any interesting and non-anticipated insights that might arise from participant responses. This also permitted the participants to talk about their values, thoughts, and experience in an unrestricted manner.

Table 5.2 Detailed research topics and questions for the focus group sessions.

Topic of Each Chapter Part	Restricted Topic	Central (overarching) Research Question	Associated Sub-questions
Part 1. Colour Information and Inclusion	Reasons for design exclusion	**RQ 2-1** Why do designers consistently continue to create inaccessible communication materials even though scholars have identified the problems that arise from them doing so?	**RQ sub-2.1.1** What colours will be proposed by designers regarding information provision for vision and colour vision impaired people?
			RQ sub-2.1.2 What do design participants predict about the needs of various information users, in comparison to what target users actually do need in relation to information accessibility?
	Designerly means of obtaining user-centred colour information	**RQ 2-3** What are the features of user-related colour information provision that designers actually access, and how do they talk about the features?	**RQ sub-2.3.1** Where do design participants search for user-related colour information for people with colour and vision impairment? Do they face any difficulties faced while doing this? What information do they need?
Part 2. Consideration of Effective Information Presentation	Factors influencing designers' information use	**RQ 2-4** How should colour information be offered to designers in an effective and efficient way?	**RQ sub-2.4.1** What features would designers like to use? What do designers think are the pros and cons of Affective Imaginary Information design prototypes (both i-cards and p-cards)?
	Investigating ways to reflect and use characteristics of designers	**RQ 4-1** How can designers' emotional characteristics be utilised/reflected in providing colour information to them?	**RQ sub-4.1.1** What do design participants feel and talk about in terms of the Affective Imaginary Information format (facial representation of emotion)?

5.3.2 Aims and Objectives

The chapter has two major aims. Objectives are then divided under these aims.

Aim 1. To explore the factors that cause difficulties for design participants in considering various information-users' perspectives.

- Objective 1-1. To explore the possible gap between design participants' assumptions and end-users' needs and preferences (vision and colour vision impaired people) in terms of accessible information provision.
- Objective 1-2. To investigate design participants first-hand experiences of accessing user-related colour information during a web search task.
- Objective 1-3. To investigate characteristics of information sources and formats which are preferred by design participants and examine in detail the reasons for this.
- Objective 1-4. To examine the actual colour information provision used by design participants when they consider various information users in order to determine the characteristics of those sources and challenges faced by designers while using such information.

Aim 2. To investigate how Affective Imaginary Information can be understood by design participants in order to find effective ways to provide user-centred colour information to designers.

- Objective 2-1. To explore responses of design participants to an AII (facial representation of emotion) format, both i-cards (online) and p-cards (conventional), by collecting and analysing descriptive expressions provoked by the facial expressions among design participants.
- Objective 2-2. To compare the advantages and drawbacks of both online (i-cards) and physical (p-cards) versions of the AII format from a designer standpoint.

5.3.3 Testing Hypotheses

Hypotheses H2-1, H2-3, and H2-4 arise from Chapter Two. Hypothesis H4-1 arises from Chapter Four (Table 5.3). Table 5.4 shows the relationships between central research questions, hypotheses, aims, and objectives.

Table 5.3 Hypotheses addressed in this chapter.

Part of Chapter	Hypothesis Code	Hypotheses tested in this chapter
Part 1.	H2-1	There will be unknown concrete barriers faced by designers in regard to searching for user related colour information. There will be large gaps between designers' assumptions, predictions and users' wants regarding information accessibility. The research will reveal new reasons/factors behind the continuing provision of inaccessible information.
	H2-3	There will be differences between where designers' search for information and their preferences regarding how they would like to access it in terms of its features when they seek user-centred colour information. It is expected also that challenges faced by designers and their desire in terms of the information provision currently used will be discovered.
Part 2.	H2-4	Colour information for designers will benefit from being presented emotionally and artistically, using emotion-based images in order to attract designers' attention. This will help them to build up their motivation and empathy.
	H4-1	Design participants will want to touch and feel formats while they are searching for information. There is likely to be a need also for tactile information forms to motivate designers. However, in the current era it is inevitable also that designers would use technology-based tools and forms of information.

Table 5.4 Relationship between research questions, hypotheses, aims and objectives.

Part of Chapter	Central Research Question	Hypothesis Code	Aim Code	Objective Code
Part 1.	RQ2-1	H2-1	A.1	O.1-1
	RQ2-3	H2-3		O.1-2 O.1-3 O.1-4
Part 2.	RQ2-4	H2-4	A.2	O.2-1
	RQ4-1	H4-1		O.2-2

5.4 Data Collection

5.4.1 Focus Groups

A qualitative exploratory approach was used by adopting focus group interviews as a main methodological tool for data collection. There were two focus groups, both addressing the same questions but with some minor additional questions put to the first group.

Focus group interview [FGI] helps to reveal diverse ideas and the feelings of each individual involved about the particular topic in question, as well as revealing the differences in views between individuals in the group (Rabiee, 2004). Although the foremost purpose of focus groups is to permit insightful understanding of data and for this to be documented and reported, there are three considerations which combined suggest that a given topic is significant: the number of individuals mentioning a topic, the number of groups mentioning it, and how enthusiastically and energetically those participating discuss the issue (Morgan and Krueger, 1998).

Table 5.2 illustrates restricted topics thematically for the FGI. The first part deals with colour, inclusion, and information use by design participants. In particular, background knowledge and experience of design for various users, use of inclusive information sources and formats, and inclusive colour suggestions by design participants for vision and colour vision impaired information users were discussed. In this part of the focus group sessions, a set of design prototypes was adopted from a previous research project conducted by the researcher (see section 5.4.5.1).

The next part of the table relates to examining how designers respond to an Affective Imaginary Information [AII] format (facial expression of information). For this part of the study, a set of AII design prototypes was created with images showing emotions and a short description (both a physical and online version). The AII formats were offered to design participants during the group sessions. Highly qualitative and descriptive responses of participants were collected through the FGI as an appropriate type of data taking into account the findings of designers' communication styles from Chapter Four. Participants' responses will be described in section 5.6.4 in detail. All focus groups were held in a seminar room at the University of Leeds. The first focus group interview lasted about 50 minutes and the second about 40 minutes.

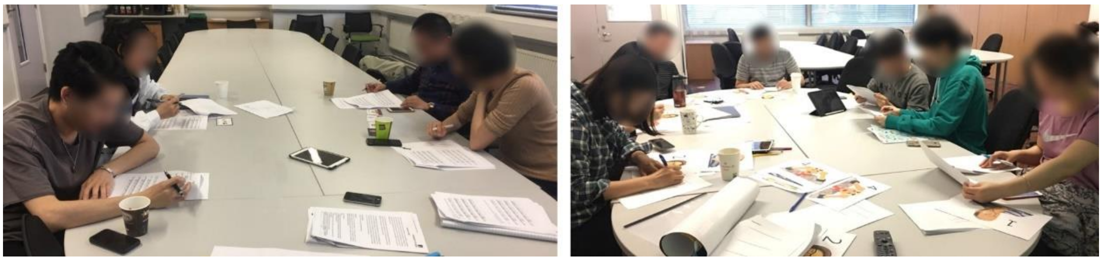

Figure 5.5 Focus group interviews: first (left) and second (right) sessions.

5.4.2 Participant Characteristics

Deciding types and numbers of participants is one of the key elements for focus group planning (Morgan, 1997). The optimal number of participants for such a group is variable (Rabiee, 2004).

According to Tang and Davis (1995), the number of people to be included in a focus group should depend on four crucial points: how many questions are asked, how much time is allocated to individual questions, the way the session is formatted, and how long the session as a whole lasts. However, most of all, the aims of the research should be the first consideration to set the number of participants for a focus group interview (Tang and Davis, 1995). Thus, the purpose of the study and objectives influenced the decision regarding who should be invited to the focus group discussion in the present study. Two focus groups were carried out with total of ten doctoral design students voluntarily taking part: the first session was composed of four participants and the other composed of six. As noted, both focus groups covered the same topic.

To recruit participants, an email was sent to PhD design students at the University of Leeds. The prerequisite for participation was the status of being a PhD student at the time of the interviews. Prior to the interviews, all potential participants were asked details of their disciplinary background and number of years of employment experience, if any, in the area of design. Each participant was assigned a code from F1a to F1d for the first group and from F2a to F2f for the second group session to identify them while ensuring their anonymity. Participants were aged from 24 to 36, and there were five males and five females in total. Table 5.5 shows the education and design career details of the participants involved in this part of the study.

In order to meet the criterion of homogeneity between interviewees, similar types of people need to be considered for participant recruitment (see Morgan, 1997). All participants in the present study held a masters' degree from various design areas and were studying doctoral design degrees in information, colour, or fashion. In addition, two types of individual were mixed together in each group session: (1) those having experience working in design practice, design education, or research, and (2) those not employed in the design area prior to commencing a PhD in design. However, as I will now explain the focus groups were composed somewhat differently to take advantage of the disciplinary background of individual members.

The first focus group interview was conducted as a mini focus group interview with four information design PhD students. Kamberelis and Dimitriadis (2005) state that for a mini focus group interview, the recommended number of interviewees are two to five experts. They also argue that this format allows the interviewing to facilitate in-depth explorations of the individuals' responses. In this session with design participants (F1a to F1d), it was expected that holding a high level of research experience and knowledge of information design would permit them to give additional feedback on the AII format. Thus, in this session additional feedback and ideas from the information design participants were applied to make minor modifications for the visual effectiveness of the AII format (see section 5.4.5.2.5). This slightly modified prototype was used during the second focus group session.

Table 5.5 Participant information for the focus group interviews.

Participant	Masters in Design	PhD Specialisation	Design Employment prior to PhD (years)	Gender
First Focus Group Session				
F1a	Information	Information	N/A	F
F1b	Information	Information	Graphic designer (1)	M
F1c	Fashion	Information	Design teacher (1)	F
F1d	Information	Information	N/A	M
Second Focus Group Session				
F2a	Product	Colour	Design lecturer and graphic designer (7)	M
F2b	Digital media	Colour	Graphic design freelancer (3)	M
F2c	Information	Colour	N/A	F
F2d	Product	Colour	N/A	F
F2e	Fashion	Fashion	Design researcher (2)	F
F2f	Information	Information	N/A	M

For the second focus group interview, six design PhD students (F2a to F2f) from the disciplines of colour, fashion, and information were invited. The number of participants comprised an adequate sample size for a classic medium size focus group interview (six in this session) as set out by various authors (e.g. Morgan, 1998; Krueger and Casey, 2015).

5.4.3 Voice Recording

Due to focus groups giving rise to substantial irreplaceable data, it is crucial to obtain high quality sound recording to achieve the qualitative research purpose. To ensure this, the focus groups took place in a quiet seminar room at the University of Leeds to prevent background noise, and which provided a familiar environment for the participants. Additionally, two recording devices were used to record responses during the group sessions to prevent data loss if one device failed.

Prior to the group sessions, participants were told that they would be recorded electronically to create audio files and that subsequently their responses would be typed into an electronic word-processed format. Individuals signed the relevant University of Leeds form to indicate their informed consent. As indicated, the recorded data from the focus groups was transcribed then utilised to ensure that thorough and accurate response data was available for later analysis.

5.4.4 Focus Group Questions

There were twenty-two focus group questions within seven sections (Table 5.6). The questions fulfil the aims and objectives of the research and were asked during both the first and second focus group sessions.

Table 5.6 Focus group questions.

Section	Focus Group Question
Legibility of colours	What colours would you apply for vision impaired people or colour-blind people and why?
Design selection	Which one do you think would be most preferred by vision and colour vision impaired people?
	Which one do you think would be least preferred by vision and colour vision impaired people?

(continued)

Design education	Have you ever been taught about design for disabled people including those with mobility disabilities, learning disabilities, vision disabilities, or hearing disabilities etc or colour blindness during any of your design education? This includes your BA, MA, or PhD course or any seminars you have attended so far (if you have answered Yes).
	What was the design subject?
	What was the target group of people?
	What did you learn from the design subject?
	What difficulties did you experience while learning the design subject?
	What types of research methods did you adopt (if any)?
Design research project	Have you ever worked on a design research or practical design project which related to information accessibility for people with vision impaired, colour vision impaired? (If you have answered Yes).
	What did the design project involve?
	What types of research methods did you adopt (if any)?
	What was the target group of people you focused on?
	How did you find the participants?
	Did you face any difficulties during the design project? If Yes, what were they?
Information use	If you needed to design for vision and colour vision impaired people. What information would you want to know and look for first?
	Write down the key word(s) you used in your search, and website address or title of website.
	Did you face any barriers in terms of finding information?
Words for image	Can you describe this picture? Tell me any words this image provokes for you?
Pros and cons, preference of information types: online and conventional AII forms	What are the advantages and disadvantages of the physical version of the cards?
	What are the advantages and disadvantages of the online version of the cards?
	Which version do you prefer? What is the reason for this?

5.4.5 Materials

This section describes the adoption and creation of two testing materials (design prototypes) and their use for each themed part of the focus group interviews (see Table 5.2).

5.4.5.1 Adoption of Design Prototype for FGI (Part 1)

The literature review (see section 2.1.3) showed that scholars identify and give reasons for inaccessible information provision still continuing. However, several questions remain unanswered at present and are explored in this chapter (RQ 2-1 and RQ 2-3). In order to explore detailed but also unknown factors/reasons behind this tendency to provide inaccessible information, participants were shown four prototypes of an accessible bus route map (Figure 5.6). These arose from the researcher's master's dissertation of 2015. The creation of the map took detailed account of vision and colour vision impaired people's first-hand experience and their opinions in an iterative design process with seven target group users. The four prototypes were shown to the design participants to gather data by asking the relevant focus group questions (see Table 5.6). From this phase, it was expected that more concrete but the hidden factors of 'why' designers consistently continue to create inaccessible information would be discovered.

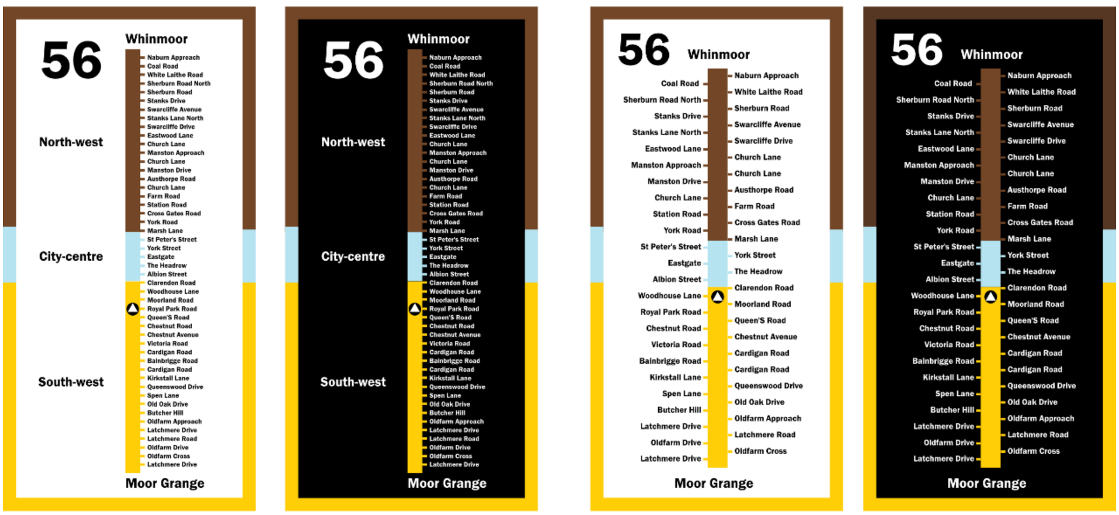

Figure 5.6 Design prototypes – set 1, adopted for the early part of focus group interviews.

5.4.5.2 Creation of Design Prototypes for FGI (Part 2)

Korhonen (2010) argues that visual images are becoming the central mode of communication in our era. Lofthouse (2006) claims that designers could be inspired in their work by visual information with a small amount of written information being provided to them.

For the second themed part of the focus groups, an Affective Imaginary Information [AII] format was created. In response to Lofthouse's claim for the benefits of coloured images and short texts, these were the dominant consideration for designing the AII format.

5.4.5.2.1 Generating Contents for Affective Imaginary Information

Reading difficulties are not only an issue for vision impaired people, but also for a number of older people. Of the latter, 1.6 million in the UK have sight loss according to RNIB (2015). For this reason, for the second prototype set, older people's challenges were listed on the AII format.

To generate short descriptions to be used along with the coloured facial images on the AII format, the challenges that older people might be confronted with in obtaining information were considered by reviewing existing literature. The main sensory factors can be summarised as two issues: reading text information and distinguishing colour-coded information. Age-related vision impairment, for instance, includes declining colour perception (Ishihara *et al*., 2001), slower reading, and longer duration of eye movements (Gordon *et al*., 2016). Such age-related decline leads to reading difficulty among the older population, but this also has a detrimental effect on the quality of their life causing experiences such as social exclusion (Paterson *et al*., 2013).

When discussing more realistic issues affecting older people's social exclusion in real life, information accessibility could be one of the factors contributing to it because this can be connected to mobility issues. For this purpose, in addition to the review of literature, two surveys were conducted with older female participants (68 and 70 years old).

After conducting the literature review and surveys, four questions and answers were generated (Table 5.7). The four questions were applied in the design of the AII format (on the front) which was developed in both physical form (p-cards) and online form (i-cards). The back of the four cards contained answers found from the review of literature and face-to-face surveys with elderly people. Thus, on three of these cards, the answers were given as illustrative quotations taken from responses gained from a small fieldwork survey of elderly people about their experiences of information use. Along with the written questions and answers the AII cards contained cartoon images of faces intended to convey emotions related to those questions and answers. These cards were used for data collection both in the investigation of designers' characteristics in terms of preferred and less preferred information in the current chapter, and a colour information search carried out by design participants related to designing information (colour) for older people in Chapter Six.

Table 5.7 Questions and answers generated via literature review and corroborated by surveys.

No.		Question and Answer Used on Affective Imaginary Information Format
1	Front	What challenges are faced by older people in reading and understanding travel information displayed on bus stops?
	Back	"Small font on timetable is difficult to read. Sometimes it is not easy to understand because of the complex layout" (70-year-old older person, Britain).
2	Front	What is the effect of age-related cataracts on the colour perception of older people?
	Back	Age-related cataracts affect colour vision (1) Yellowish and brownish (2) colours look faded (3) Hard to distinguish colours
3	Front	What is the most effective information source during a whole bus journey?
	Back	"I carry printed timetable to get back home" (68-year-old older person, Britain)
		"I do not know how to get information from the website" (70-year-old older person, Britain).
4	Front	Where do old people find travel information when they go to an unfamiliar place?
	Back	"Asking the local librarian for bus timetable then double check with friend about the location of bus stop" (70-year-old older person, Britain).

5.4.5.2.2 Selection of Photos and Drawing Cartoon Images

At this stage of the creation of AII format, an expert graphic designer with fourteen years of practical experience in the design area, and an information design researcher who was a third-year doctoral student became involved. They were both from the researcher's professional network. Communication with them was by online and face-to-face conversation respectively.

The researcher collaborates with them in terms of selection of a set of photos, drawing cartoon images based on them, and designing two versions of AII formats - physical (p-cards) and online (i-cards). The procedure for the creation of this set of design prototypes went through six stages (Figure 5.7).

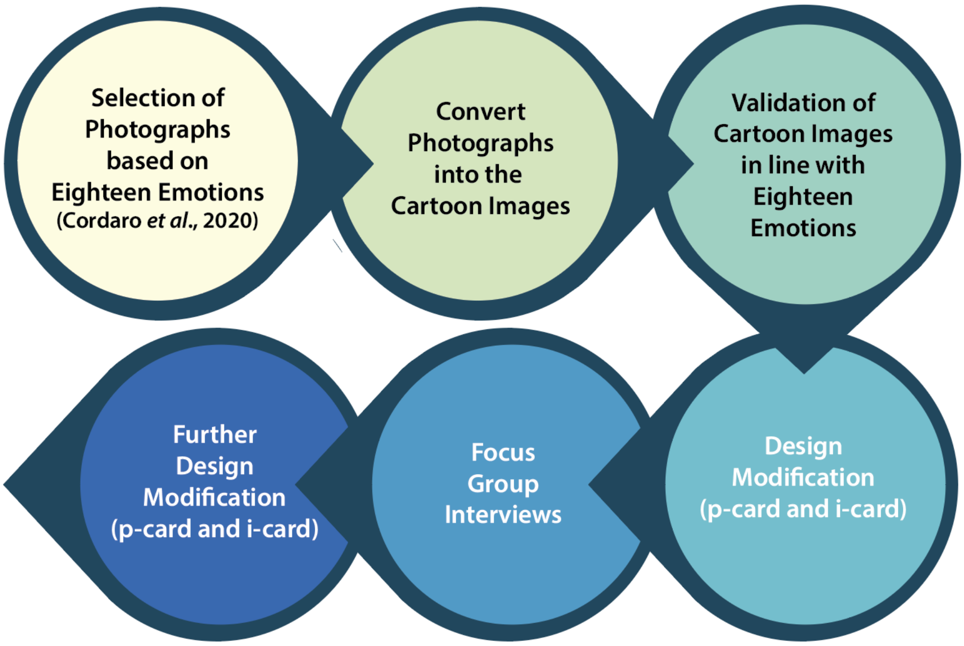

Figure 5.7 The procedure for the creation of Affective Imaginary Information format.

The first stage of this process involved a review of literature. In reviewing the literature, it became apparent that while distinctive universal signals such as facial expressions are one of the characteristics of basic emotion (Ekman, 1999), issues of universal/basic human emotions have long been debated. Well-known theories of universal emotions and related studies (see Ekman *et al*., 1969; Ekman and Friesen, 1978; Ekman, 1999; Eimer *et al*., 2003) suggest a relatively small number (around six) basic emotions.

A limitation of categorising of a dataset into particular emotions is that it often depends on context. However, the eighteen body and facial emotions identified by Cordaro *et al.* (2020) are widely identified across cultures in ten countries. Eighteen emotions were accepted as a basic set of emotion categories then utilised throughout the process of the design prototype creation. This is because drawing on a larger range of identified emotion allowed the researcher to create images distinctively and wider options for designing the AII card prototypes.

For the preparation phase, human facial expression photographs were selected from free online image repositories. Each of the photographs would reflect or relate to the subject of one of the questions (see Table 5.7) and were also encompassed by one of the eighteen cross cultural emotions identified by Cordaro *et al.* (2020). After this, the selected photographs were drawn on an iPad as cartoon images intended to reflect a set of four of the eighteen emotions that had been set out by Cordaro *et al.* (2020) (Figure 5.8).

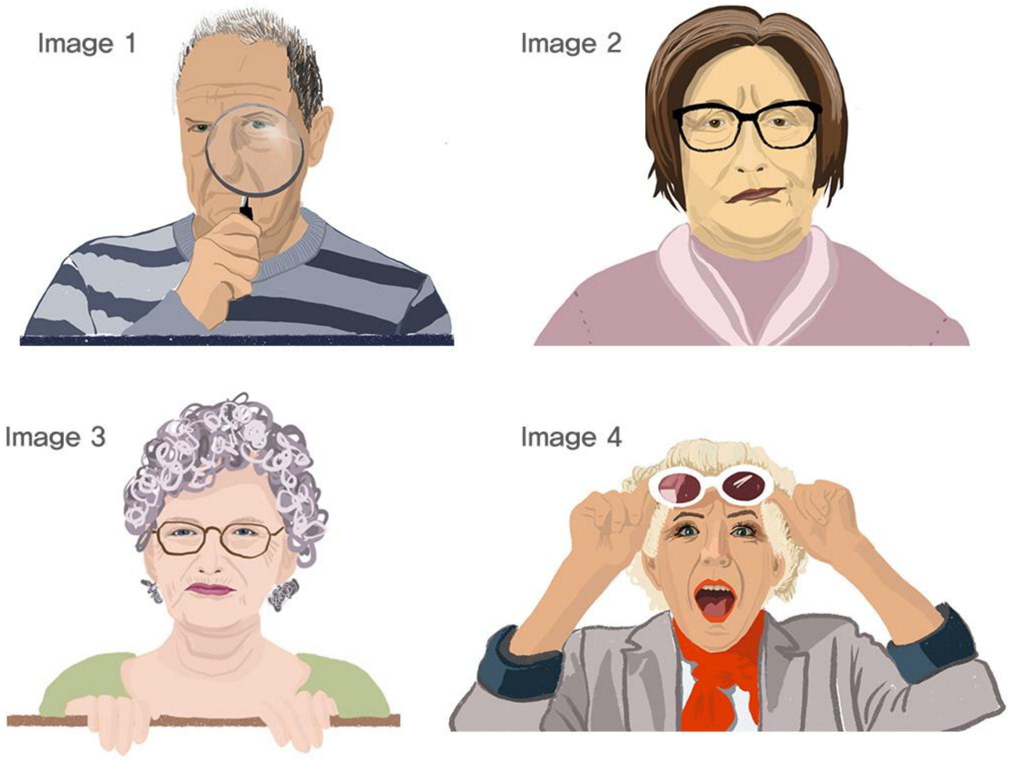

Figure 5.8 Cartoon images based on selected photographs.

5.4.5.2.3 Validation of Affective Images to Universal Human Emotions

In order to validate whether the cartoon images created (Figure 5.8) matched the emotion intended images were tested by older people. This was conducted with sixteen older people in person at Older People's Action in Locality in Horsforth and Belle Isle Senior Action in Leeds. There were eleven female and five male senior participants. The average age was 72 (the oldest 89 and the youngest 61 years old).

The older participants were shown four cartoon images (Figure 5.8). Then they were asked to write down their answer to a question: ‘Are there any words this image provokes for you?’ for each of the images. The responses collected from older participants ranged from single words to multiple sentences. In this study, only emotion related content has been selected and counted for analysis. Examples are given below.

> Find this bit creepy though probably quite innocent (68-year-old, female participant, describing image 1).

> She looks as if she disapproves of the situation perhaps by something she've been told or seen on TV (68-year-old, female participant, describing image 2).

> Curious and interested (64-year-old, female participant, describing image 3).

> The lady looks quite surprised and seems happy at what she is seeing (70-year-old, female participant, describing image 4).

The collected dataset was categorised for correlation with the eighteen emotions identified by Cordaro *et al.* (2020). A total of eleven emotion categories (Table 5.8) from among the eighteen emotions were extracted from the four images. However, the emotional words fitting into a given emotional category identified by Cordaro *et al.* (2020), and occurring most often for an image were deemed to represent the main emotion for that image from the older participants’ view point (Table 5.9).

Therefore, it was confirmed that the images created from the selected photographs matched the emotions from the human basic emotion categories that had been assumed by the researcher. These images were used in developing two types of information formats (p-cards and i-cards) for the next stage.

Table 5.8 Clustered dataset into eighteen identified emotions proposed: eleven emotions extracted.

Broad Emotion Category	Image No.	Related Basic emotions from Collected Dataset
1. Fear	1	Creepy (1)
	2	N/A
	3	Concerned (1)
	4	N/A
2. Interest	1	Inquisitive (1), Detective (1)
	2	Questioning (1)
	3	Curious (1), Interest (1), Inquisitive (1)
	4	N/A
3. Confusion	1	Confusion (2)
	2	Confusion (2), Unsure (1)
	3	N/A
	4	N/A
4. Anger	1	Grumpy (1)
	2	Disgruntled (1), Nasty (1), Trouble (1), Angry (1)
	3	N/A
	4	N/A
5. Pain	1	N/A
	2	Tired (2)
	3	N/A
	4	N/A
6. Boredom	1	N/A
	2	Fed-up (1)
	3	N/A
	4	N/A
7. Sadness	1	Unhappy (1)
	2	Sad (2), Unhappy (1)
	3	N/A
	4	N/A
8. Happiness	1	N/A
	2	N/A
	3	Pleased (1), Happy, happier, happily (6), Love (1)
	4	Happy(6), Win (1)
9. Contentment	1	N/A
	2	N/A
	3	Confidence (1)
	4	N/A
10. Surprise	1	N/A
	2	N/A
	3	N/A
	4	Surprised (5), Amazed (1), Wow (1), Shocked (1), Stunned (1)
11. Amusement	1	N/A
	2	N/A
	3	N/A
	4	Fun (1)

Table 5.9 Final emotions extracted for each image from sixteen older participants.

Image 1	Image 2	Image 3	Image 4
			
Emotions Extracted (number of occurrences)			
Confusion (2)	Anger (4)	Happiness (8)	Surprise (9)
Interest (2)	Confusion (3)	Interest (3)	Happiness (7)
Fear (1)	Sadness (3)	Contentment (1)	Amusement (1)
Anger (1)	Pain (2)	Fear (1)	-
Sadness (1)	Boredom (1)	-	-
-	Interest (1)	-	-

5.4.5.2.4 Modifying AII Design Prototype

The four images tested were used on the front of each card with one simple question which was intended to motivate design participants to try to think about older information users and challenges faced by them while reading information. Four draft designs of cards created by the researcher, were refined by the expert graphic designer in terms of their visual attractiveness and effectiveness of information legibility (Figure 5.9).

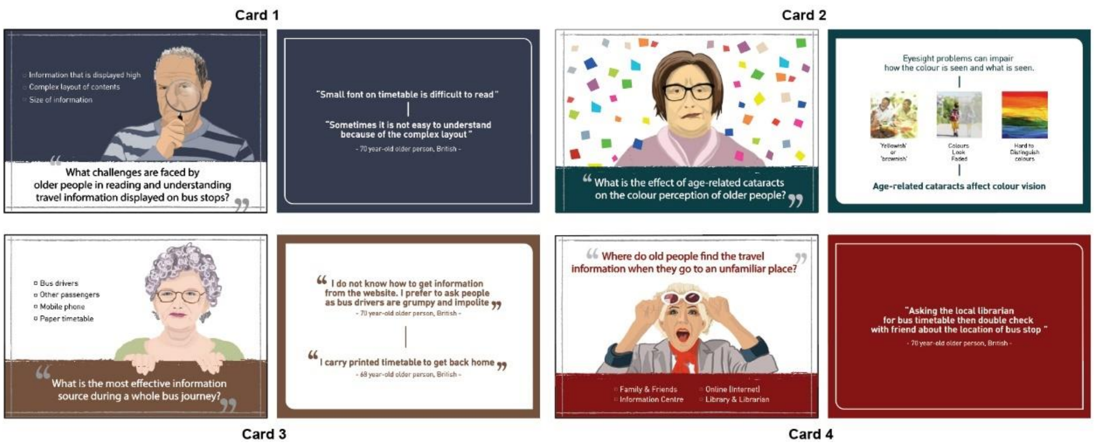

Figure 5.9 Design prototypes modified by the expert designer.

5.4.5.2.5 Formative Evaluation and Further Design Modification

The first focus group, as noted, was conducted with four information design doctoral students. One of the objectives of this group session was to conduct four aspects of evaluation for the AII prototypes (card format) (their visual style and utility as information formats) in order to develop further ideas and feedback to make the set of AII formats more appropriate.

There were four broad aspects of the evaluation (from E1 to E4) which the researcher wished to address:

- **E1. Card answer evaluation**: was the answer on the back side of the card appropriate for the question on the front?
- **E2. Card image evaluation**: did the image on the card represent the feelings participants would expect an older persons to experience in relation to a card's question and answer?
- **E3. Layout evaluation**: did each card seem to have elements such as visual language, in the right place?
- **E4. Usefulness**: did the set of cards make participants think about and search for more information user's needs compared to other types of information?

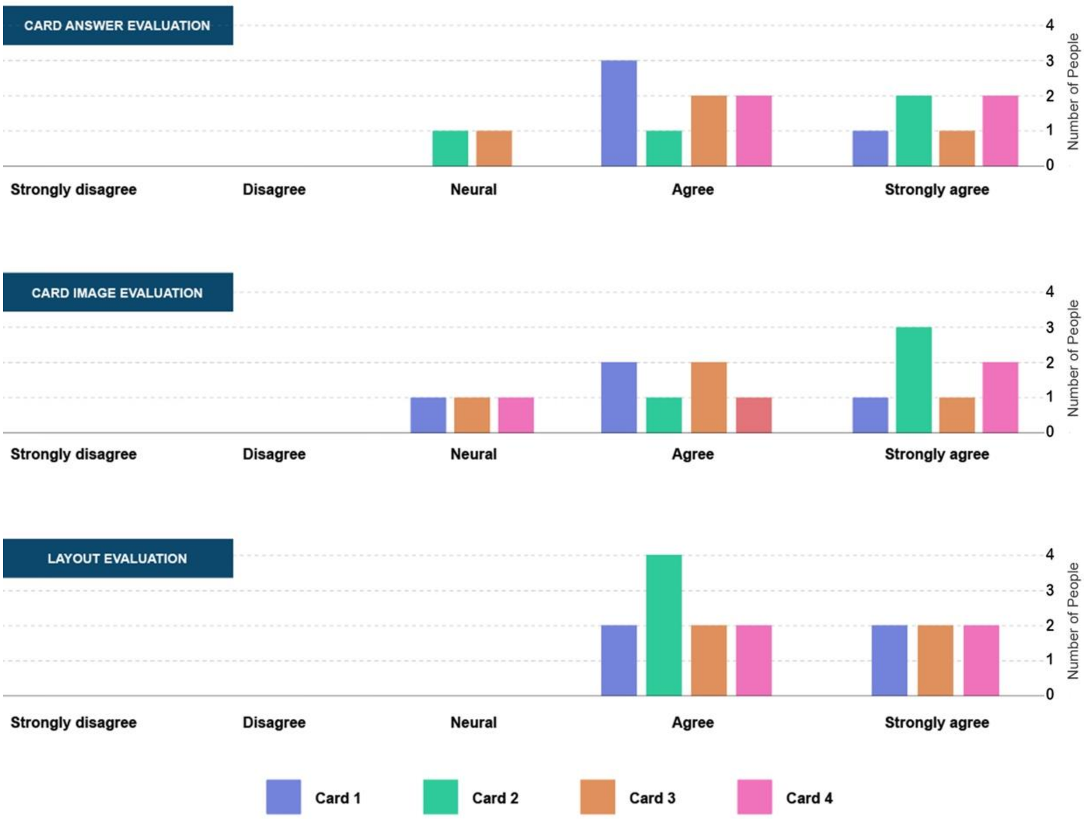

Figure 5.10 Evaluation of design prototypes by four information design doctoral students.

The AII card prototypes (Figure 5.9) were presented to the participants during the first focus group session. Participants (from F1a to F1d) were then asked to measure each card on a five-point Likert-type scale ranging through Strongly disagree, Disagree, Neutral (neither agree nor disagree), Agree, and Strongly agree in light of aspects of evaluation E1, E2, and E3. These aspects of evaluation were explained to them verbally by the researcher.

With regard to card answer evaluation (E1), all responses about cards 1 and 4 were in either the agree or strongly agree categories. As for the other prototypes, while cards 2 and 3 each received one neutral score, each card also received positive scores from three participants (Figure 5.10).

In terms of card image evaluation (E2), three out of four participants agree or strongly agree that the images used on the front side of cards 1, 3, and 4 represent older people's feelings and experiences in relation to the written contents on the card. Each of these cards also received a neutral rating. All ratings were either agree or strongly agree for card 2 (Figure 5.10).

Table 5.10 Summary of the suggestions by information design participants for further possible development of the AII information format.

Summary of Possible Suggestions	Example Quotations (during the first focus group)
▪ Remove vertical line on the back side if it has no meaning or purpose	"I cannot understand the short vertical line on the back side, I do not know why the line is here" (Participant F1d).
	"Does that mean different person? Sorry I do not like it" (Participant F1a).
▪ Do not use so many colours	"Why do you put many colour on the background of the person (card 2)? Is that celebration?" (Participant F1a).
▪ Avoid small pictures	"I think on the back side of the picture should be improve as it is quite small and complex (card 2)" (Participant F1a).
	"I agree. People might think some printing defect, not what you intended to present" (Participant F1d).
▪ Aim for layout consistency	"I prefer the card 4 front side, she is good looking. But for the back side I prefer card 1 or 4, if you combine these together" (Participant F1b).
▪ Use icons or symbols	"How about try to use some icons and simple symbols like question mark?" (Participant F1c).

For all of the cards, all respondents agree or strongly agree that layout of the card format (E3) was well presented visually (Figure 5.10). However, there was additional feedback for the modification of the format. Table 5.10 summarises the feedback from information design doctoral students and their suggestions for further possible development of the card design prototype. Adopting these suggestions by information design participants, the number of colours used were reduced and decorative elements (such as lines) were removed. For better design consistency, the front and back side of all cards was given same layout. Finally, a slightly modified set of prototype cards was developed in both physical (p-cards) and online (i-cards) forms (Figure 5.11).

The usefulness of the set of AII card formats (E4) was judged for the set of cards as a whole rather than individual cards. All responses were positive. Three respondents agreed and one strongly agreed that such a format would be useful to make them to consider and think more about information users.

The procedure for adoption of the bus route map prototypes and creation of AII card prototypes outlined so far was preparation for the next step which aimed to answer the central research questions for the chapter (see Table 5.2). The qualitative data collected by using these two sets of design prototypes during the focus groups will be analysed and described in the following section.

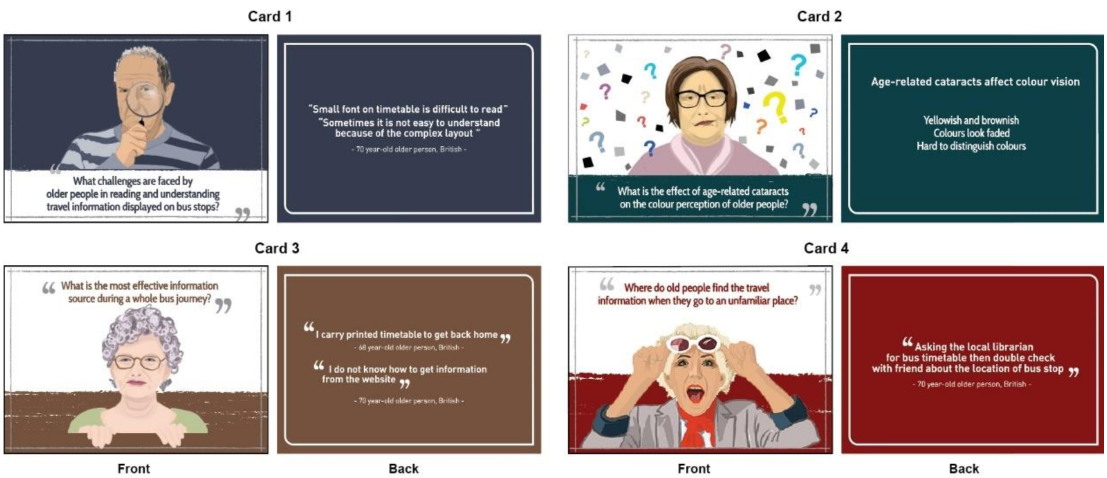

Figure 5.11 Modified design prototype.

5.5 Data Analysis Strategy

5.5.1 Application of General Inductive Approach

The decision was taken to use a qualitative data analysis approach. A general inductive method was chosen as the study's major data analysis approach. Thomas (2006) argues that one of the advantages of general inductive approach is that it helps researchers to find frequent and important themes from data without a restricting structured methodology. This author also notes that such an approach is utilised for qualitative data analysis to locate themes from raw data which are connected to the evaluation objectives. This permits themes that could arise unexpectedly to feed into the data analysis while the data is being coded (Roberts *et al*., 2019). In the present research the features of the collected data from the focus group interviews were highly qualitative and descriptive in nature. In order to generate themes and categories to identify relationships and establish hierarchical links between them, a general inductive approach was regarded as the most appropriate data analysis strategy. The transcribed qualitative data was thematically analysed within the inductive approach described below.

5.5.2 Data Coding and Analysis Procedure

The data analysis was conducted thematically within five steps after reviewing other scholars' suggestions for the TA process (see Table 3.11 in section 3.4.3.1). These steps are (1) immersion in dataset, (2) identifying codes, (3) developing thematic categories, (4) constructing themes (reviewing, refining, and defining), and (5) presenting findings.

5.5.2.1 Immersion in Dataset

5.5.2.1.1 Transcribing and Annotating

The raw data from the focus groups was transcribed (from audio to text) into two Microsoft Word documents. An initial indication of important and relevant features was gained by manually colour coding and annotating printouts of transcripts. The transcribed document was re-read line by line in order to get intimately familiar with the data. In addition to this, the Word transcriptions were re-formatted to facilitate the next step which was coding using qualitative data analysis software (QSR NVivo12 Plus was utilised in this research).

5.5.2.2 Identifying Codes

5.5.2.2.1 Selection of Coding Strategy and Method

Saldaña (2009, p.3) states that coding most frequently involves using single words or phrases that reflect “a summative, salient, essence-capturing, and/or evocative attribute” to parts of linguistic or visually presented data. Coding is a “heuristic” (Saldaña, 2011, p.95), which frequently involves combining highly focused textual analysis of some sections of data with rougher summaries and classifications for other sections (Flick, 2009). Coding helps the researcher or interpreter in focusing on significant characteristics of the dataset *(*Nowell *et al*., 2017).

There are at least thirty types of coding methods documented by Saldaña (2016). For this part of the study, mainly ‘descriptive’ coding and ‘in vivo’ coding were selected at the earliest stage of coding, and after that ‘theming the data’ were selected for the code formation.

The primary means of ‘descriptive’ coding is through the use of nouns which represent topics within the data (Miles and Huberman, 1994 cited in Saldaña, 2011). Within the ‘in vivo’ coding approach, data units are described using an actual word or phrase spoken by the participants (Onwuegbuzie *et al*., 2016). Such ‘in vivo’ coding permits insights into participant communication about entities or concepts because units of code are developed using the very utterances of the participants (Castleberry and Nolen, 2018). The third method, ‘theming the data’ is used to “identify codes in the form of sentences capturing the essence and essentials of participant meanings” (Onwuegbuzie *et al*., 2016, p.135).

5.5.2.2.2 Storing Coding in Nodes

In NVivo, coding is stored within nodes. According to (QSR international, 2020a), a node contains collected references to single themes, cases or relationships. References are gathered together through sources being coded to nodes (QSR international, 2020a). In this study, to generate initial codes, the coded texts were assigned to nodes using the NVivo program by keeping details of the research questions in mind (Figure 5.12).

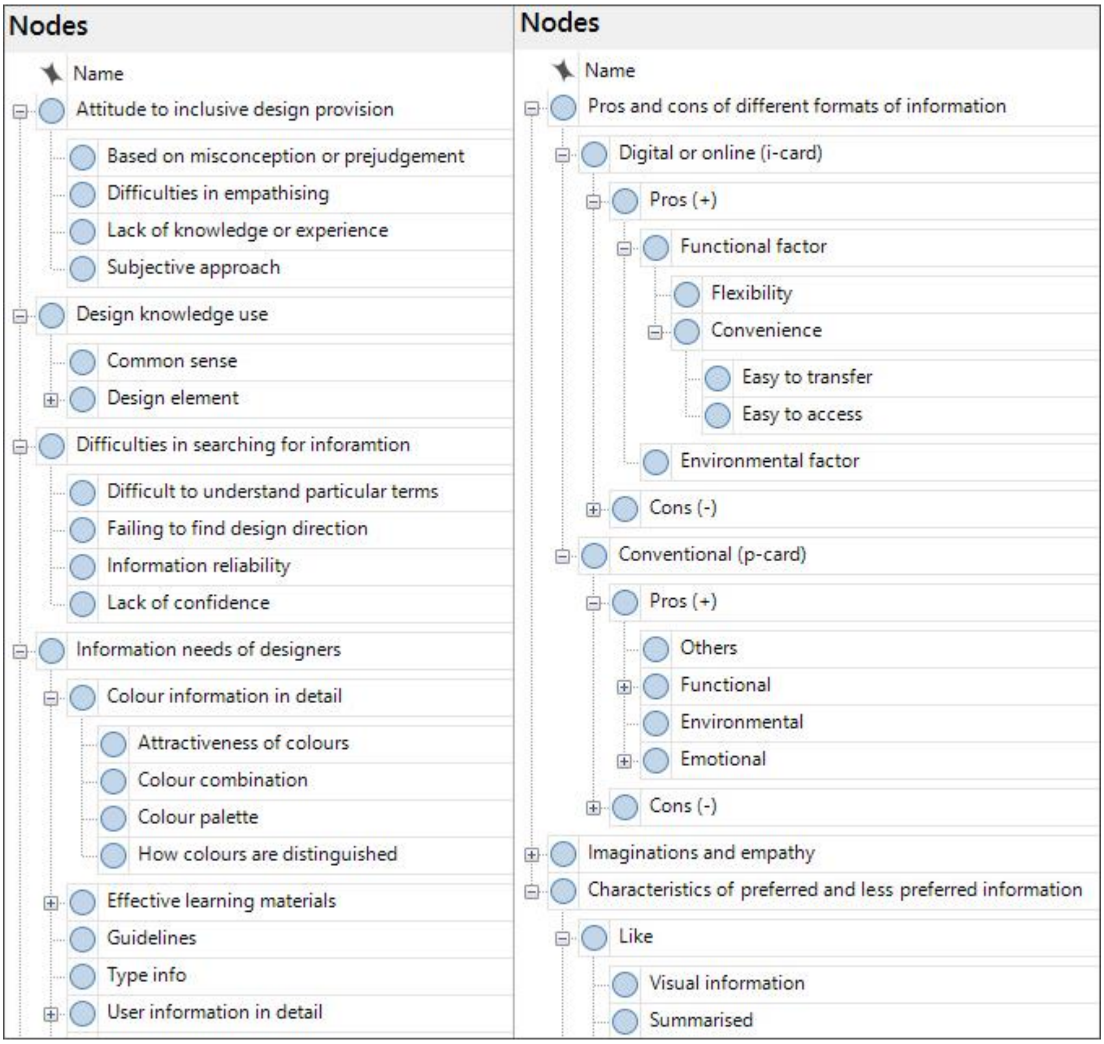

Figure 5.12 Early coding process: node structure of part 1 (left) and part 2 (right) of the focus groups.

5.5.2.2.3 Formulating Codes

As outlined early in this chapter, there were two main topics for the focus group interviews (Table 5.11). Data from each topic from focus groups were coded and compared using NVivo 12 program.

Table 5.11 Overview of data analysis process adopting TA method in this study.

Section	Topic	Data Collection	Inductive Data Analysis Approach
Part 1	Colour information and inclusion	First focus group	Comparison contrast classification synthesis
		Second focus group	
Part 2	Effective information presentation consideration	First focus group	Comparison contrast classification synthesis
		Second focus group	

Every single line of transcription was looked at closely to generate codes. Codes were generated inductively without a pre-set coding framework. While clustering nodes, initial codes were listed based on common properties in a hierarchical order (Figure 5.12). Similar codes were merged, but others were grouped to produce higher-order codes while coding the data.

The comparison diagram below illustrates the list of initial codes which came from one or other or both focus groups (Figure 5.13). In the diagram, the codes listed in the red dashed section came from the first focus group. The codes in the green dashed area connect to the second focus group. The common codes from both groups are located in the black dashed area.

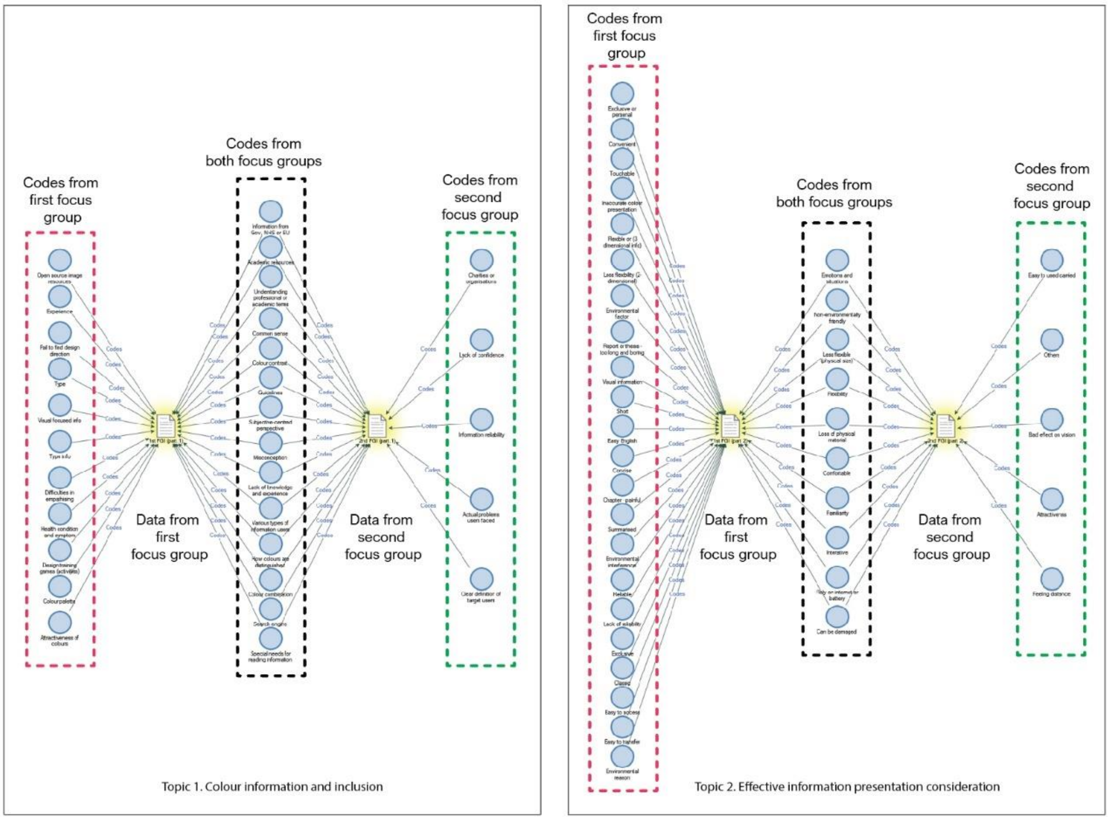

Figure 5.13 Comparison diagram showing which codes came from one or other or both focus groups (using NVivo 12 program).

The coded data in each group was compared by applying a matrix query and comparison diagram on NVivo. Table 5.12 refers to the density (number of occurrences of a coded feature) of coded data in each part of focus group from the first and second focus groups respectively. Thus, the matrix query permitted comparison of generated codes in each focus group in a numeric table with shading (of a yellowish green) with light shading indicating lower numbers of occurrences and dark indicating higher occurrences.

Table 5.12 Matrix coding for initial codes comparison (using NVivo12 program).

Initial Code (Part 1)	1st FGI	2nd FGI	Initial Code (Part 2)	1st FGI	2nd FGI
1 : Flexibility	1	1	1 : Search engine	1	2
2 : Easy to transfer	1	0	2 : Open source image resources	1	0
3 : Easy to access	1	0	3 : Administrative (Gov, NHS or EU)	2	2
4 : Environmental factor	1	0	4 : Experience	1	0
5 : Rely on internet or battery	2	2	5 : Charities or organisations	0	2
6 : Environmental interference	1	0	6 : Academic resources	1	1
7 : Bad effect on vision	0	1	7 : Visually focused information	2	0
8 : Less flexibility (2-dimensional)	1	0	8 : Various types of information users	1	3
9 : Lack of reliability	2	0	9 : Special needs for reading information	1	3
10 : Feeling distance	0	1	10 : Health condition and symptom	1	0
11 : Others	0	3	11 : Clear definition of target users	0	3
12 : Interactive	1	1	12 : Actual problems users faced	0	1
13 : Flexible (3 dimensional info)	1	0	13 : Type info	3	0
14 : Convenient	1	0	14 : Guidelines	1	1
15 : Easy to use	0	3	15 : Design training games (activities)	1	0
16 : Environmental reason	1	0	16 : How colours are distinguished	1	5
17 : Touchable	3	0	17 : Colour palette	1	0
18 : Reliable	2	0	18 : Colour combination	1	1
19 : Familiarity	1	1	19 : Attractiveness of colours	2	0
20 : Personal	1	0	20 : Lack of confidence	0	1
21 : Exclusive	2	0	21 : Information reliability	0	1
22 : Comfortable	1	1	22 : Fail to find design direction	1	0
23 : Classic	1	0	23 : Difficult to understand particular terms	1	1
24 : Attractiveness	0	2	24 : Typographical features	2	0
25 : Non-environmentally friendly	2	1	25 : Colour contrast	4	4
26 : Loss of physical material	2	2	26 : Common sense	5	2
27 : Less flexible (physical size)	2	1	27 : Subjective perspective	2	7
28 : Inaccurate colour presentation	3	0	28 : Lack of knowledge or experience	1	3
29 : Can be damaged	1	1	29 : Difficulties in empathising	1	0
30 : Emotions and situations	25	19	30 : Based on misconception or prejudgement	2	2
31 : Visual focused information	2	0			
32 : Summarised	1	0			
33 : Short	2	0			
34 : Plain English	1	0			
35 : Concise	1	0			
36 : Too long and boring	1	0			
37 : Chapter - painful	1	0			

As shown in Figure 5.13 (comparison diagram) and Table 5.12 (matrix coding), there are common features and differences in codes. However, it was judged that there were no significant differences in codes between the two focus groups for each topic. This is because all of these codes can be included in one of the thematic categories listed in Table 5.13 below.

5.5.2.3 Developing Thematic Categories

Detailed classification and decisions about categorisation of responses were undertaken during the coding process based on similarity of features. There are eight themes categorised from both focus groups (Table 5.13). All codes were subsumed under one of the eight thematic categories. These eight meaningful groups help the researcher to produce hierarchies and aggregation between codes systemically in order finally to identify the study's themes. These categories were further refined and classified for superordinate and subordinate order during the data analysis process (see Table 5.14).

Table 5.13 Eight identified categories at each part of focus groups.

Section of Focus	Thematic Category
1. Colour information and inclusion	Attitude to inclusive design provision.
	Designers' knowledge use.
	Information needs of designers.
	Designers' use of information sources.
	Difficulties: searching for, using, and understanding information.
2. Effective information presentation consideration	Factors in information format choice.
	Characteristics of preferred/disfavoured information.
	Imagination and empathy.

5.5.2.4 Constructing Themes (Reviewing, Refining, and Defining)

The eight thematic categories identified in the previous stage were used to draw a concept map (Figure 5.14). The concept map was drawn considering qualities and features of each thematic category according to the chapter's major aims. It visualises the relationship and hierarchy among thematic categories. Thus, there are five superordinate thematic and three subordinate categories. This hierarchical thematic structure arising in the concept map will be utilised to list the main and sub themes in the next step (see Table 5.14). Within this thematic structure, themes either merge into each other or split into separate themes in minute detail.

Figure 5.15 illustrates the process of generating themes by applying in vivo coding, descriptive coding, and thematic coding techniques in this research. Themes were generated from a literal level to interpretive understanding through the thematic category development. The outcomes are shown in Table 5.14 where themes and subthemes are presented in line with each thematic category.

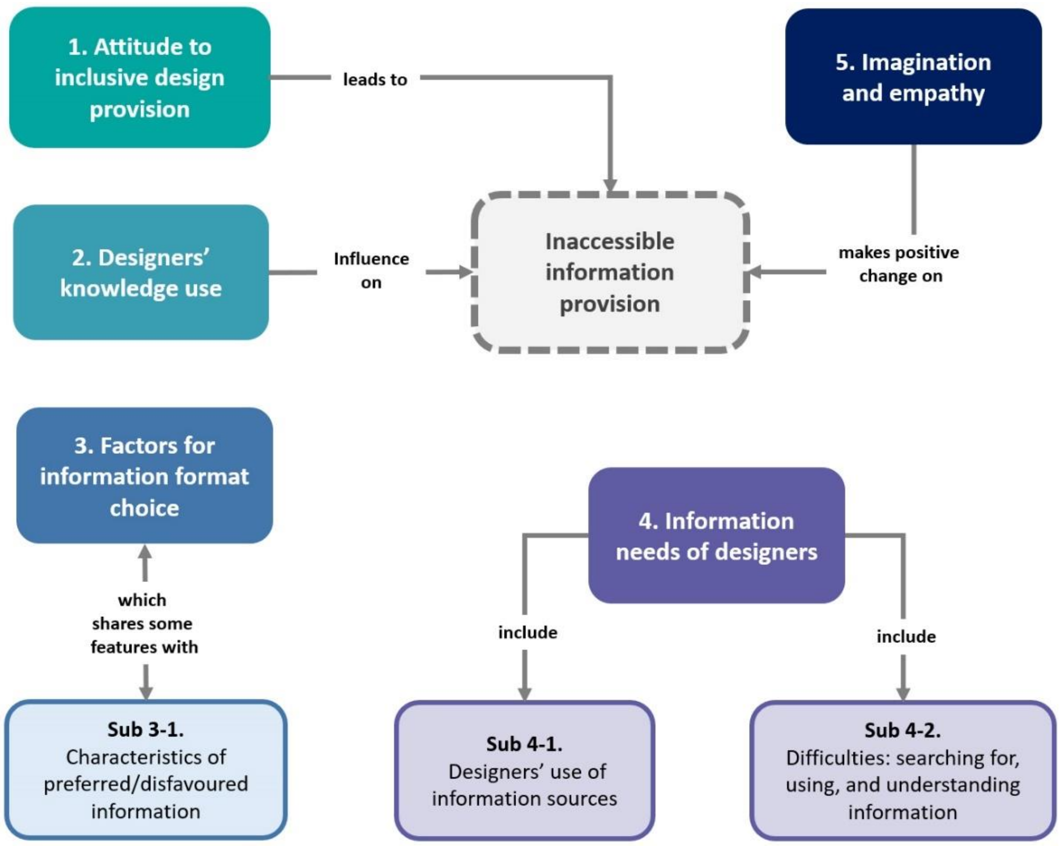

Figure 5.14 Synthesised theme-driven concept map showing the relationship among thematic categories.

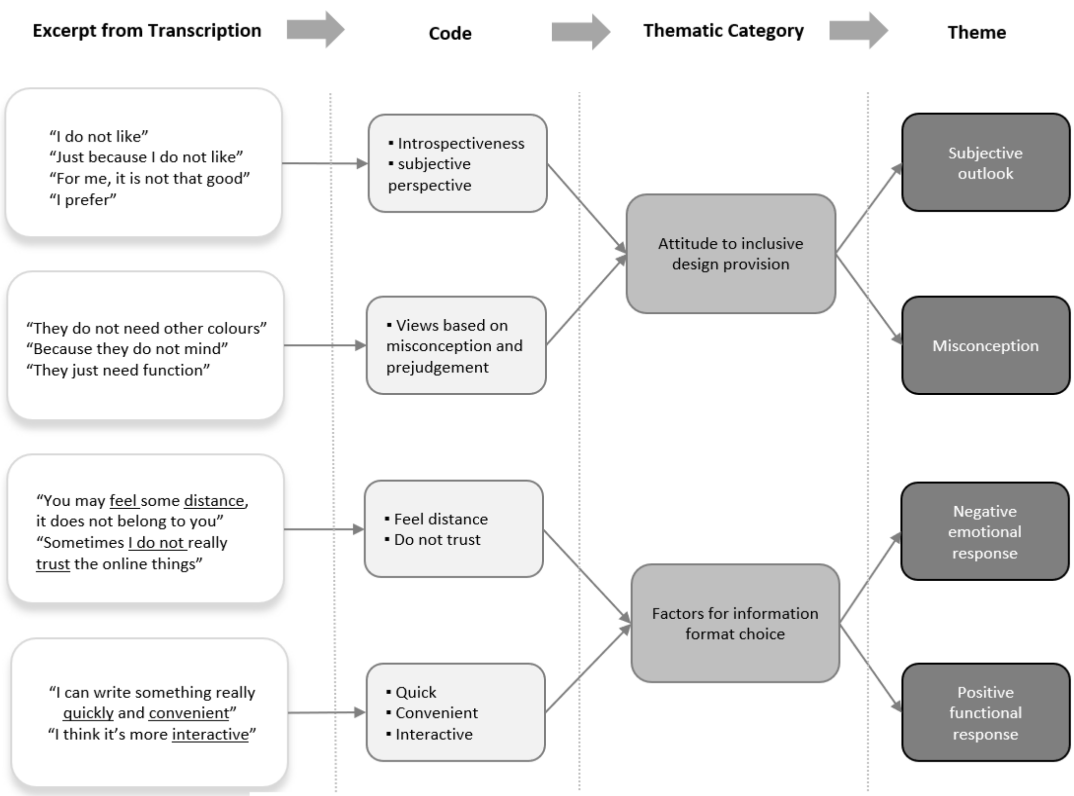

Figure 5.15 Direction of data analysis: codes, thematic categories, and themes development using data from focus groups.

Table 5.14 Thematic categories, themes, and related research sub-questions.

<table>
<tr><th colspan="6">Themes at Each Thematic Category
& Related Research Questions</th></tr>
<tr><th colspan="3">Thematic Category 1
Attitude to inclusive design provision</th><th colspan="3">Thematic Category 2
Designers’ knowledge use</th></tr>
<tr><td colspan="2">Subjective outlook</td><td rowspan="4">RQ sub-5.1 and sub-5.2</td><td colspan="2">Common sense</td><td rowspan="4">RQ sub-5.3</td></tr>
<tr><td colspan="2">Misconception</td><td colspan="2">Experience (personal)</td></tr>
<tr><td colspan="2">Lack of knowledge</td><td colspan="2">Basic design knowledge</td></tr>
<tr><td colspan="2">Lack of experience</td><td colspan="2">-</td></tr>
<tr><th colspan="6">Thematic Category 3
Factors for information format choice</th></tr>
<tr><td colspan="5">Physical information format (p-card)</td><td rowspan="19">RQ sub-5.4</td></tr>
<tr><td rowspan="11">Positive</td><td colspan="4">▪ Emotional response</td></tr>
<tr><td>Attractiveness</td><td>Aesthetic</td><td colspan="2">Comfortable</td></tr>
<tr><td>Personal</td><td>Familiarity</td><td colspan="2">Reliability</td></tr>
<tr><td>Touchability</td><td>Exclusivity</td><td colspan="2"></td></tr>
<tr><td colspan="4">▪ Functional response</td></tr>
<tr><td>Convenience</td><td>Interactivity</td><td colspan="2">Flexibility
(3D information)</td></tr>
<tr><td colspan="4">▪ Environmental response</td></tr>
<tr><td colspan="4">Recyclable</td></tr>
<tr><td colspan="4">▪ Other</td></tr>
<tr><td colspan="4">Less impairing to eyes</td></tr>
<tr><td rowspan="7">Negative</td><td colspan="4">▪ Physical response</td></tr>
<tr><td>Size is fixed</td><td>Bad colour quality</td><td colspan="2">Easy to be damaged</td></tr>
<tr><td colspan="4">▪ Environmental response</td></tr>
<tr><td colspan="4">Not eco-friendly</td></tr>
<tr><td colspan="4">▪ Other</td></tr>
<tr><td colspan="4">Easy to lose</td></tr>
<tr><td colspan="5">Online and digital information format (i-card)</td><td rowspan="13">RQ sub-5.4</td></tr>
<tr><td rowspan="4">Positive</td><td colspan="4">▪ Functional response</td></tr>
<tr><td colspan="2">Convenient</td><td colspan="2">Flexibility (size)</td></tr>
<tr><td colspan="4">▪ Environmental response</td></tr>
<tr><td colspan="4">Eco-friendly</td></tr>
<tr><td rowspan="7">Negative</td><td colspan="4">▪ Functional response</td></tr>
<tr><td colspan="4">Less flexibility (two-dimensional information)</td></tr>
<tr><td colspan="4">▪ Emotional response</td></tr>
<tr><td colspan="2">Feeling distance</td><td colspan="2">Relies on battery</td></tr>
<tr><td colspan="4">▪ Other</td></tr>
<tr><td colspan="2">Environmental interference</td><td colspan="2">Relies on battery</td></tr>
<tr><td colspan="2">Relies on internet environment</td><td colspan="2">Bad effect on vision</td></tr>
</table>

(continued)

<table>
<tr><td colspan="5">Thematic Category 3-1 (sub)
Characteristics of preferred (+) and disfavoured (-) information</td></tr>
<tr><td rowspan="2">Positive</td><td>(+) Visual</td><td>(+) Short</td><td>(+) Summarised</td><td rowspan="3">RQ
sub-5.4
sub-5.5</td></tr>
<tr><td>(+) Concise</td><td colspan="2">(+) Non-complex English</td></tr>
<tr><td>Negative</td><td>(-) Boring</td><td>(-) Long</td><td>(-) Painful</td></tr>
<tr><td colspan="5">Thematic Category 4
Information needs of designers</td></tr>
<tr><td colspan="4">Visual information</td><td rowspan="6">RQ
sub-5.3</td></tr>
<tr><td colspan="4">User information in detail</td></tr>
<tr><td colspan="4">Colour information</td></tr>
<tr><td colspan="4">Typographical features</td></tr>
<tr><td colspan="4">Effective learning materials</td></tr>
<tr><td colspan="4">Guidelines</td></tr>
<tr><td colspan="5">Thematic Category 4-1 (sub)
Designers’ use of information sources</td></tr>
<tr><td colspan="4">Image archive</td><td rowspan="5">RQ
sub-5.3</td></tr>
<tr><td colspan="4">Administrative (Gov, NHS, or EU)</td></tr>
<tr><td colspan="4">Organisations/Charities</td></tr>
<tr><td colspan="4">Search engines</td></tr>
<tr><td colspan="4">Academic resources</td></tr>
<tr><td colspan="5">Thematic Category 4-2 (sub)
Difficulties: searching for, using, and understanding information</td></tr>
<tr><td colspan="4">Information reliability</td><td rowspan="5">RQ
sub-5.3</td></tr>
<tr><td colspan="4">Lack of confidence</td></tr>
<tr><td colspan="4">Failing to search for design directions</td></tr>
<tr><td colspan="4">Difficulties understanding professional/academic terms</td></tr>
<tr><td colspan="4">Difficulties in empathising</td></tr>
<tr><td colspan="5">Thematic Category 5
Imagination and empathy</td></tr>
<tr><td colspan="4">Imagining user's emotion</td><td rowspan="2">RQ sub-5.5</td></tr>
<tr><td colspan="4">Imaging user's situation</td></tr>
</table>

5.5.2.5 Presenting Findings

Codes, thematic categories, and themes were generated during the data analysis across the entire dataset. In section 5.6, detailed interpretation, key findings, and their implications will be determined by organising theme-driven formats (focused on the most important themes) and also including evidence (extracted excerpts) from the dataset. However, it should be noted that most participants did not have English as their first language and this may impact on the grammar of quotations at times.

5.5.3 Evaluation of Data Coding and Analysis Approaches

Credibility and trustworthiness were constructed in several ways in the present study. Firstly, the data analysis procedure was designed by applying a range of closely related qualitative coding approaches within the five-stages in this study. Four different qualitative data coding processes were compared and analysed in terms of common properties at each of their own stages (see Table 3.11), then synthesised before implementing data analysis. Each part of the data analysis process was described in chronological order within the five-phase framework used and included relevant figures and tables (although the data analysis process was fully iterative). In addition to this, excerpts from the transcribed data (participants' actual language) were shown as illustrative evidence. Lastly, transcriptions were checked by a native English-speaking person to make sure that there were no mistakes made during the transcription process (see section 3.6.2.1) before the analysis process started. All these efforts strengthen the reliability of this study.

5.6 Results and Discussion

Emergent themes in the data analysis can be counted as answers to the research questions within this chapter. Themes will be denoted in bold. The overall implications of the findings will be discussed here as well.

5.6.1 Reasons behind Consistently Produced Inaccessible Information

It is indispensable to examine what design participants know and think about accessible information provision, and how they apply design elements for designing information for people with a range of physical and cognitive abilities. To examine this, two associated research sub-questions were asked during the focus groups.

RQ sub-2.1.2 What colours will be proposed by designers regarding information provision for vision and colour vision impaired people?

Misconceptions among Design Participants

Colours can be used to draw people's notice, enhance recognition, and help in the organisation of information (Nilsson, 2006a). The use of effective colour schemes in information provision may be more important for people with visual impairments and colour vision deficiency than for those without such difficulties. To improve information accessibility, colour contrast may be a crucial issue.

Design outcomes can be thought of as the final decisions made by design professionals (Ahmed *et al*., 2003). By exploring how design participants apply colours during user-focused colour application tasks, it is likely that we could discover the concrete reasons for why designers produce inaccessible information provision in user-focused colour design contexts. In order to examine designers' knowledge and thoughts about the use of colour for various users, design participants were asked to suggest colour coding as a part of information legibility for both colour and vision impaired users respectively. For this task, the researcher converted the four-prototype bus route design samples (see Figure 5.6) into grey mode using the program Adobe Photoshop in advance. These were presented to the design participants during the focus group sessions.

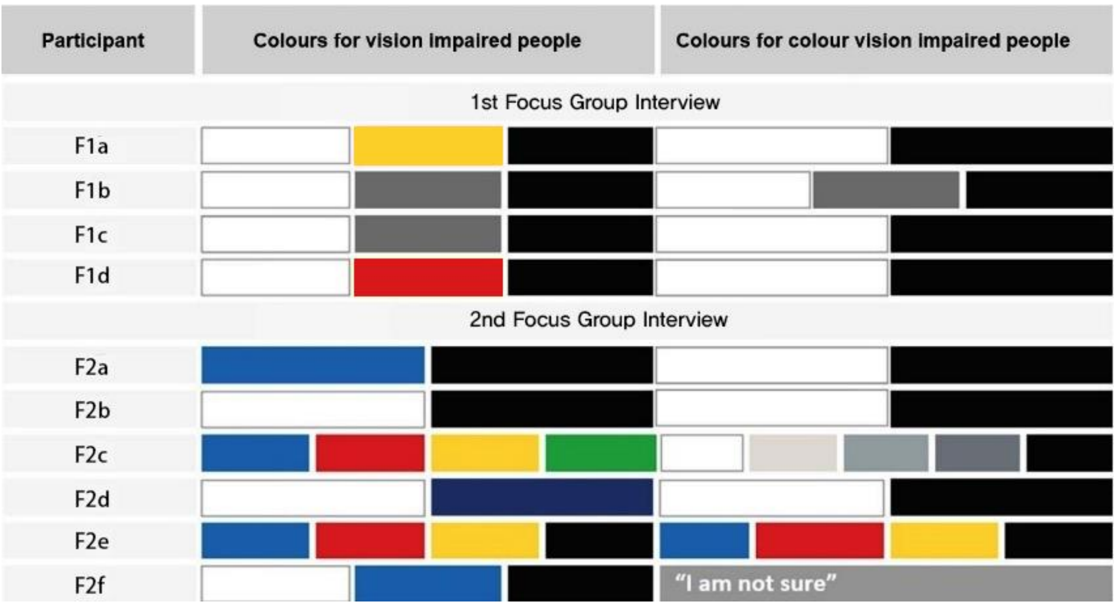

Figure 5.16 Design participants' colour coding suggestions for vision and colour vision impaired people respectively.

Figure 5.16 illustrates the colour suggestions made by each of the ten design participants for visual legibility. Despite making colour-coding suggestions, they were not likely to think in-depth about the difficulties faced by target users in seeing/distinguishing colours.

In terms of colour suggestions for people with vision impairment, participant responses included the comments below:

> In my mind, I will just use black and white colours for the design because they do not mind what colours we use, they just want to read it clearly. We can just add some colourful logos for small details. We can choose the main colour, black and white (Participant F2d).

> In terms of colours, I guess I use a high contrast for colours. I am not sure about the colour for vision impaired people (Participant F2a).

When asked about colour suggestions for colour blind information users the responses included the following:

> They see certain colours looking quite similar. I am not really sure what colour combination to avoid for colour blindness, so I do not really know (Participant F2f).

> I am not sure if colour blind people cannot see black (Participant F2e).

It was found that most of the design participants have difficulty and also misconceptions in terms of using colour coding for various user groups who face difficulties in seeing and distinguishing colours. When discussing colour, they only (or primarily) considered colour blindness despite being asked to consider both visual impairment and colour vision impairment. Designers' misconceptions regarding information users and use of an essential design element for them (colour in this context) could provide an answer to one of the study's central research questions (RQ 2-1). Use of inappropriate colours, which arises from designers' misconceptions, may produce negative results in reading information for vision and colour vision impaired people more than other user groups. Design participants may need to be helped to recognise and overcome these misconceptions through appropriate methods or providing appropriate materials to them.

RQ sub-2.1.2 What do design participants predict about the needs of various information users, in comparison to what target users actually do need in relation to information accessibility?

Subjective Outlook

After the colour suggestion stage described above, the coloured printed bus route prototypes were shown to design participants in their four forms (see Figure 5.6). Participants were instructed to select which type of design would be most and least preferred by vision and colour vision impaired information users. The designs selected by design participants were different from those chosen by these information users. Only one design participant selected design type B – the design most preferred by the users. Otherwise, the rest of them found it hard to guess the most and least preferred design selected by the users (Table 5.15).

Table 5.15 Predictions of designers regarding vision/colour vision impaired users' most and least preferred prototypes (matches with visually impaired preference shaded in grey).

	First Group Session				Second Group Session					
Participant code	F1a	F1b	F1c	F1d	F2a	F2b	F2c	F2d	F2e	F2f
Most preferred	A	C	A	B	A	A	C	A	A	A
Least preferred	C	A	D	C	D	D	B	D	C and D	D

During both group sessions, it was repeatedly observed that most of the design participants talked about their own preference rather than carefully considering the task to consider what target user groups (vision and colour vision impaired people) would choose. Examples are below.

> <u>I prefer</u> […] A. A and C are quite similar. Others are messy with too much information. A is more clearly organised [than the others] (Participant F2a).

Similar characteristics were revealed by other participants as well.

> I think that's D. Yeh, <u>just because I do not like it</u>. Listed side to side (Participant F2f).
>
> <u>I do not like</u> B (Participant F2b).
>
> <u>I do not like</u> black background (Participant F1b).
>
> Because this is very well-organised so <u>I can search</u> the category first and then <u>I can see</u> the contents (Participant F2b).

Their attitude was emphasised by frequent use of the first-person pronoun 'I' and the first-person possessive 'my', and utterances of the form 'I prefer to [X]', or 'I like [X]'. Similar characteristics were found in Chapter Four where design participants often tended to be distracted from a set task during a design experiment. It was revealed that participants with a design background focused upon what they preferred rather than seeing a task objectively. This characteristic of designers may impact on their designs reducing their orientation towards users.

Lack of Education and Experience about Design Inclusion

Among the design participants in this study, none of them had been taught design for a range of users at different cognitive and physical levels during the course of their education, even though they were now studying design at the highest level of design education.

Apart from participant F1d whose doctoral study was based on inclusive information and environments for vision impaired people, other participants had no experience of design or research projects taking such users into consideration. It is noteworthy that participant F1d was the only participant to correctly identify users most and least preferred design prototypes (Table 5.15). This could serve as evidence that lack of experience in education or design research and projects in this area may be one factor that causes designers to produce inaccessible designs.

An experiment using ten design participants may be small for generalisations. However, what we draw from the findings here are a lack of knowledge, education, and research experience regarding a wider range of information end-users, and that an introspective feature of designers during design tasks may lead them to design based on their own intuition with inadequate consideration for these users. There is in fact a huge gap between what designers assume and the actual needs of target users.

5.6.2 Features of Colour Information Sources that Designers Actually Accessed

RQ sub-2.3.1 Where do design participants search for user-related colour information for people with colour and vision impairment? Do they face any difficulties faced while doing this? What information do they need?

Prior to the focus group sessions, participants were notified by email that they needed to bring their own information search tools. Personal laptops, tablets, and mobile phones were used to obtain user-related colour information during the group sessions.

Participants were set the task of searching for information if they thought they needed it to design for colour vision and vision impaired information users during the web search task. During the web search task, participants were asked to record which search terms they had used as well as which websites they had visited, and make any other comments about their experience of the task. This was because by collecting key terms, it would be possible to gain data about what types of information design participants believed they needed.

In addition, by examining the information on web sites visited, the researcher was able to gain insights into the available information currently used. Also, participant experience would reveal important information about their needs.

Four Main Information Needs Revealed by Design Participants

As noted, design participants were set the task of taking notes about searched terms, websites visited and their experience of the task. The collected data was written in noun form or sentences. These data were grouped for common features and the number of mentions were counted. The findings could be interpreted as what designers would like to know when they try to design for colour or vision impaired information users. They can be broken down into four broad categories, as shown in Table 5.16.

Table 5.16 Information needs of designers established by clustering key terms used by design participants.

Category	What Design Participants Want to Know	Number of Mentions
Colour information detail	Colour combination	3
	Attractiveness of colour	1
	How colours are distinguished	4
	Colour palette	2
Design guidelines	How to design for vision impaired people	2
	Design elements (type and colour use)	2
	Visual guidelines and examples	2
Effective learning materials	Design training games (activities)	1
User information	Special needs for reading information	2
	Clear definition of information users	6
	Actual problems users faced while reading	2

In particular, when we consider detailed colour information that designers would like to know, four of ten participants mentioned the issue of how colours are distinguished by different information users. Because designers do not have colour or vision impairments in general, it may be difficult for them to understand and empathise with different types of information readers in terms of what challenges they confront in daily reading situations.

During the group session, participant F1a indicated:

> I just feel that <u>it is difficult to imagine that I am the visually impaired person</u>.

Such a quotation clearly shows that there is a need for guidance for designers about the experience of different types of information users.

As regards actual online information sources where design participants visited to search for information, this is shown in Table 5.17. They accessed various websites which could be classified into five types. These included administrative sites. It is likely that participants sought guidelines or regulations when visiting these sites but they did not say so. One participant (F2e) accessed an organisation website such as Korea Blind Union. She presumably tried to look for user information in detail.

So where do they search for colour information when designing for various information users? Image archives were used for this purpose with short descriptions for images. However, there was no clear colour information providing website to facilitate designers to think about designing information for vision and colour vision impaired users.

Table 5.17 Online information sources design participants used during the task of searching for user related colour information.

Category	Visited Online Source	Name of Website
Administrative (Gov, NHS, or EU)	accessibility.blog.gov.uk	Accessibility in Government
	ghr.nlm.nih.gov	U.S. National Library of Medicine
	nhs.uk	National Health Service
	ict4ial.eu	Information Accessibility for Learning
Academic resources	library.leeds.ac.uk	University of Leeds library
	scholar.google.com	Google scholar
Image archive	behance.net	Behance
	pinterest.co.uk	Pinterest
Search engine	google.com	Google
Organisation	kbuwel.or.kr	Korea Blind Union
	nibs.org	National Institute of Building Sciences
	webaim.org	Web accessibility in mind

Five Difficulties that Design Participants Stated

At the final stage of the web search task, participants were asked to speak about barriers and difficulties confronted in terms of finding information. Several challenges were mentioned as emerging during information searching task. These may be divided into five classes. Table 5.18 shows these five classes with clear evidence of what was actually stated during the focus groups. Firstly, it was revealed that information reliability is one important concern among design participants. Some participants did not have confidence in themselves in terms of looking for appropriate information for designing for vision and colour vision impaired information users. Understanding academic or professional terms from other disciplines was also recognised as one of the challenges for them. There were certainly attempts to search for visually presented design directions or concepts to meet the needs of vision and colour vision impaired information users, but it was hard to find them for design participants.

Table 5.18 Five identified difficulties (in terms of searching for, using, and understanding information).

Difficulties	Excerpt from Data Corpus
Information reliability	“I do not know what information I exactly need to design for them because I do not have knowledge whether the website I searched for, or material is reliable” (Participant F2c).
Lack of confidence	“I am just wondering if it is correct information or not. I think I need professional information, but I am not sure” (Participant F2e).
Understanding professional terms from other disciplines	“Academic terms are too professional to understand” (Participant F1a).
	“In some case, it would show me some academic papers about what I searched. It is not easy for me to read these professional academic papers and find the answers” (Participant F2d).
Failure of search for design direction	“I tried to find the direction or concept of design for colour and vision impaired people, but I could not do that” (Participant F1c).
Difficulties in empathising	“I just feel that it is difficult to imagine that I am the visually impaired person” (Participant F1a).

As demonstrated earlier in section 5.6.1, there are various factors which cause designers to create information which is inaccessible. The discussion that follows will demonstrate that these factors link together in complex ways. There seems to be a clear connection between the five categories of difficulty experienced by design participants identified during the web search task (listed in Table 5.18 and displayed in Figure 5.17) and designers producing inaccessible information. The statements of seven out of ten design participants related to the factor of subjective perspectives (subjective outlook) in Figure 5.17. An implication of these points is the possibility that various factors need to be integrated to better understand designers' information use and make positive changes to allow them to create more accessible information in an inclusive information design context.

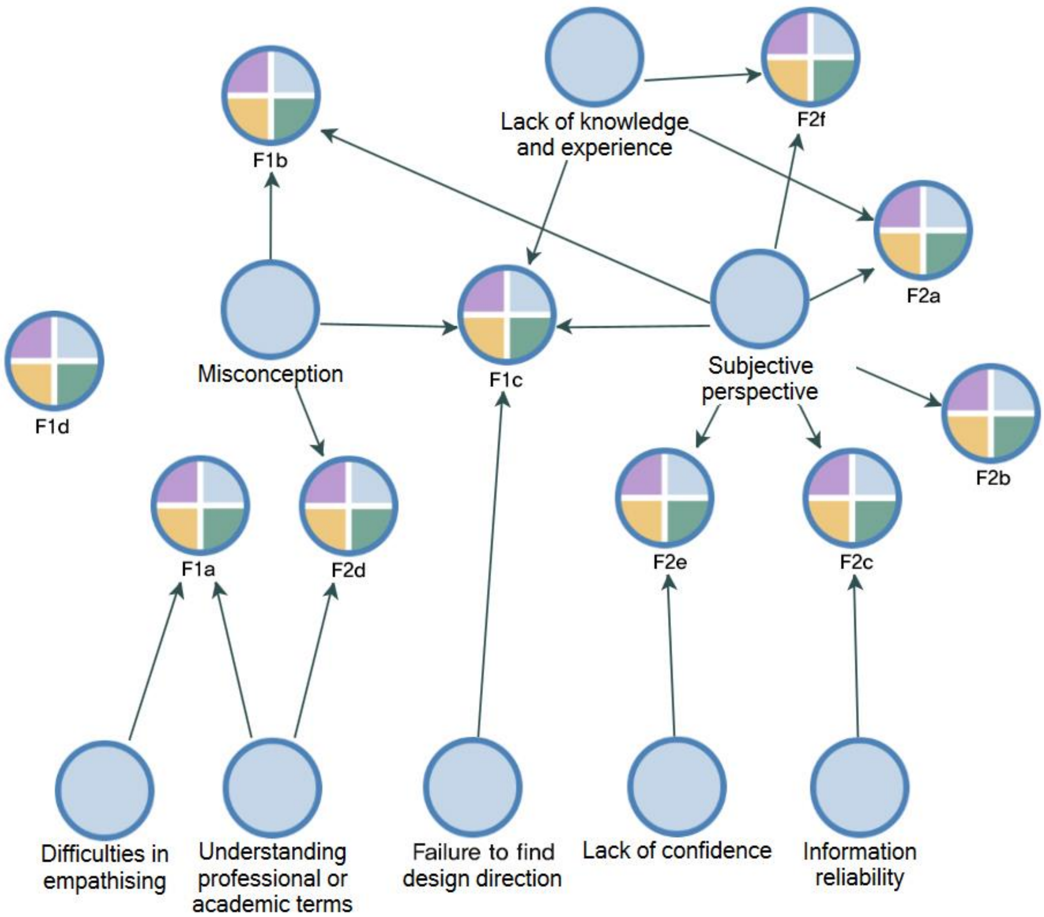

Figure 5.17 Project map depicting how each of the ten participants are linked to particular themes (using NVivo 12 program).

5.6.3 Effective Approaches to Providing Information for Designers

RQ sub-2.4.1 What features would designers like to use? What do designers think are the pros and cons of Affective Imaginary Information design prototypes (both i-cards and p-cards)?

Short, Visual, Summarised, Concise, and Plain English in Bullet Points

It is necessary to clarify also exactly what other characteristics are preferred or less preferred by designers. It was discovered that design participants prefer to find short, visual, summarised, and concise information written in non-complex English, based mainly in bullet points rather than finding information in a range of chapters or sections of guides or books. One of the participants (participant F1b) stated that he spends little time reading in order to find information which is related to emotional reasons (boring and painful). Especially, there was prominent desire for visual information expressed during the group sessions.

> It was difficult to find it, <u>if I can see visual examples</u> for them, it would be working efficiently (Participants F1c).
>
> I want to read <u>everything visually, visual things</u> like photographs (Participants F1b).
>
> I want to use <u>visual information</u> (Participants F1a).

The findings here are in agreement with the findings of Goodman *et al*. (2007) which show that for designers, information presentation is preferred by them when it is “quick and easy to use, visual, flexible, open-minded, concise, stimulating, generating insights, exploratory, experiential, and tangible” (p.122) but also related to design issues clearly and precisely.

Factors for Information Format Choice: Emotional Experience of Using Information

This part of the focus groups was intended to find out through comparison about ways in which design participants’ use different types of information formats. The thoughts, values, and experiences of design participants were verbalised in terms of using two different types of information formats during the focus group sessions. Before asking questions, the printed versions of the AII prototype format (p-cards) were given to them individually. At the same time, participants were also given the web address to access the online information (i-cards) using their personal laptops, mobile phones, or tablets.

With respect to preferred types of information format, it was found that aside from two participants, all others preferred to look for and read information from the paper-based sources (p-cards) rather than online or digital. They gave various reasons for this. Table 5.19 indicates thirteen identified reasons as to why design participants prefer to use physical information formats. These are classified into the following four factors: emotional, functional, environmental, and other. It is apparent that there are a large number of reasons for utilising information on paper.

In most design areas, searching for specific information is supposed to be aimed at gaining objective information. Despite these objective reasons for searching for information, design participants tended to react emotionally when they interacted with information sources. They expressed their preferences for information use based on how they felt (emotional reasons) rather than usefulness when they searched for information during the focus groups.

Table 5.19 Four identified factors in the preference for physical information format by design participants.

Factor	Characteristic	Excerpt From Transcription
Emotional factor	Attractiveness	"Paper card format may attract people"
		"I prefer the paper one. I do not know, it is just more attractive"
	Aesthetic	"People would like it. it is very classic"
	Comfortable	"Ah just my feelings, if I look at card or a printed paper, I will focus my mind to read"
		"I feel comfortable, and I want to save it, keep it"
	Personal	"I just feel the paper based is more personal"
	Familiarity	"I am familiar with a book having ideas, knowledge, map having directions, but at the same time I am using the online version like an e-book. But for me it is more familiar to have printed one"
		"I feel familiar with it"
	Reliability	"I still prefer that printed thing that make me feel very reliable"
		"I have choice I definitely choose printed one because printed things make me feel reliable"
	Touchability	"That's I like to touch it and hold it"
		"I prefer the paper because I can touch"
	Exclusivity	"It is easy to give others"
		"I feel I can collect them or give to a person I like"
Functional factor	Convenience	"I think the advantage of a printed one is easy access all the time"
		"I can use this anywhere"
		"Sometimes if my phone is out of power, I can't search anything online so the card may be more convenient for me"
	Flexibility	"I can use both sides for providing information"
	Interactive	"I can write something really quickly and convenient"
		"I think it's more interactive I can write my name or drawing something I can do that"
Environmental factor	Recyclable	"You can recycle the paper"
Other	Less impairing to eyes	"In my opinion, as for the physical version. I think the physical one is less impairing my vision"

Haptic Mode of Communication

As shown in Table 5.19, one of the features of information format that design participants would like to use is 'touchability'. What is interesting in this data is that the finding here can be linked to the findings in Chapter Four. In the previous chapter, it was revealed that design participants tried to touch colour samples and described them as if they had touched them. Taken together, these findings suggest that tactile communication modes would be useful for designers to motivate or encourage them.

Physical Information: No Negative Emotion

Regarding the shortcomings of physical information formats mentioned by design participants, these relate mainly related to its physical features (paper material itself). By applying the in vivo coding method, three codes were identified: 'easy to be damaged', 'bad colour quality', and 'size is fixed', which were categorised into a physical factor (Table 5.20).

Table 5.20 Disadvantages of physical information use identified by design participants.

Factor	In vivo code	In vivo description
Environmental factor	Not eco-friendly	"This is not environmentally friendly. This is not eco-friendly".
		"Disadvantage is wasting paper".
		"That's not environmentally friendly".
Physical factor	Easy to be damaged	"That's because it can be damaged by rain or food".
		"It is easy to be damaged. And for long time, it may be easy to lose its colours".
	Bad colour quality	"Paper information can give bad colour quality it the printing quality is not good. But we can manage that we can use high quality printer for a better quality of colours".
		"Colour is not accurate as what was supposed to be".
	Size is fixed	"The size is fixed if people have low vision they cannot see".
		"I cannot manage the font size".
Other	Easy to lose	"But it easy to lose as well".
		"It is easy to carry but also easy to be missing".
		"It's easily gone missing because they have four pieces".

Online Information: No Positive Emotion but Convenience

In the case of advantages and drawbacks of online information, for design participants the functional factor (easy to access and transfer) was the main reason for liking information online (Table 5.21). However, they do not seem to have positive values towards using information online because of emotional distance and lack of reliability. Some examples are shown below.

> Because electronic version you may feel some distance, it does not belong to you (Participant F1d).
>
> I do not really trust the online things (Participant F1b).

The most interesting finding in this part is that design participants not only overlook the design task because of their emotional traits, but also they have a preference for or dislike of using information because of emotional reasons and feelings. Figure 5.18 is a visual representation of positive and negative factors affecting designers' information use behaviour for both formats.

Table 5.21 Pros and cons of online information format stated by design participants.

Factors	Characteristics	
	Pros	Cons
Functional factor	Convenient	-
	- easy to access	
	- easy to transfer	
	Flexibility (Zoom in and out information)	Less flexibility (two-dimensional information)
Emotional factor	-	Feeling distance
		Lack of reliability
Environmental factor	Eco-friendly	-
Other	Environmental interference	
	Reliance on battery	
	Reliance on internet environment	
	Bad effect on eyesight	

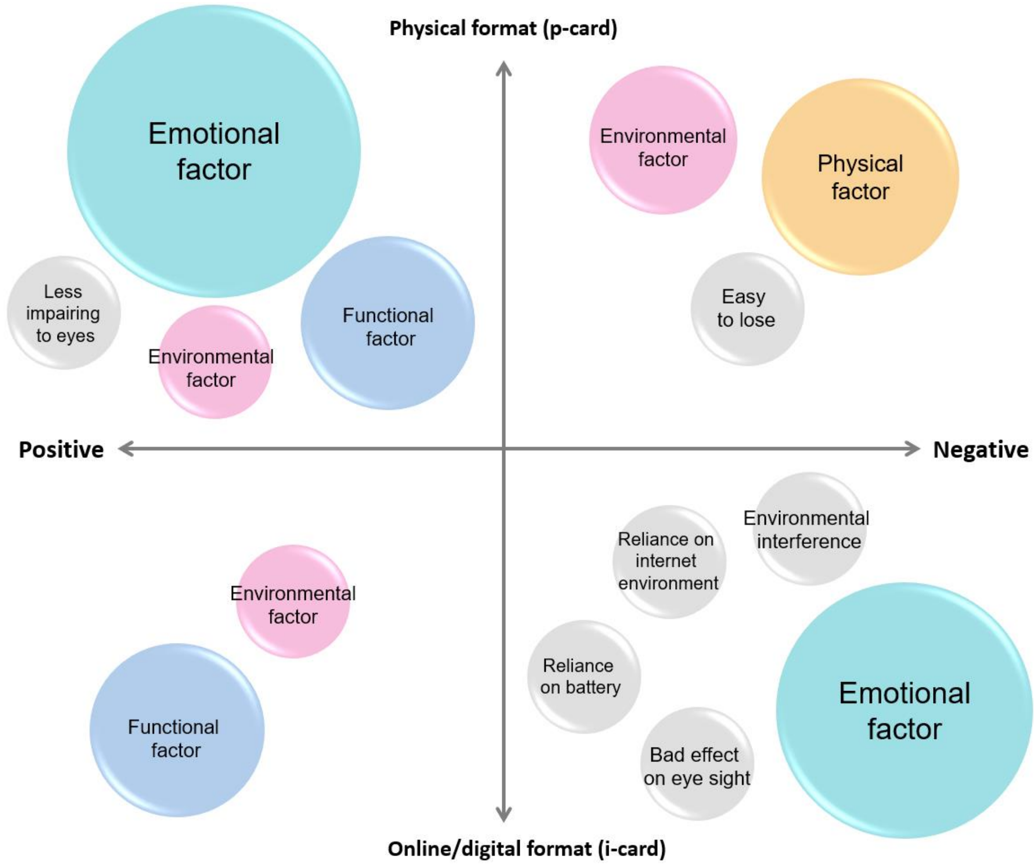

Figure 5.18 Various factors that affect designers' information use behaviour.

The AII design prototypes (both i-cards and p-cards) were designed to test the value of different information formats among design participants within this study. However, during the group sessions some of participants said that they would like to possess the physical card format because of its attractiveness. Participant F1a stated that if well designed sets of information cards existed, she would like to have access to them. Participant F1d indicated also that he would like to hold the cards, collect them, and give them to others. If a physical information format was designed well, it appears that it would be used by designers and could be a useful tool to give them necessary information.

It is inevitable that designers will use computers in the current era, but participants were concerned about an unstable internet environment, low batteries on gadgets (tablets, mobile phones, and laptops) and any bad effects on their eyesight from looking at electronic products. These results suggest the need for further research to consider the benefits and drawbacks of both types of information formats (physical and online based) to determine how to provide information for designers in an effective and efficient manner.

5.6.4 How Designers’ Characteristics Are Reflected in Providing Colour Information

RQ sub-4.1.1 What do design participants feel and talk about in terms of the Affective Imaginary Information format (facial representation of emotion)?

Imagining the Situation and Emotions of Information Possible Users

In order to explicate how designers’ emotional and evocative characteristics can be reflected when providing them with information, the participants were asked to respond to the cartoon images on the AII cards (representing older people’s facial emotion). The responses of design participants to each image were collected during the focus groups.

As we can see in Table 5.22, the statements from the design participants are interesting because they imagine the situation the person on the image may be facing just by looking at the facial image. Another important practical implication is that design participants expressed not just what the person on the image might be feeling related to the situation in their imagination, but also the association of colour with emotions as well as the person’s desire (on the image).

By extrapolating from the responses by design participants (Table 5.22), it may be that providing information through affective images may be useful for designers. Such Affective Imaginary Information formats might need to contain objective information (see Table 5.14 - thematic category 4) as well as conveying emotional information about information end-users, such as the emotional reaction of information users to an inaccessible information environment. This could help designers in being emotional, motivative and feeling empathy.

Table 5.22 Responses to facial images by design participants during the focus groups.

Image 1	Image 2	Image 3	Image 4
			
Participants' responses to each image (below)			
Responses to image 1.			
"A person is trying to find looking for truth and saying stop lying".			
"He wants to read something maybe details of the pictures or newspaper because of letters small".			
"He is not happy. He cannot recognise or read something clear. So quite confused".			
"He wants to see something carefully".			
"Telling others I'm watching you, be careful".			
"He feels confused as things are too small, so he needs that magnifier".			
Responses to image 2.			
"I can see an unhappy old woman. She is disappointed with young generation. She lost patience".			
"She is disappointed and annoyed because she cannot understand about everything".			
"It is too unclear, so she is unhappy with things like contents or size of something".			
Responses to image 3.			
"Maybe she is waiting for her husband".			
"Peaceful, homesick because she looks like a grand mum waiting for her grandchildren".			
"Very satisfied, for me I see a kind and adorable grandma waiting for someone. Because of the light purple, the colour says like really fresh and delightful".			
"I think she is satisfied and proud of her appearance".			
Responses to image 4.			
"Meeting a family or friend or a loved one for a long time or for a surprise".			
"She is just waiting for someone. "It's you!" Like that yeah. Old lovers? It feels like that, old lovers like ex-boyfriend".			

5.7 Conclusions

5.7.1 Five Factors which Influence Designers Information Use

This chapter sought for answers to four central research questions by asking five associated sub-questions (see Table 5.2). The synthesis of responses in the chapter also revealed five factors that influence designers' information use behaviour.

- **Attitude factor** (attitude to inclusive design provision): subjective outlook and difficulties in empathising.
- **Knowledge factor** (designers' knowledge use): common sense, misconception, basic design knowledge, and lack of knowledge and experience.
- **Response factor** (factors for information format choice): emotional factor, environmental factor, functional factor, physical factor, and other.
- **Information factor** (information needs of designers): designers' use of information sources and difficulties in searching for, using, and understanding information.
- **Imagination and empathy factor** (imagination of designers): imagining the situation and emotions of users.

This suggests that designers are affected by a complex range of factors in terms of using information. These findings could guide us to define what we need to consider to provide information to designers in a designer-friendly way, which also could contribute to an inclusive environment.

5.7.2 Evidence for the Need for Designer-driven Information Formats and Sources

The word 'emotion' represents one of the main characteristics associated with designers. Designers' emotional responses had a large impact on their attitude to the design task in this chapter as participants as well as their information use behaviour.

This chapter has examined the factors which make designers produce inaccessible information and considered how to provide information to make designers themselves think about various disadvantaged information users. It did this by reflecting on designers' characteristics (see findings in Chapter Four), and especially focused on emotional responses to tasks, emotional language use, and tactile behavioural characteristics. In order to seek to answer questions, firstly, prototypes of accessible design provision were adopted from the researcher's previous design project then utilised to identify the attitude, knowledge, and values of design participants toward accessible design provision and various information users (in this case, vision and colour vision impaired people). Moreover, a set of Affective Imaginary Information formats [AII] (carrying facial representations of older persons' emotions) were created in both physical (touchability) and online (untouchability) forms then provided to design participants. Two focus groups were carried out with ten doctoral design students. The data collected was thematically analysed within a five-steps framework using qualitative data analysis software. The findings of this chapter are summarised as follows:

- **Misconception among design participants** regarding various information users and accessible information provision.
- **Lack of education and experience** about design inclusion.
- **A subjective outlook which** causes designers to create information that is inaccessible.
- **Four main information needs were stated:** (1) colour information detail, (2) design guidelines, (3) effective learning materials, and (4) user information in detail.
- **Five major challenges were identified:** (1) information reliability, (2) lack of confidence, (3) understanding professional terms from other disciplines, (4) failure to search for design direction, and (5) difficulties in empathising.
- **Factors for Information format Choice:** emotional, functional, physical, and environmental reasons for conventional paper information format.
- **Haptic mode of communication** can be considered by reflecting designers' tactile behaviour.
- **Reason for using online information:** no positive emotion of using information but convenience.
- **Five factors influencing designers' information use**: attitude factor, knowledge factor, response factor, information factor, and imagination and empathy factor.
- **Facilitating imagination and empathy of design participants** would be possible by applying facial representation of emotion as one of the information features.

Overall, there is a need for designer-friendly information sources and formats developed by and for designers themselves in order to encourage designers to consider various types of users and create information that is more accessible to users. This could help to change designers' attitudes, behaviour, and the value they place on providing accessible information for various information users. Of course, designers may ultimately need to consult detailed guidance to comply with legislation and understand requirements in detail. However, designer friendly guidelines/formats such as Affective Imaginary Information [AII] formats may help to communicate with, inspire and inform designers in the first place and enhance their ongoing commitment to providing accessible information. The findings here have a number of important implications for future practice.

5.8 Summary

Much effort was made in this chapter to answer questions about how to offer colour information to designers to make them consider various disadvantaged users. In the next chapter, the Affective Imaginary Information [AII] format will be offered to designers with different levels of experience as an information providing tool. The purpose of this is to explore distinguishing problem-solving abilities between groups of designers in terms of experience, focusing on colour design practice in real life colour use and use of colour information provision. Finally, the usefulness of the AII formats will be evaluated by professional design educators in order to gain feedback for further development.

*** Note.** Related Publications to Chapter 5.

Book chapter

Lee G., Westland S., Tang T. 2020. Designer attitudes to accessible information provision on a bus route map: focus group discussions. In: Langdon P., Lazar J., Heylighen A. and Dong H. eds. *Designing for Inclusion*. CWUAAT 2020. Springer, Cham.

Conference papers

Lee, G. Designers' responses to information accessibility needs. 2019. In: *Disability Studies: Past, Present and Future. 11-12 July 2019, Leeds, United Kingdom*. Leeds: Centre for Disability Studies Leeds (CDS Leeds), pp.13-14.

Lee, G., Walker, V. 2018. Creating accessible transport information for people with vision and colour-vision impairment: A focus group interview. *Lancaster Disability Studies conference #CeDR18. 11-13 September 2018, Lancaster, United Kingdom*. Lancaster: Centre for Disability Research (CeDR), pp.129-130.

Chapter 6 DESIGNER STUDY 3

6.1 Introduction

In Chapter Two, distinguishing characteristics of design ability in terms of level of design expertise, regardless of different design areas, were reviewed. However, little is known about the characteristics and limitations of designers in the subject of colour design and it is not clear what factors affect colour use behaviour of designers when creating real world design artefacts. It is necessary to explore how designers actually use colours and colour information in order to find directions for changing designers' colour-using behaviour. Thus, this chapter now looks in detail at differences between different levels of designers in terms of use of actual colours on real-world products and colour information use by addressing the overarching research question RQ 2-5 and sub-question RQ sub-2.5.1 below.

> **RQ 2-5** Are any distinguishing characteristics between different levels of designers revealed in a problem-solving design task in terms of use of colours and colour information?
>
> **RQ sub-2.5.1** What differences can be seen between designer groups (student, novice, and expert designers) in terms of actual use of colours and user-related colour information in relation to real-world design products?

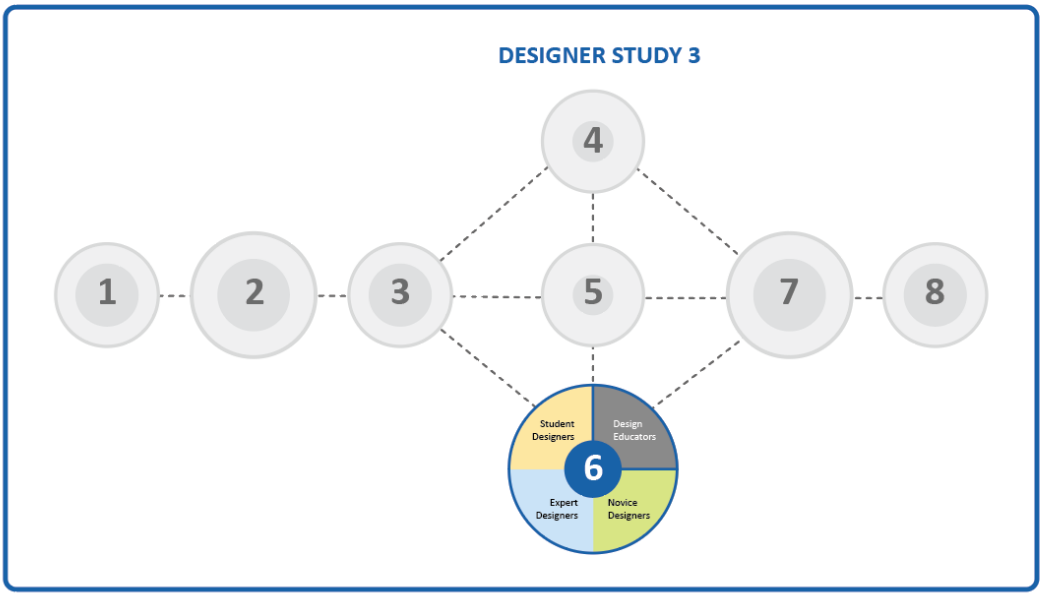

Figure 6.1 Position and context of Chapter Six within the whole research process.

In order to seek answers to these research questions (see above), a set of Affective Imaginary Information [AII] formats (see Figure 5.11, section 5.4.5.2.5) was tested during email interviews, colour design experiments, and web-based surveys with designers with different levels of experience. During the colour design and colour information search tasks, designers' reflections on their overall experience in relation to the AII formats and their satisfaction with the formats was investigated. In addition to this, email interviews were carried out with design education experts in Higher Education [HE] in the UK in order to evaluate the AII formats and gain new insights for their further development as tools for encouraging designers in general to have a user-centred approach in mind when designing information.

6.1.1 Overview of the Procedure

In line with the above comments, the process in the present chapter, as a whole, involved four phases (Figure 6.2). The first three phases were carried out with designers with various levels of experience. The fourth phase was implemented with professional design educators in HE in the UK.

1) Phase One: initial email interviews.
2) Phase Two: colour application tasks and second email interviews.
3) Phase Three: colour modification tasks and web-based surveys.
4) Phase Four: third email interviews.

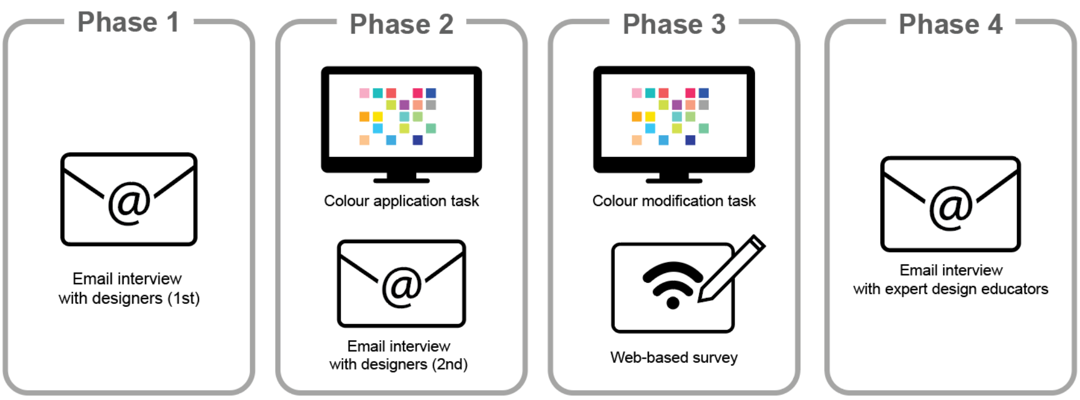

Figure 6.2 Overview of the research process in Chapter Six.

In the initial phase, an email was sent to thirty individual designers to ask them for detailed information about design education (major in BA, MA, or PhD), current job position, years of employment experience, design area they are working in or had worked in. In this initial email process, individual designers were also required to answer questions about their general knowledge about design elements and the principles they consider in their design work.

During the second phase, for the colour application task on product cases, limited information about the product cases and product users were offered to designers, in order to explore the usual way they use colour information and their actual colour application behaviour with real world products. A second email was sent to the individual designers asking them to give answers to the relevant questions in an open-ended style.

After these sets of tasks were completed, colour modification tasks were undertaken in the third phase. At this stage, participants were offered end-user information, to be taken into account also in the web-based survey. During this stage, a set of Affective Imaginary Information [AII] formats (see Figure 5.11 in section 5.4.5.2.5) was provided to designers in an online form (i-cards). The individual AII formats comprised an image with a question in order to inspire design participants to think about the users' position and ask them to search for relevant colour information to address the difficulties that users might be faced with. The colour modification behaviour of designers was examined based on information searched for by them. In addition to this, each design participant was required to give a final account of their experience of the design task and satisfaction with the information they accessed, through a web-based survey.

Lastly, email interviews were conducted in order to evaluate a set of Affective Imaginary Information [AII] formats as well as explore future directions for the further development of the AII formats in a designer friendly manner. Lecturers in visual communication design in a UK University were involved in this part of the research.

6.2 Research Setup

6.2.1 Aims and Objectives

There are three overall aims in this chapter (Table 6.1). In order to meet the aims of the chapter, three types of research methods were used (Figure 6.3). The colour design experiments were designed to meet the first aim, while the email interviews and a web-based survey meet the second aim. For this, thirty individual designers were involved. To meet the third aim, email interviews with design education experts were used.

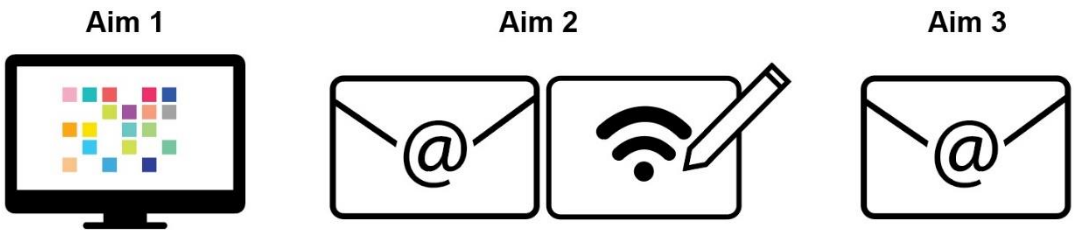

Figure 6.3 Three ways of achieving main goals of Chapter Six.

Table 6.1 Aims and objectives of research techniques used in this chapter.

Colour Design Experiments	
Aim 1	To explore how colours are directly dealt with by designers to present information on real-world product packages by offering a set of AII formats.
Objective 1-1	To compare the differences in terms of actual colour use behaviours among those with different levels of design experience.
Email Interviews and Web-based Survey	
Aim 2	To explore designers' current colour information use behaviour and their background experience.
Objective 2-1	To identify information resources used by designers, the resources they believe they need, and types of information they want.
Objective 2-2	To investigate designers' usual colour information use behaviour based on different levels of user-information in a design task.
Objective 2-3	To discover overall positive and negative perceptions of colour information use during colour design experiments.
Objective 2-4	To explore overall satisfaction regarding existing colour information sources and formats they used during the colour design experiment.
Email Interviews	
Aim 3	To evaluate a set of Affective Imaginary Information [AII] formats, and explore future directions for the further development of the AII formats in a designer friendly manner.
Objective 3-1	To elicit views from design education experts in Higher Education in the UK regarding the amount of information that should be given in the AII formats, as well as priorities for the types of user-information which are needed in these formats in order to encourage designers and design students to take a user centred approach.

6.2.2 Hypotheses

Overarching hypothesis

Decisions of designers can be seen in design outcomes (Ahmed *et al*., 2003). Therefore, an assumption underlying this chapter is that an investigation of decisions of designers during colour design experiments (application and modification of colours) and colour information search tasks would reveal what further information and resources need to be provided to different levels of designers in order to change their colour use decision-making behaviour, and motivate them to search for appropriate information to make use of colours more accessible to a wider range of information users.

Experts are generally regarded as better problem solvers based on their domain knowledge and deep understanding of a problem situation (Johnson *et al*., 1981). This is also true in the design field. The results of previous research examined in the literature review (section 2.2.2.3.1), have led to the prediction that there would be significant differences among designers by level of expertise during the colour design tasks in using and understanding colour in their design outcomes and in searching for additional information. More specifically, the following hypotheses are relevant to this study.

Hypothesis 1

It is predicted that different levels of designers would show different colour use behaviours. Thus, it is also expected that more experienced designers would use distinctive colour use skills which may be presented in their colour selection.

The colour design experiments (application and modification) have been set up to test hypothesis 1. However, if there are no distinctive differences among different levels of designer groups, the reason needs to be investigated, since it was considered in Chapter Two that experienced designers are better problem solvers because of their accumulated design knowledge and project experience. These reflect a holistic understanding of the subject matter.

Hypothesis 2

Colour information that is currently provided for information accessibility may not be suitable for designers in terms of formats and sources because it is initially developed by and for non-design professionals. Thus, it is hypothesised that although all design participants may use some information sources to apply colours considering target users (during the colour modification task), they may need more designer friendly information resources. This will be investigated by carrying out email interviews and a survey in this chapter.

6.2.3 Selection of Participants

6.2.3.1 Designer Groups

Thirty design participants took part in this phase of the research. Eligibility criteria required individuals to have received a design degree in higher education (BA, MA, or PhD). Participants comprised students but also non-students working in the design field at the time of the study. There were three groups of ten design participants in each group. The three groups were split up depending on level of employment experience in practical design areas and were divided into the following categories: expert designers, novice designers, and student designers.

Prior to conducting data collection, how other scholars divide designer groups in their experimental design studies was reviewed in order to establish a criteria for grouping designers. As seen in the review in Chapter Two, numerous design studies focus on ability of designers by comparing different levels of designers (see Tables 2.15 and 2.16). When we discuss classifications of designers, based on previous design research, there does not seem to be a set rule behind the categories of expert, novice, and student designers, but there was a general indication that such a division is helpful. This was explained in section 2.2.2.3.2 in detail.

As noted, although the design participants have different levels of design education, all had at least a bachelor's degree in design. For this phase of the research, however, education level was not the primary factor in setting the criteria for dividing participants into groups. This was based instead on level of employment experience in the practical design area. Three designer groups were settled on for the studies in this chapter, as set out below:

- **Expert designers.** At least five years of employment experience in the design area.
- **Novice designers.** Those with more than two years of employment experience in the design area but less than five years.
- **Student designers.** Less than a year of employment experience including students with no employment experience.

Figure 6.4 provides demographic information about participants from three designer groups based on average age and years of employment experience.

The average amount of employment experience of the participants is ten years for experts, two years for novice designers, and none or less than a year for student designers. The age of the participants ranges from 20 to 37 years.

In terms of level of education (Figure 6.5), the expert designer group studied design for a relatively shorter time than other designer groups. None of the expert designers were studying a doctoral degree at the time of the study. Only two from this group studied design at master's level, and most of them held only a bachelor's level degree. In contrast, many of the students (50%) and novice (60%) group of designers held doctoral degrees or were studying a PhD during the period when this research was undertaken in 2019.

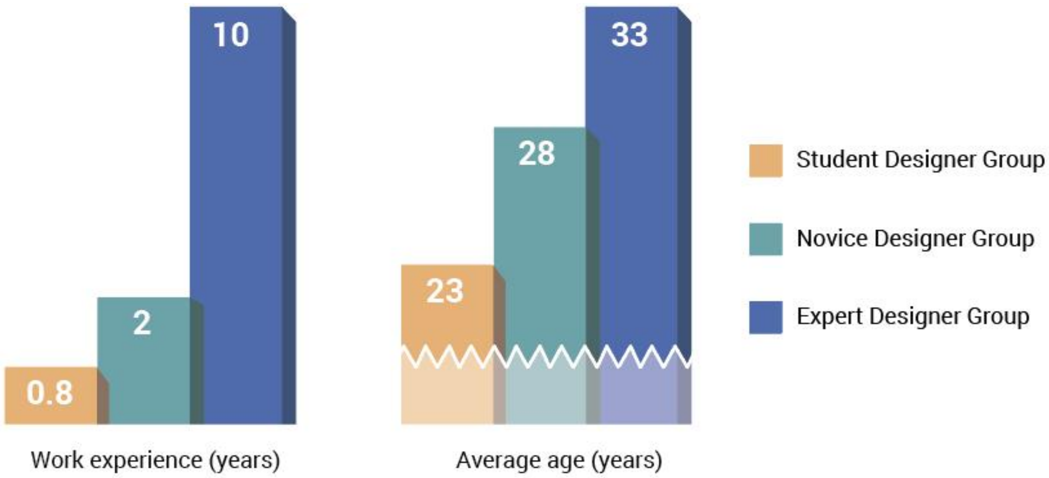

Figure 6.4 Three groups of design participants: average age and design experience through employment.

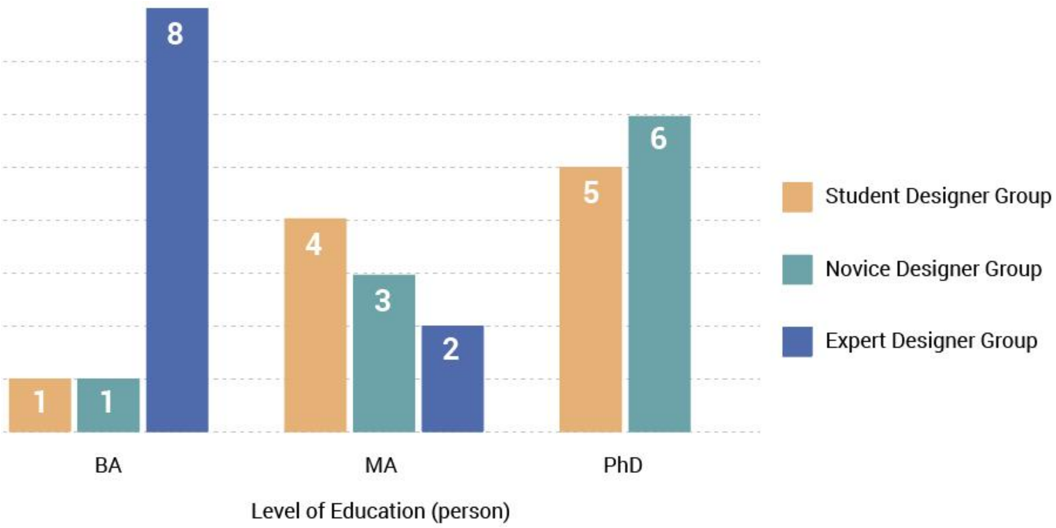

Figure 6.5 Three groups of design participants: levels of education.

6.2.3.2 Design Educators

In order to evaluate the AII formats and gain in-depth feedback about them, and opinions about their future development, email interviews were carried out with academic professionals in design. A total of six participants were selected via purposive sampling (Tables 6.2 and 6.3). Participants included lecturers or senior lecturers in visual communication in HE in the UK. All these participants also had experience in the design industry.

Table 6.2 Participant information for the email interviews with HE lecturers: years of employment experience both in higher education and the design industry.

Participant Code	Number of Years of Teaching Experience in HE	Number of Years of Work Experience within the Design Industry
L1	6	30
L2	16	20
L3	12	24
L4	13	14
L5	8	7
L6	8	4
Average	10.5 years	16.5 years

Table 6.3 Participant information for the email interviews with HE lecturers: education level.

<table>
<tr><th>Participant Code</th><th colspan="2">Level of Education</th></tr>
<tr><td>L1</td><td>BA</td><td>Graphic Design</td></tr>
<tr><td rowspan="3">L2</td><td>BA</td><td>Industrial and Communication Design</td></tr>
<tr><td>MSC</td><td>Industrial and Communication Design</td></tr>
<tr><td>PhD</td><td>Design Education</td></tr>
<tr><td rowspan="3">L3</td><td>BA</td><td>Visual Communication/Photography</td></tr>
<tr><td rowspan="2">PgCert</td><td>Research Practice</td></tr>
<tr><td>Learning and Teaching in Higher Education</td></tr>
<tr><td rowspan="3">L4</td><td>BA</td><td>Fine Art</td></tr>
<tr><td>MA</td><td>Fine Art</td></tr>
<tr><td>PGCHE</td><td>Art and Design</td></tr>
<tr><td rowspan="2">L5</td><td>BA</td><td>Fine Art</td></tr>
<tr><td>MA</td><td>Fine Art</td></tr>
<tr><td rowspan="2">L6</td><td>BA</td><td>Visual Communication</td></tr>
<tr><td>MA</td><td>Communication Art and Design</td></tr>
</table>

The average amount of teaching experience in HE for the participants is around 10 years. They also have an average about 16 years of work experience in the design industry. In terms of educational level, apart from participant L1, all participants hold bachelors and master's degrees (or an equivalent postgraduate certificate) in art or design. Compared to other participants, participant L1 has a lot of experience in the practical design area (30 years), covering a wide range of activities in the visual communication design area such as brand identity, publishing, and editorial design. Participant L2 has a higher level of educational attainment compared to other participants, with a doctoral degree in design education.

6.2.4 Mixed Methods Approach

This chapter combines qualitative and quantitative methods. A triangulated methodological approach is used to improve the validity of the research (Figure 6.6). Data were gathered through three kinds of research techniques. These were email interviews, colour design experiments, and web-based surveys. Each of the methods used will be demonstrated with a rationale for their selection. Additionally, questions which were asked while conducting each of the research methods will be presented in the section below.

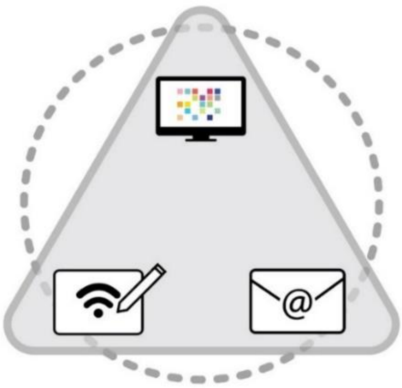

Figure 6.6 Triangulated methodological approach within Chapter Six.

6.2.4.1 Colour Design Experimentation

The colour design experiment was broken down into two parts split between phases 2 and 3 (see Figure 6.2). In the first part, task objects (Figure 6.7) were provided to design participants in an Encapsulated PostScript [EPS] file format. At this stage, limited information was offered to design participants about specifics of the product cases and possible user information in order to explore their usual colour application and colour information use behaviour. In the second part, a set of AII formats which had been created and tested in the previous chapter (Figure 5.11 in Chapter Five) was provided in i-card form (online). These were designed intentionally to help to motivate designer participants to search for relevant colour information related to users during the colour modification task. The instructions on colour design experiments are outlined in Table 6.4. In total sixty Adobe Illustrator Artwork [AI] or EPS formats were collected at the end of the colour design (application and modification) experimentations.

Table 6.4 Colour design experiment instructions: task 1 (colour application) and task 2 (colour modification).

Task	Colour Design Experimental Procedures
Task 1 (application)	Fill in the form with colours. (do not change text or other design elements)
Task 2 (modification)	1. There are questions on the card images.
	2. Search for answers about the questions on the cards.
	3. What colours do you apply to answer the questions on the cards? Based on your information search, modify colours, save it (eps or ai format) then sent it to me.
	4. Please access the below link to complete an online survey.

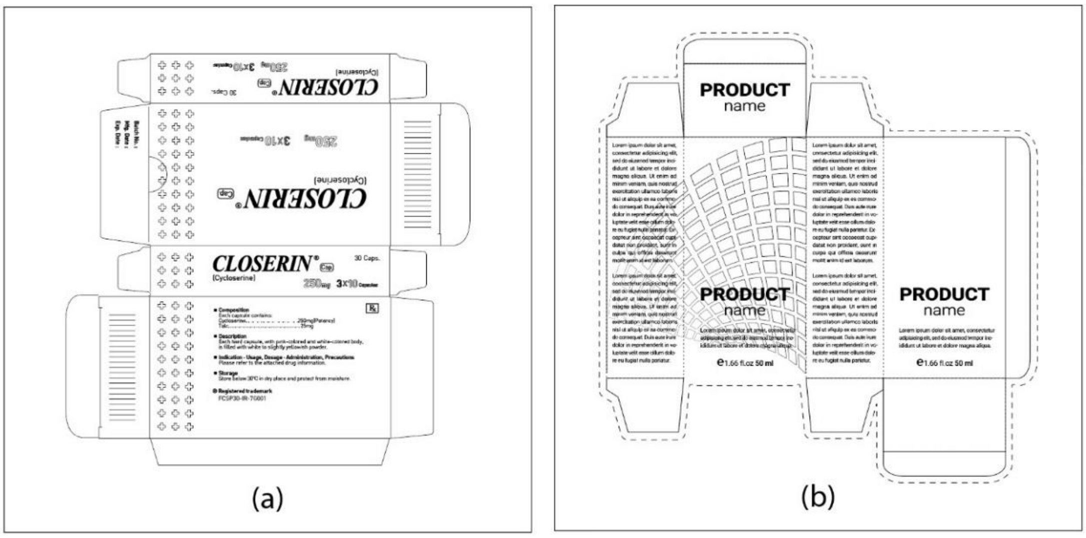

Figure 6.7 Materials used for colour design experimentations: (a) medical product case and (b) commercial product case.

Colours can be analysed either quantitatively or qualitatively. Colours (as visual contents) were described in a qualitative form by the researcher in order to compare colour use between the designer groups. For the visual comparison of colours used by designer groups, the NCS colour triangulation and circle were utilised. This has been illustrated in section 3.4.3.2.2 in Chapter Three in detail.

6.2.4.2 Electronic Mail Interview

Challenges associated with some qualitative research methods (e.g. observation and in-depth interviews) especially financial, time constraints, and inaccessibility (geographical or time differences) are identified by previous scholars. Meho (2006) claims that an email interview can be a viable alternative to some qualitative research techniques as high-quality data can be generated on a particular subject if it is handled appropriately. This author also states that face-to-face and email interviews in prior studies have drawn the same conclusions. Interviewees in email interviews are more likely to focus on the interview questions (Curasi, 2001; Meho and Tibbo, 2003). With regard to the data quality of an email interview, Curasi (2001) argues that it depends on who is involved, who is the interviewee, but also the interviewer's skills in an online interview. A strong point of this method is that it allows participants to build up a more complete account of their experiences by putting their message together carefully (Curasi, 2001).

In this chapter, email interviews were applied in different phases to meet different research aims (see Table 6.1 and Figure 6.3). In the first and second phase, semi-structured in-depth email interviews were conducted individually with thirty designer participants from around the world including Britain, China, Hong Kong, and South Korea. Interview questions were mainly developed to investigate how designers currently use colour information by dealing with actual colours for the medical and commercial product packages (Figure 6.7).

A first email was sent to each participant as a short advance notice, and asking about basic design knowledge in short questions. The second mail-out was the actual email interview, distributed after participants had completed the colour application task. Designers were asked to recall their experiences and viewpoints towards relevant topics while conducting the colour application task in order to answer the questions in this second email interview.

As noted, a third set of email interviews were applied with design education experts in HE in the UK in the fourth phase in order mainly to evaluate the set of Affective Imaginary Information [AII] formats as well as explore future directions for their further development and enhance their designer friendly qualities. In this stage, a set of open-ended interview questions was created in order to elicit data-rich information based on respondents' reactions to the AII formats using their own words. Table 6.5 lists the questions that were used in the email interviews.

Table 6.5 Questions asked in the email interviews at the first, second, and fourth phases.

Phase	Interview Questions
First email interviews (1st phase)	Perception of colour from standpoint of designers.
	E1-1. What are the design elements that you need to consider in your everyday design tasks? **E1-2.** What are the design principles that you need to consider in your everyday design tasks?
Second email interviews (2nd phase)	Attitude toward use of colour information.
	E2-1. Why did you not use any additional information for your colour application test? and how did you apply colours without any other information sources for this task? **E2-2.** If you found and used information, where did you find it to help with your colour application?
Third email interviews (4th phase)	Experience of teaching user-centred visual communication design.
	E4-1. What are the main difficulties in terms of making student designers think about users first, while teaching and supervising them within the visual communication design area? **E4-2.** Do you have your own methods, teaching skills, or materials to make student designers consider the user first? What other approaches do you use to deal with this issue? **E4-3.** Do you think it is important for student designers to have a user-centred approach in mind when conducting design projects?
	Evaluation of Pictures
	E4-4. Please indicate whether you agree that the picture of the facial expression successfully relates to the question on each card. Please tick (✓) to give your answer in the table and provide brief reasons for your answer.
	Evaluation of Text
	E4-5. Please indicate whether you agree that the answer on the back side of each card would provide an appropriate amount of information to encourage designers in general to consider information users? Please tick (✓) to give your answer in the table and provide brief reasons for your answer.
	Amount of information
	E4-6. Please indicate whether you agree that the amount of information on both sides of each card is appropriate? Please tick (✓) to give your answer in the table and provide brief reasons for your answer.
	Usefulness
	E4-7. Overall, do you think the AII formats (see above) would be useful to encourage designers in general to have a user-centred approach in mind when designing information?
	Suggestions for further development
	E4-8. Please also provide suggestions for further development in general for the AII formats, in terms of design elements, contents and so on which should be added or deleted?

6.2.4.3 Web-based Survey

According to Creswell (2011, p.376), surveys are “procedures in quantitative research in which investigators administer a survey to a sample or to the entire population”. The web-based survey may be one of the data collection tools of survey research (Sue and Ritter, 2007). A Web-based survey can be described as “the collection of data through a self-administered electronic set of questions on the Web” (Hernon *et al.*, 2015, p.68). In comparison with conventional paper-based surveys, web-based surveys have several advantages such as cost effectiveness, speed, data collection accuracy, and rapid access to results (Creswell, 2008; Greenlaw and Brown-Welty, 2009; Fleming and Bowden, 2009; Richey and Klein, 2009).

Table 6.6 Contents of questionnaire for web-based survey.

Web-based Survey	
Binary perception on colour information use	**S1.** What was your overall positive perception of the information you found during this colour application task? (Please tick (✓) as many boxes as you like for statements you agree with)
	S2. What was your overall negative perception of the information you found during this colour application task? (Please tick (✓) as many boxes as you like for statements you agree with)
Useful information types for designers	**S3.** Paper-based information: what types of information sources would be useful for designers when they find colour information in relation to information users?
	S4. Online and digital information: what types of information sources would be useful for designers when they find colour information in relation to information users?
	S5. People information: what types of information sources would be useful for designers when they find colour information in relation to information users?
Ease of information accessibility and overall satisfaction	**S6.** Overall, was it easy to find information that you tried to use for the colour application (modification) test?
	S7. What is your overall satisfaction with the quality of colour information you found and used during this task?
	S8. Can you tell me your overall feelings or experience while finding and using information about colour modification for older people and why?

In this study, a survey was administered online to thirty designers individually. It was designed in a cross-sectional manner to investigate any trends in responses from three designer groups (students, novices, and experts). It tackled research questions by comparing groups by their opinions, perception, and satisfaction in terms of experiences of colour information use during the colour design experiments. Individual designers were required to access a link to fill in the form while conducting the colour modification task or just after finishing this task. The questions in the survey questionnaire are listed in Table 6.6. Close-ended questions (S1 to S7) are the main ones. However, an open-ended qualitative question (S8) was also included at the end of the survey form to examine the feelings, attitudes, and experiences of designers during the colour design (application and modification tasks) and colour information search experiments. This is because the simplicity and limited range of answers made available by the close-ended questions did not allow the participants to reflect their actual feelings.

6.3 Data Analysis and Discussion

As noted, three different data collection methods (see Figure 6.6) were adopted to meet this chapter's main goals (see Table 6.1). In this section, data collected from each of the collection methods will be analysed separately. Results and interpretations will be discussed here as well.

6.3.1 Email interviews with Designers

The email interviews were undertaken with thirty designers individually. Figure 6.8 illustrates the overall structure of the email interviews and the techniques applied for data analysis. This will be explained in detail in this section.

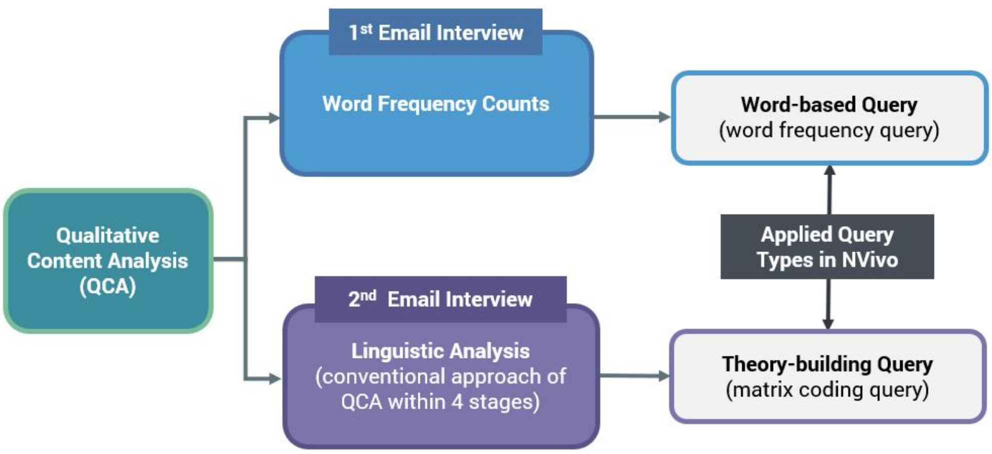

Figure 6.8 Overall structure of data analysis from email interviews.

6.3.1.1 Data Analysis Procedure

In order to analyse textually rich data gathered from email interviews, different kinds of analysis techniques and coding queries were utilised from the content analysis [CA] method. According to Sage Research Methods (2020), CA in a qualitative approach covers three narrower terms: directed content analysis, linguistic analysis, and word frequency counts (Figure 6.9). These three techniques are described in the paragraphs below.

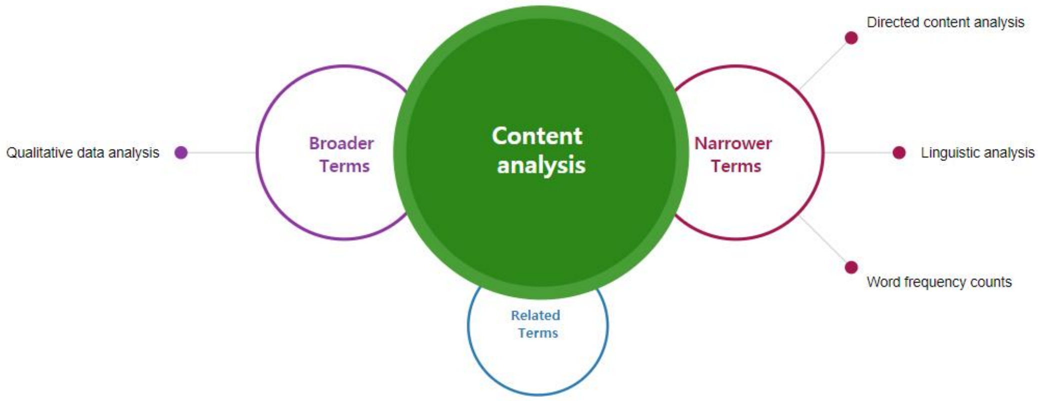

Figure 6.9 Method map (source: adopted from Sage Research Methods, 2020).

6.3.1.1.1 Word Frequency Counts

Word frequency counts in content analysis are defined as “counts of the number of times particular words appear in some text or texts” (Sage Research Methods, 2020). For the data analysis of the first email interview, a word-based query was applied in NVivo 12 to use the word frequency counts technique. The word frequency query in NVivo 12 makes a list of the words that occur most often in a dataset. In terms of word scoping for the word frequency query, synonyms in the dataset were grouped together for the representation of results. These results will be listed in section 6.3.1.2.1 in Table 6.7.

6.3.1.1.2 Linguistic Analysis

Linguistic analysis was used for analysis of responses from the second email interviews. In this chapter, linguistic analysis is the same as “corpus analysis, in which linguistic analysis is performed on a body (corpus) of language taken from real-world usage” (Sage Research Methods, 2020). The linguistic analysis technique is utilised within a conventional approach of qualitative content analysis (see section 3.4.3.2.1) in accordance with four stages. Therefore, for this study, four stages were involved for code-based analysis that was applied to reduce and summarise texts to generate categories and themes.

First Stage. Selection of Meaning Unit and Condensation

The highly narrative responses of individual designers were collected through the second email interviews. Close reading was conducted to allow initial insights. At this stage, the corpus was divided into several sections based on meaningful responses (relevant things that designers talk about).

A meaning unit can be understood as "the constellation of words or statements that relate to the same central meaning" (Graneheim and Lundman, 2004, p.106). According to Robson (1993 cited in Elo *et al*., 2014, p.5), the meaning unit can be a "letter, word, sentence portion of pages, or words". Several meaning units were generated and listed in Tables 6.10, 6.11, and 6.12. These were then further condensed to facilitate generation of codes in the next stage.

Second Stage. Identification of Codes

A description-focused coding strategy was used for coding the interview data. According to Adu (2019, p.28), the main purpose of adopting the description-focused coding strategy is to "generate codes that are closely connected to the empirical indicators". This author (2019) indicates some of the characteristics of description focused coding as using "no interpretation or inference", the use of "In Vivo coding" and codes generated being "more concrete" (pp.28-29).

In this part of the data analysis, in order to identify the particular behaviour of designers during the design task experiment, the 'in vivo' coding technique was adopted to create codes with a description-oriented coding approach in mind. Thus 'in vivo' codes were taken from interviewees' own words meaning the codes would be concrete and less abstract. It is also appropriate to describe phenomena without the researcher's interpretation based on her subjectivity. As a result, twenty-six codes were yielded, all of which are listed in Tables 6.10, 6.11, and 6.12 with empirical indicators (excerpts from raw data).

Third Stage. Inductive Category Development

As noted, twenty-six codes emerged. These were revisited and carefully looked at within context, keeping in mind the aim and objectives of the interview questions. Then all codes were grouped into seven categories and two sub-categories as below:

1) Self-expression
2) Personal judgement (self-reliance)
3) Level of confidence
    a. High in confidence
    b. Lacking in confidence
4) Need for appropriate amount of instruction
5) Personal experience
6) Lack of skills and ideas
7) Difficulties in finding information

Each of these categories will be demonstrated with evidence from the data to clarify their meaning (see Table 6.13). These categories were further refined to generate four themes in the next stage.

Fourth Stage. Thematic Exploration

In the fourth stage, there are four themes to be explored: (1) attitudes, (2) guidelines and instructions, (3) knowledge and experience, and (4) information accessibility. The interpretation for each of these themes will be presented in an individual theme-driven format in section 6.3.1.2.2.

6.3.1.1.3 Directed Content Analysis

Directed content analysis is "a type of qualitative content analysis in which coding is initially guided by a theory or by relevant research findings" (Sage Research Methods, 2020). In this chapter, however, pre-structured formats or guiding theories were not applied for the data analysis, rather a bottom-up approach was used. Thus, the current chapter does not utilise directed content analysis.

6.3.1.2 Interpreting the Findings of Email Interviews

6.3.1.2.1 Perception of Colour from Standpoint of Designers

It is apparent that designers need to manipulate diverse design elements at the same time as using design principles harmoniously in their design work. According to Poulin (2018), the elements of design such as form, shape, colour, frame, image, light, typography, line, and point, are a "graphic designer's basic vocabulary" (p.7). The author also notes that principles of design refer to a "graphic designer's basic framework for using design elements" (p.7). These principles include balance, tension, contrast, proportion, grid, asymmetry, movement, symmetry, and expression (Poulin, 2018).

Although such elements and principles of design are fundamental for visual communication, they are not exclusively restricted to the field of graphic and visual communication design. Designers deal with such design vocabularies and frameworks regardless of the design areas they focus on. They interpret each of these design lexicons to construct frameworks for designing artefacts by interpreting and adjusting appropriately to their domain area of design. Understanding the interrelationship between such design elements and principles is at the heart of achieving successful visual literacy at the same time as design literacy.

Wong (1997) states that design is an idea that has been visualised. A composition is used to express the idea (Wong, 1997). This composition is comprised of shapes (with varying positions, sizes, and directions) onto which a colour scheme is added (Wong, 1997). His statement implies the importance of colours for visualisation of the idea in design. On the basis of Wong’s argument, it is apparent that consideration of how colours are applied within overall design structure and how designers perceive and actually utilise colours in their design activities is one of the significant areas of visual and design literacy. Thus, prior to commencing colour design experimentation, in the first email interview, design participants were required to answer the two open-ended questions below:

> **E1-1.** What are the design elements that you need to consider in your everyday design tasks?
>
> **E1-2.** What are the design principles that you need to consider in your everyday design tasks?

The collected data from thirty designers in answer to these two questions were imported into NVivo 12 program. First, the most mentioned ten words were listed after applying a word frequency query (Table 6.7). The term ‘colour’ was the most frequently mentioned from both questions. This might be interpreted as showing the importance of colours in design from the designers’ point of view and what they consider in their everyday design practice. Second, regardless of levels of design education, level of design (years of employment experience), and area of design, there are common terms used about design elements and principles that are used by designers. These are listed in Table

6.8 respectively. These terms would indicate fundamental components that designers take into account in their design activities.

Table 6.7 Results of interview questions E1-1 (elements) and E1-2 (principles) from thirty designer participants.

Element	Count	Weighted Percentage (%)	Principle	Count	Weighted Percentage (%)
Colour	**29**	**15.26**	**Colour**	**28**	**8.38**
Shape	17	8.95	Use	17	4.34
Line	7	3.29	Information	13	3.74
Individual	5	2.63	Balance	11	2.99
Used	5	2.63	Design	14	2.99
information	4	2.11	Contrast	10	2.79
Texture	4	2.11	Make	11	2.26
Element	4	1.84	Legibility	10	2.25
Space	4	1.84	Product	6	1.8
Font	4	1.71	Attract	6	1.6

Table 6.8 Selection of fundamental design elements and principles in everyday design work by thirty designers irrespective of areas of design, levels of education, and design experience.

Common Elements	Common Principles
Colour	Colour
Information	Repetition
Typeface	Balance
Pattern	Readability
Line	Contrast
Shape	-

6.3.1.2.2 Attitude Toward Use of Colour Information

A colour application task for product cases was completed by designer participants, prior to the second email interviews being implemented. These second emails were sent to each designer in order to investigate their usual colour information use behaviour while they had insufficient information about users of the product cases. Basically, designers were asked whether they tried to search for any additional information during the colour application task. The responses from designers were categorised into two broad classifications (Figure 6.10): (1) a negative group (these answered no) and (2) affirmative (these answered yes). Each group was then asked a unique question in an open-ended form respectively.

For the negative group question E2-1 was asked:

> **E2-1.** Why did you not use any additional information for your colour application test? and how did you apply colours without any other information sources for this task?

For the affirmative group question E2-2 was asked:

> **E2-2.** If you found and used information, where did you find it to help with your colour application?

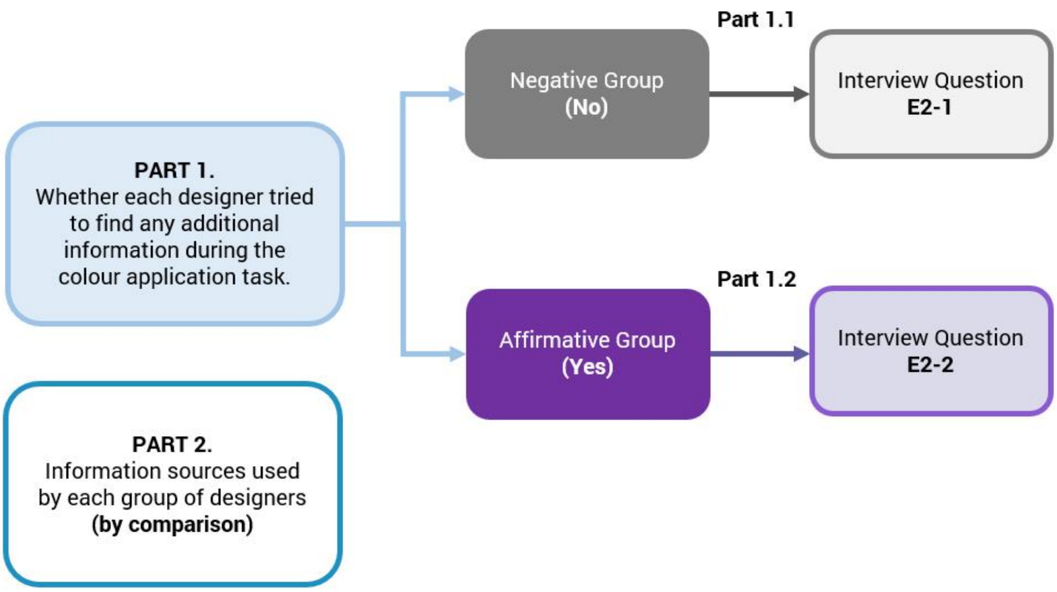

Figure 6.10 Procedure of second email interviews.

❖ **Part 1.** Contrasting Attitude: Affirmative (Yes) or Negative (No)

As indicated, designers were asked whether they searched for any information during the colour application task. In total, around two-thirds of design participants (63%) said that they did not try to search for any information (Table 6.9). However, they indicated that they did use information resources in other ways. They indicated they relied on other things, such as experience, feelings, common sense and so on (Figure 6.11).

Table 6.9 Design participants (by their unique identifying number) based on their answers.

Designer Group	Affirmative (Yes)	Negative (No)
Student	S4, S5, S6	S1, S2, S3, S7, S8, S9, S10
Novice	N2, N3, N5, N7, N9	N1, N4, N6, N8, N10
Expert	E5, E8, E9	E1, E2, E3, E4, E6, E7, E10

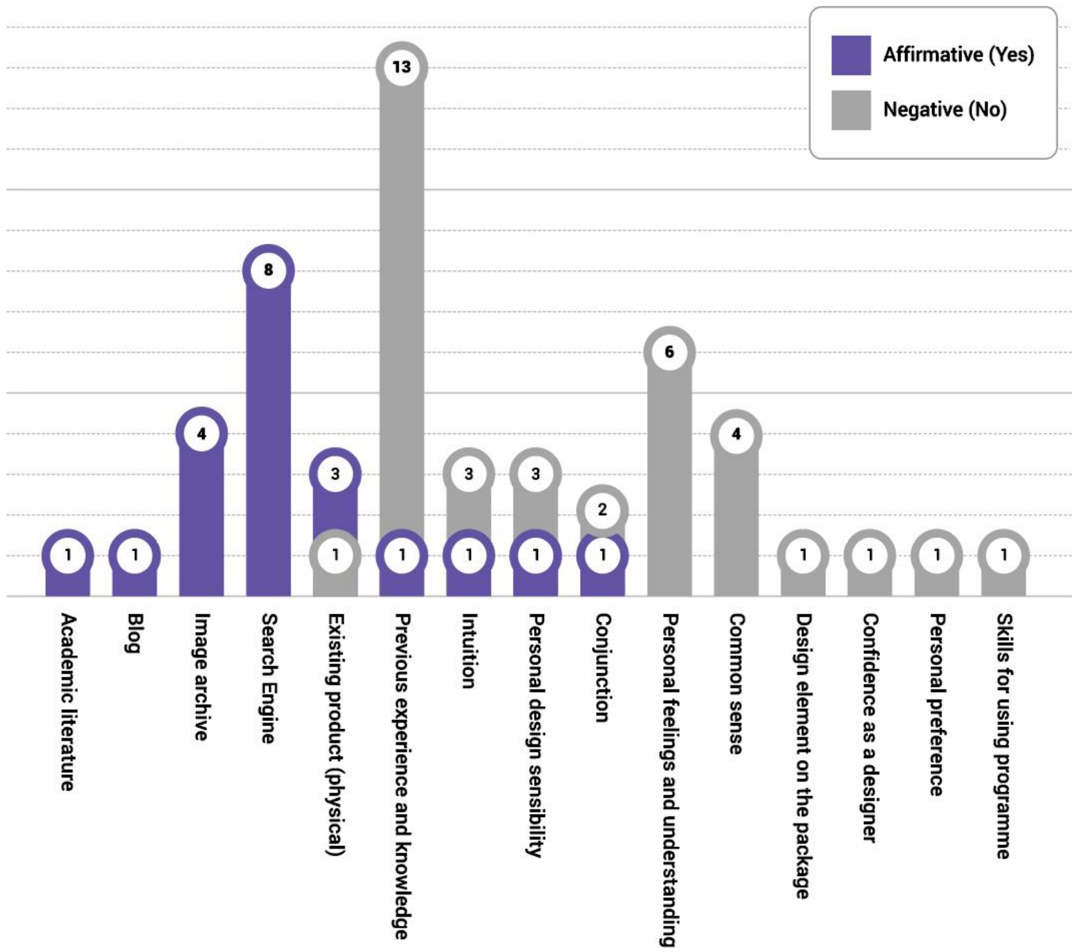

Figure 6.11 Output of matrix coding by NVivo 12 program: information resources used during the colour application task from the affirmative and negative group.

The affirmative and negative responses from the student, novice, and expert designer groups were coded and processed through a matrix coding query in NVivo in terms of what resources were actually used by those responding whether affirmatively or negatively. The results produced in an NVivo table were extracted and rendered in a more visually attractive manner by the researcher (Figure 6.11). Thus, in Figure 6.11, the numbers represent how many times a resource was mentioned by designers.

Figure 6.11 indicates where each group (affirmative and negative) of designers gained information during the colour application task. Among the affirmative designer group, even though there was little information about product cases and information users, designers searched for the information in academic literature, existing physical products, or visual based information from designers' blogs, or image archives.

Designers in the negative group seem to rely heavily on implicit knowledge (e.g. previous experience and knowledge) or subjective factors (e.g. personal feelings, understanding, and design sensibility) during the colour application task rather than more objective sources.

❖ **Part 1.1** Answers to Interview Question E2-1: Four Influential Factors for Negative Response Group

Focusing specifically on factors that prevent designers from searching for task-related colour information, a question was asked to designers whose answer was negative.

> **E2-1.** Why did you not use any additional information for your colour application test? and how did you apply colours without any other information sources for this task?

Responses from three designer groups (student, novice, and expert) were carefully looked at to condense their meaning using excerpts from the interviews. In order to identify preliminary codes, the 'in vivo' coding technique was used. Verbs in the excerpts were focused upon to produce codes exploring what designers did. Thus, characteristics of the generated codes are action-oriented. The codes and examples of data excerpts from answers by each group of participants to the question are listed in Tables 6.10, 6.11, and 6.12.

There were various factors behind designers not actively searching for and using colour information during the colour design tasks. There were twenty-six codes in the initial stage of coding. These codes were grouped into seven main categories and two sub-categories. These categories were further refined to generate four themes:

- Attitudes;
- Guidelines and instructions;
- Knowledge and experience; and
- Information accessibility.

Each of the themes is considered to be an influential factor in colour information use behaviour of designers. These themes are regarded as answers to interview question (E2-1). Each theme will be addressed with interpretations in the following section. It should be noted that many of the participants did not have English as their first language. Their English has not been changed.

Table 6.10 Reasons for not actively seeking information during the colour application task among student designers.

Participant	Meaning Unit (Example quote)	Condensation	Preliminary Code
S1	"The red colour gives me specific emotion"	Emotion evoked by particular colour related to personal colour preference.	Feel special emotion
	"It is not easy to find a colour palette for these kinds of products. I tried to use my knowledge and experience"	As searching for colour palette is hard, she used her own knowledge and experience.	Not easy to find
			Use knowledge and experience
S2	"[…] I want to show my first impressions about those packages using colours"	She wants to express herself.	Want to show first impressions
S3	"I have no idea about what it is and what information is needed"	She is confused about what information is needed.	No ideas emerge
S7	"I read what on the page, then put the colour I feel make sense to the product"	He used personal sensibility when applying colour.	Feelings make sense
S8	"I don't know how to find colour information. But I am a designer. I know which kind of colour suite is used for different packages"	Although she does not know how to search for information, she trusts herself.	Do not know how to do something
			I am a designer
S9	"The package layout has the images on it which allow me to guess the function of the product"	Personal assumption based on effect of images/pictures on the package.	Informed guess of functions
S10	"There were no instructions to guide me what to do. So, I didn't think I should search for any information"	Lack of instructions make him think he does not need to do anything.	No instructions to guide
			I didn't think I should

Table 6.11 Reasons for not actively seeking information during the colour application task among novice designers.

Participant	Meaning Unit (Example quote)	Condensation	Preliminary Code
N1	"There was no requirement to ask me to find extra information"	No requirement means no need for the designer to act.	No requirement
N4	"I inferred the information from images and short texts on the package"	Paucity of instructions cause her to apply personal assumption.	Informed guess of functions
N6	"I didn't want to be distracted by other information"	She does not want to be interrupted.	Did not want to be distracted
N8	"I did not look for any information as I was not sure what types of products were involved and there was no information about manufacturer"	Lack of guidance and information.	Lack of instruction
N10	"It was not clear whether I should or not, also I felt that if I had then I would be influenced by what is already used for that product and stick […] close to that"	Lack of confidence whether I should find information or not (related to amount of information).	Unsure whether I should or not

Table 6.12 Reasons for not actively seeking information during the colour application task among expert designers.

Participant	Meaning Unit (Example Quote)	Condensation	Preliminary Code
E1	"I did not think I needed to find any information. I wanted to be more creative when I work with colours. I do not want to be inspired by other factors […]. I did not know about this task a lot. So, I did not research in the particular field"	Personal assumption instead of searching for information.	Do not think I need
		Expressing themselves.	Want to be more creative
		Lack of ideas (what to do for this task).	Uncertain about the task
E2	"I feel more creative when I work without outside inspiration"	Instruction hinders creativity.	Desire to be creative
E3	"I do not think I need to do"	Lack of information leads to no research.	Uncertain about the task
E4	"I was worried that I might look for wrong information"	She worried about finding wrong information.	Worried about looking for wrong information
E6	"I have confidence that I am able to work without information based on my previous experiences about what colours should be used"	Confidence as a designer based on previous design experience.	Have confidence based on experience
E7	"I only thought about colour combination, and how these colours would look good"	Lack of information causes use of intuition and self-reliance.	Paucity of information
			Thought about colour combination
E10	"I only think about colours"	Thinks about colours only.	Colour-focused

Table 6.13 Summary of findings from second email interviews showing themes, categories, and excerpts.

Theme	Category		Empirical Indicator (excerpt)		Count
Attitudes	Self-expression		"The red colour gives me specific emotion"	S1	5
			"[…] I want to show my first impressions about those packages using colours"	S2	
			"I do not want to be inspired by other factors […]"	E1	
			"I feel more creative when I work without outside inspiration"	E2	
			"I didn't want to be distracted by other information"	N6	
	Personal judgement (self-reliance)		"I read what on the page, then put the colour I feel make sense to the product"	S7	6
			"The package layout has the images on it which allow me to guess the function of the product"	S9	
			"I inferred the information from images and short texts on the package"	N4	
			"I did not think I needed to find any information"	E1	
			"I only thought about colour combination, and how these colours would look good"	E7	
			"I only think about colours"	E10	
	Level of confidence	High in confidence (sub)	"I am a designer. I know which kind of colour suite is used for different packages"	S8	2
			"I have confidence that I am able to work without information based on my previous experiences about what colours should be used"	E6	
		Lacking in confidence (sub)	"It was not clear whether I should or not, also I felt that if I had then I would be influenced by what is already used for that product and stick […] close to that"	N10	2
			"I was worried that I might look for wrong information"	E4	
Guidelines and instructions	Need for appropriate amount of instruction		"There were no instructions to guide me what to do. So, I didn't think I should search for any information"	S10	6
			"There was no requirement to ask me to find extra information"	N1	
			"I did not look for any information as I was not sure what types of products were involved and there was no information about manufacturer"	N8	
			"I did not know about this task a lot. So, I did not research in the particular field"	E1	
			"I do not think I need to do"	E3	
			"But there was no other information about it. I only thought about colour combination, and how these colours would look good"	E7	
Knowledge and experience	Personal experience		"I tried to use my knowledge and experience"	S1	3
	Lack of skills and ideas		"I have no idea about what it is and what information is needed"	S3	
			"I don't know how to find colour information"	S8	
Information accessibility	Difficulties in finding information		"It is not easy to find a colour palette for these kinds of products"	S1	1

Theme 1. Attitudes

The first theme is about the attitude of designers. This is quite intricate and subjective. However, from the analysis of the data, this arises from three specific categories: self-expression, personal judgement (self-reliance), and level of confidence. Most of all, it is revealed that designers tended to want to express themselves (their feelings and creativity) using colours. Also, designers seem to make personal judgements about the use of appropriate colours by themselves. Probably previous knowledge and experience as well as other personal factors (e.g. intuition, design sensibilities, and common sense) of designers would influence their personal subjective decisions. The confidence factor could be polarised between opposite points of view: being high in confidence and lack of confidence. Thus, individual designers seem to have different confidence levels on colour information use regardless of level of design experience.

Theme 2. Guidelines and instructions

According to Vredenburg *et al*. (2001), in the product design area, there is a serious mistaken belief that some dedicated group somewhere will learn user-centred design and then magically produce wonderful products. The second theme here is in line with such an argument, although the current research focuses on the area of colour, information, and inclusivity. Particularly, in relation to using colour for information, three designers from each designer group stated the below:

> There were no instructions to guide me what to do. So, I didn’t think I should search for any information (Participant S10).
>
> I did not look for any information as I was not sure what types of products were involved and there was no information about manufacturer (Participant N8).
>
> I do not think I need to do (Participant E3).

The responses of designers above may suggest that there should be provision of appropriate forms or sources of information to designers to make their attitude to design more objective when they need to be. This is because designers are highly subjective and emotional during design tasks.

Theme 3. Knowledge and experience

Knowledge and experience would influence colour information use as well as actual colour use behaviour. Thus, knowledge and experience are the third theme. This includes level of skills and ideas based on statements from participants S3 and S8 (Table 6.13). One of the designers (participant S1) tried to apply her experience instead of looking for additional information during the colour application task. Accumulated expertise in design is acquired by conducting and managing design projects. Because of this, especially for inexperienced designers, there may be difficulties in gaining knowledge and experience to apply it to colour design tasks when they are in the early career stage in design.

Theme 4. Information Accessibility

Difficulties in accessing an appropriate colour palette and related information may be one of the reasons behind a lack of consideration among designers in terms of producing more accessible information. As noted, under the category of ‘difficulties in finding information’, participant S1 mentioned that "it is not easy to find a colour palette for these kinds of products”.

- ❖ **Part 1.2** Answers to Interview Question E2-2: Colour Information Sources used under Paucity of Instruction

As seen earlier in Table 6.9, eleven design participants tried to look up a certain level of information. They revealed this in answered to the question below after completing a colour application task:

> **E2-2.** If you found and used information, where did you find it to help with your colour application?

The responses of designers about the information sources they accessed during the colour application task are listed in Table 6.14. This tells us how designers gain initial colour information and what forms of information they prefer to use, especially for more accessible colour selection for older information users. The information resources can be classified into two categories: most are image-based resources, but a few are textual information.

In many cases, designers seem to find image-based guidance or used existing images and physical designs to infer guidance. In addressing this issue, one participant said

> I google the general package, what it looks like. Some general pictures can provide the guidelines for me (Participant S5).

Likewise, other designers (participant S4, N2, N3, N7, N9, and E8) commented that:

> I looked at existing packaging images on google and according to this I chose colours that I felt would match the packaging (Participant S4).
>
> I referenced some designs from a Chinese design to see, medicine package design pictures (Participant N2).
>
> Some pictures which I collected a few months ago Pinterest and personal blogs (Participant N3).
>
> Blogs there are lots of design references (Participant N7).
>
> I used image sites like Behance and Pinterest (Participant N9).
>
> I used keyword search ‘medicine package’ on google image. It shows some colours blue, magenta, green and orange. I referred these colours for colour application task (Participant E8).

As shown above, designers in the affirmative group (*n*=11) heavily rely on image-based information (7 out of 11). However, academic literature, physical products, and web portals were also used during the colour application task (Table 6.14). The results in this part of the thesis are similar to those reported in Chapter Five (section 5.6.3).

Table 6.14 Colour information resources used after active searches during the colour application task.

<table>
<tr><th colspan="2">Category</th><th>Resources Used</th></tr>
<tr><td rowspan="8">Image-based</td><td rowspan="7">Image and photo sharing online platform</td><td>Huaban.com</td></tr>
<tr><td>Google image</td></tr>
<tr><td>Pinterest.co.uk</td></tr>
<tr><td>Behance.net</td></tr>
<tr><td>Trendhunter.com</td></tr>
<tr><td>Personal blogs</td></tr>
<tr><td>Designer’s blog</td></tr>
<tr><td>Physical image</td><td>Existing physical design product</td></tr>
<tr><td rowspan="2">Text-based</td><td>Academic source</td><td>Books, journal article</td></tr>
<tr><td>Web portal</td><td>Google search</td></tr>
</table>

❖ **Part 2.** Comparison of Information Sources Used by Designer Groups

The responses of designers were coded by designer group (student, novice, and expert). A matrix coding query in NVivo was used to compare information sources each designer group used during the colour application task regardless of whether their answers had been affirmative or negative.

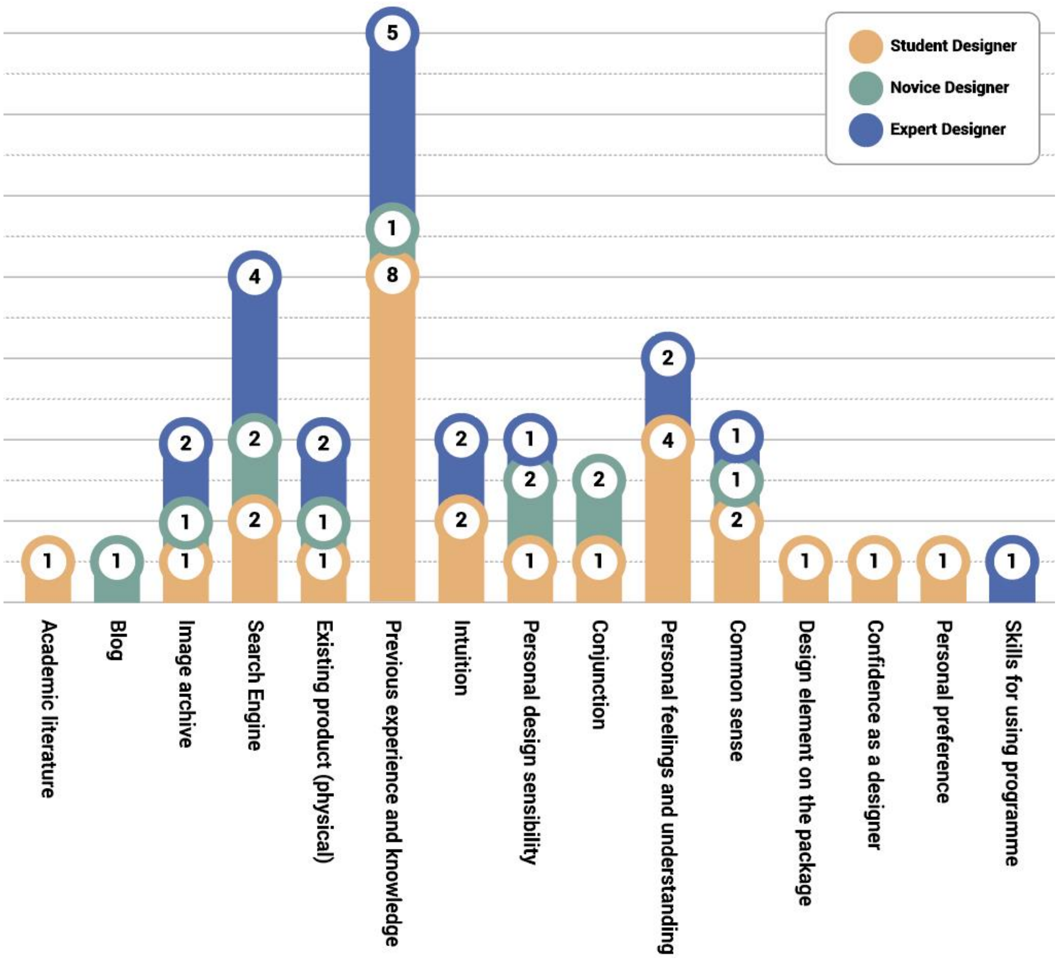

Figure 6.12 Information sources used during the colour application task by student, novice, and expert designer groups (numbers in figure refer to frequency of use of sources).

In Figure 6.12, it is shown conclusively that there do not appear to be meaningful differences between designer groups, because many resources for colour information are shared by designer groups. Designers are unlikely to make much effort to search actively for information irrespective of level of their design experience. Rather they tend to rely heavily on 'previous experience and knowledge' more than other sources. This is an unexpected result because colour information search and use behaviour (when searching for appropriate colours in designing information for older users) was expected to be a distinguishing feature of experienced designers based on the review of literature. This showed distinguishing characteristics for them during design tasks regardless of the field of design (see section 2.2.2.3.1).

In other words, the decisions of designers in terms of whether to look for colour information seem to be down to individual issues rather than level of experience. They often tended to use their personal attributes such as intuition, personal preference, conjunction, and common sense which could be related to the tacit knowledge of designers. Tacit knowledge in design is associated with prior design experience and education. However, this could be a problematic issue in some cases based on investigation in Chapter Five (see section 5.6.1). Although caution is needed because of the small sample size, it is noteworthy that ten design participants (PhD design students) had little design education, project or research experience in terms of design inclusion and different ranges of users. The findings in this section suggest a need for improvements in education, research, or design projects to take into account needs of various users with various levels of cognitive and physical abilities in relation to the design artefacts.

6.3.2 Colour Design Experimentation with Designers

6.3.2.1 Procedure of Visual Content Analysis

For the colour design experiments, individual designers were asked to select colours on pre-formatted proposed design artefacts – the medical and commercial product cases discussed earlier (see Figure 6.7) using Adobe Illustrator. Figure 6.13 shows one of the colour selections made by a participant (participant E8) from the expert designer group for the medical product case. This is intended to illustrate how colour data was gathered from colour design experimentation in this part of the study.

All colours selected by individual designers were listed and coded using Natural Colour System [NCS] by the researcher. While arranging colours on NCS colour circle and triangle, if black colour was used only for text, it was excluded. However, if designers applied black for any faces of the artefacts except from text, this was included as an independent colour. Also, specific shapes of object such as plant parts (flowers, leaves), and animals were not included on the product case as these are related to colour association. There is a possibility that the presence of such shapes can limit the range of colour selection by designers. A detailed description of how selection of colours by designers was located in the NCS chart with matching NCS codes using Adobe Illustrator was explained in Chapter Three (see section 3.4.3.2.2).

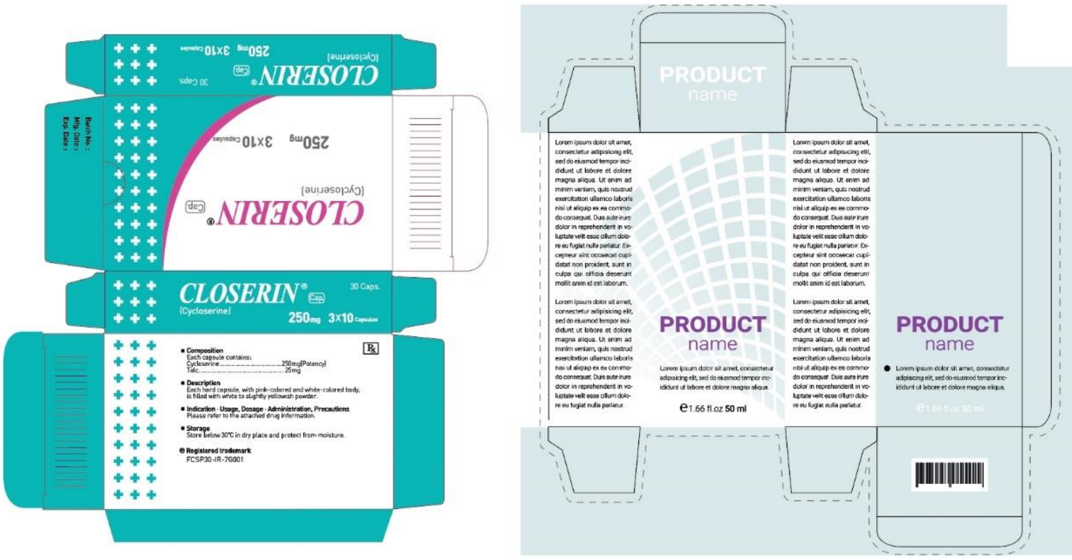

Figure 6.13 One of the outputs from the colour application design task from an expert design participant.

The results of the colour design experiment will be illustrated in the following section at an individual level and a group level. In order to explore general tendencies in use of colours by each designer group, the findings will be addressed comparatively by examining differences and similarities between groups and whether there are changes between the colour application and colour modification tasks. However, the behaviour of individual designers will be taken into account also to assess whether changes take place between these stages.

6.3.2.2 Results of Colour Design Experimentation

6.3.2.2.1 Colours Used for Medical Product Case by Each Designer Group

- ❖ Student Designer Group

Figure 6.14 presents the selection of colours collected from the colour application and modification tasks for the medical product case from the student designer group (*n*=10). As can be seen, there does not seem to be much difference between the application and modification stages. Only three in ten participants made changes in colour between these stages. For example, participant S1 added an additional colour but the rest of the colours are all the same. Participant S3 made two colours more similar whereas participant S7 made two selected colours less similar. However, most of the student designers did not change their colour selection throughout the colour design experiment for the medical case.

Looking at the colour circles in Figure 6.14, colours are mainly distributed in the areas B and R both for the application and modification colour tasks. Student designers used a relatively small number of colours in the GY and Y areas. In the colour triangles (nuance of colour), they were likely to apply colours between medium and high chromaticness (colourfulness). The selected colours became somewhat scattered including a lower level of chromaticness in the modification stage. As for the brightness, most selected colours are located between high and medium brightness during the application task. There is no significant change between application and modification stage colours for nuance. Overall, there are not many differences between application and modification colours for the medical case by the student designer group.

Figure 6.14 Colour selection for the medical product case by ten student designers: application (left) and modification (right).

- Novice Designer Group

The colour selection results for the medical product case from novice designers (*n*=10) are shown in Figure 6.15. There was little change in colour between the application and modification task. Three novice designers (participant N1, N2, and N6) did make colour changes for the modification. This can be explained at an individual level. For example, participant N1 changed colourfulness and blackness within same colour. Participant N2 modified colours from the yellow (Y10R) initially chosen, to blue (R90B and R70B). Participant N6 added a new colour to the previous colour selection. Apart from these three designers, the rest of them kept their first colour selections even though they were required to make changes, if they felt they needed to when undertaking the colour information web search task. When we glance at colours in Figure 6.15, the colours look almost identical.

Thus, at a group level for both the application and modification stages, colours are mainly distributed either in B, R, and YR area on the colour circles. Greenish colours were selected less for the medical product case. Regarding colourfulness, the majority of colours are highly saturated. Most colours are also located in the area of either high or medium level of brightness in the colour triangles. The results show that novice designers mainly take into account hue differences within a similar level of colourfulness (chromaticness) rather than differences in blackness (or whiteness). This makes colours look colourful.

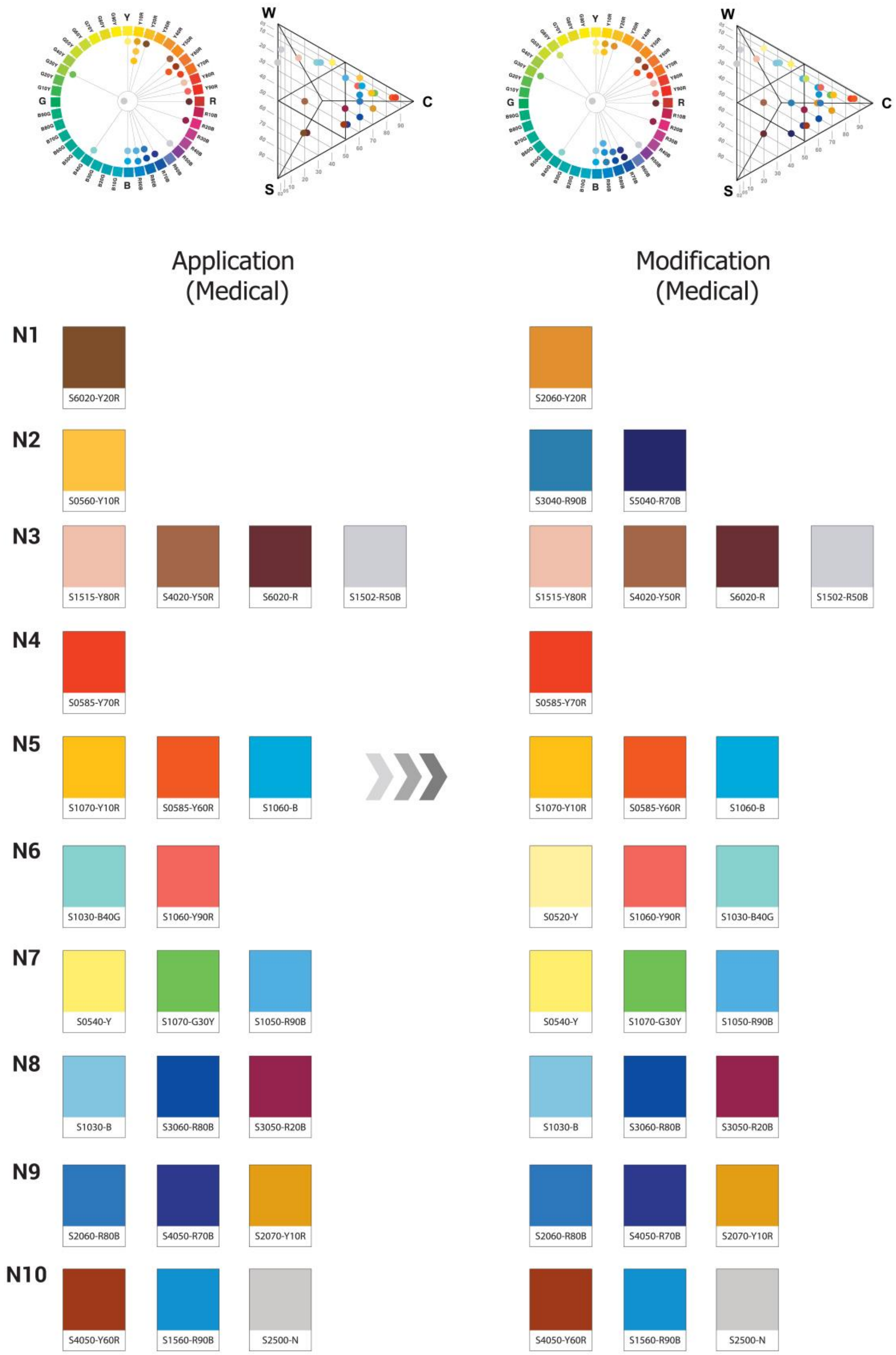

Figure 6.15 Colour selection for the medical product case by ten novice designers: application (left) and modification (right).

- Expert Designer Group

When it comes to the selection of colours for the medical product case by expert designers (*n*=10), small changes were made by four of them between the application and modification stage (Figure 6.16). At an individual level we see the following. Participant E2 removed two colours then added one new colour. The two colours finally selected (S0560-G90Y and S1505-Y) look distinctive because of a huge difference in colourfulness. Participant E5 used the same number of colours both for the application and modification tasks. The modified colours have higher colourfulness compared to the colour selection for the application. She made two colours more similar in three values (chromaticness, blackness, and hue). Participant E6 made intensive contrasts in colourfulness between two colours, at the same time as eliminating one when modifying colours. Participant E8 used less colour during the modification task. The modified colours from this participant show slight difference in colourfulness but this is not a large gap (S0580-Y70R and S1050-Y40R). Apart from participants E5 and E8, the expert designer group clearly shows an intensive contrast between colours either in brightness, hue, or chromaticness in comparison with student and novice group of designers.

In terms of the general tendency in colour use in both the application and modification tasks, from the colour circles in Figure 6.16, we can see that colours were mostly selected from either the B or R areas for the medical product case by expert designers. Colours in the G and Y areas are less likely to be used by them. In the case of nuance of colours, the range of colourfulness and blackness is wide from low to high.

Figure 6.16 Colour selection for the medical product case by ten expert designers: application (left) and modification (right).

6.3.2.2.2 Colours Used for Commercial Product Case by Each Designer Group

❖ Student Designer Group

Selection of colours for the commercial product case from the student designer group are presented in Figure 6.17. Participant S1 made some small changes between the application and modification stages. One colour became brighter while other one became a bit darker. Participant S3 used one less colour. On the other hand, participant S7 changed colour from bluish (R80B) to reddish (Y60R). One interesting point here is that the three student participants who made changes for the commercial case were the same ones who changed colour for the medical case (participants S1, S3, and S7). The rest of the student designers did not make any changes in colours. The findings in this part may indicate that personal factors are influential for these individuals.

In terms of the general tendency of colour use for the commercial product case in both the application and modification tasks, like the medical case, colours were mostly selected in the areas B or R. The students rarely selected colours in the areas of G and Y. The realm of brightness varies from very high (S0510-R20B) to very low (S9000-N).

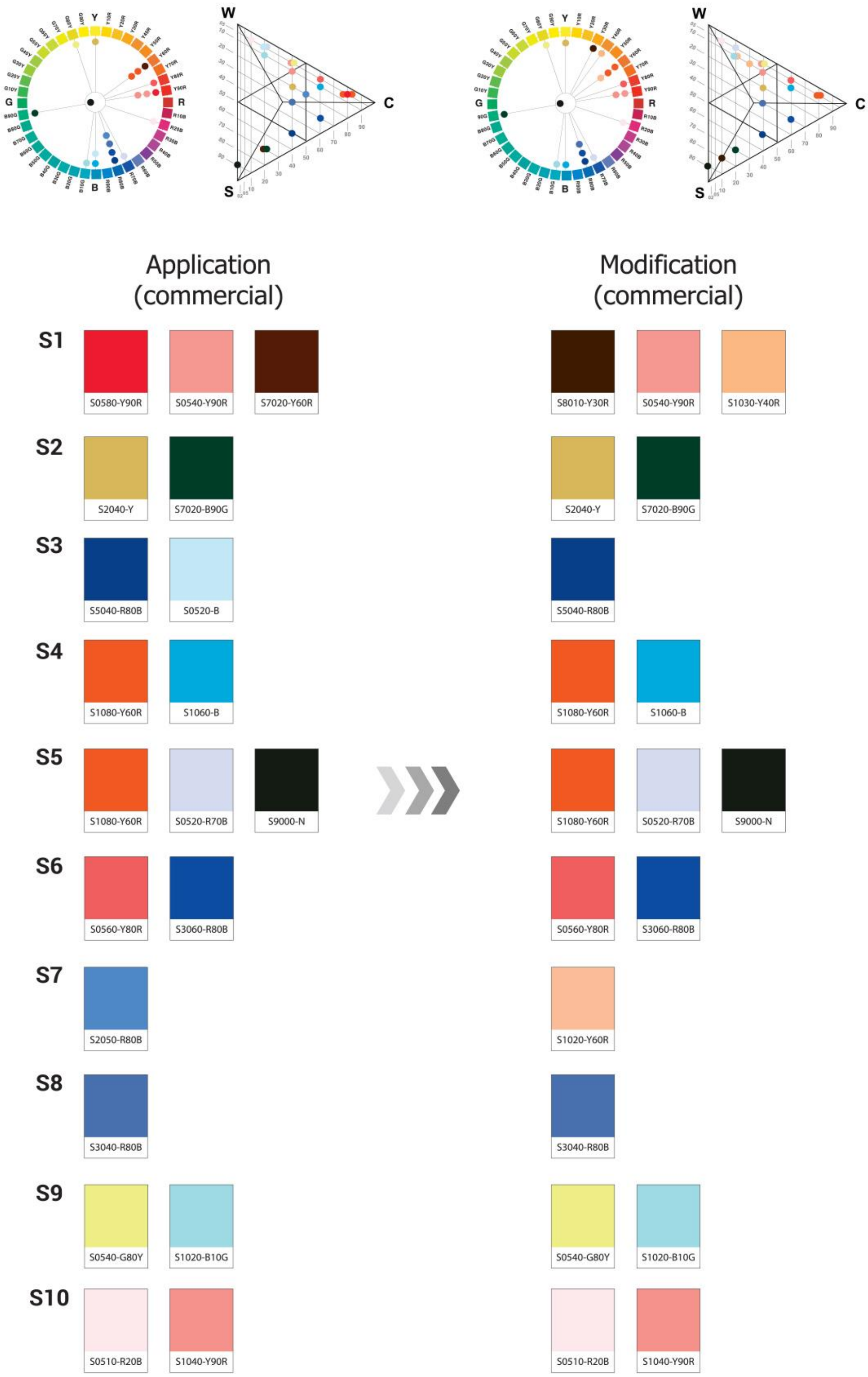

Figure 6.17 Colour selection for the commercial product case by ten student designers: application (left) and modification (right).

- ❖ Novice Designer Group

Figure 6.18 illustrates colour selections for the commercial product case by novice designers. Although most colours were retained in the colour modification task, there were small changes by four designers (participants N3, N6, N7, and N10). Participant N3 changed one colour completely from B10G (blue) to Y10R (yellow). These two colours are in fact opposite in hue. Participant N6 removed the darkest colour (S6030-R90B) from the colour application palette, then two other brighter colours were added. Participant N7 changed two highly saturated colours into three colours with lower saturation. When we look at the selection of colours by Participant N7, we see she tended to choose colours with different hues but similar colourfulness. Participant N10 showed a similar tendency to participant N7.

With respect to the overall colour selection by novice designers in both the application and modification tasks, most colours are located either in the B or RB areas on the NCS circles. Colours in the G and Y areas are seldom selected. Brightness and colourfulness of colours are spread widely in the NCS triangles.

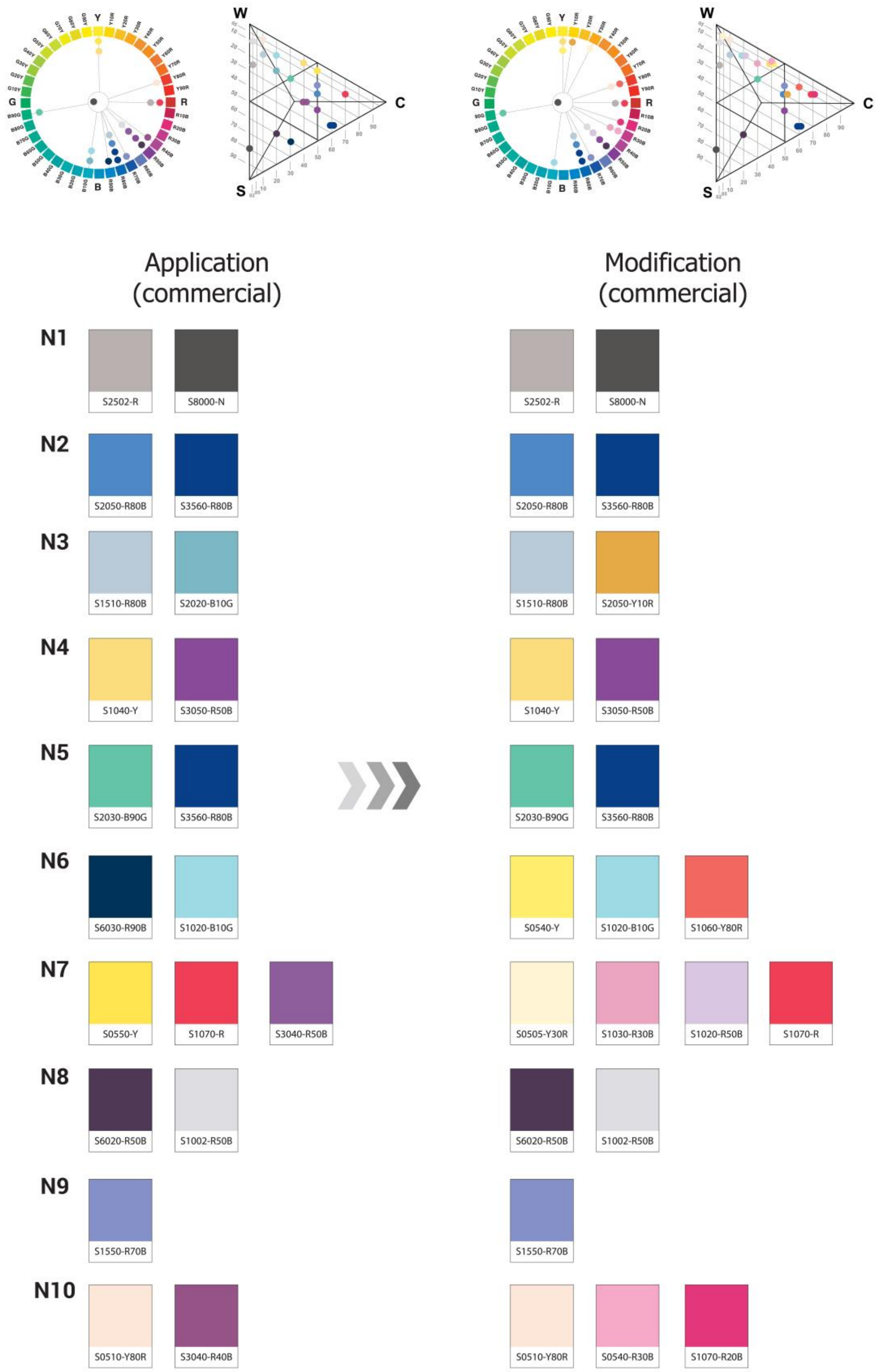

Figure 6.18 Colour selection for the commercial product case by ten novice designers: application (left) and modification (right).

- Expert Designer Group

Colour selections for the commercial product case by the designer group are presented in Figure 6.19. At an individual level, participant E2 shows huge changes in colour between application and modification. For the application he selected three reddish colours with similar colourfulness and blackness. However, for the modification he removed all those three colours then selected two dark colours (S8010-R50B and S6030-R20B). These two dark colours do not have large differences in terms of their blackness and colourfulness. Participant E3 eliminated two colours from her colour application palette during the modification. Participant E5 changed one colour adjusting to higher brightness and higher colourfulness within the same hue area. This created a prominent contrast between the selected colours. Participant E6 showed big changes in blackness, colourfulness, and hue. Firstly, she selected two grey colours around medium the level (S3000-N and S6000-N) in her colour application task. However, during the modification task, she converted the grey colours into S1040-G90Y and S8502-B. These two colours are highly contrasted with each other. Participant E7 added light blue (S1510-B) colour in the modification colour palette. Participant E8 showed apparent contrast between two colours in chromaticness. Although these two colours (S0570-Y90R and S0515-R10B) are red dominant with same blackness, they show intensive colour contrast due to the huge difference in colourfulness. Overall, the expert designer group seemed to make large changes in the selected colours by adjusting blackness, colourfulness, hue, or changing colour altogether.

As shown in the colour circles, in the application and modification tasks most of the colours are distributed in the areas R, RB, and B. Expert designers hardly ever selected purely green and yellow colours. As for the nuance of colours (see the colour triangles in Figure 6.19), noticeable contrasts in brightness are seen during the colour modification task. By comparing the two colour triangles, it can be shown that colours in medium blackness moved to lower levels of blackness (became darker) during the colour modification task. These changes are not found in the other groups of designers.

Figure 6.19 Colour selection for the commercial product case by ten expert designers: application (left) and modification (right).

6.3.2.3 Overall Colour Design Tendency

Table 6.15 lists each designer who changed their colour selection during the modification task. This seems to show that more experienced designers are more engaged in the stage of the colour design task involving colour modification for older people's needs than less experienced designers. However, caution is needed regarding the generalisability of these findings because of sample size: there were only ten designers in each of the three designer groups. Looking at Figure 6.20, irrespective of designer group and type of product case, designers are in favour of using colours predominantly in the areas B, R, and RB. In contrast, they seem less likely to use colours in the areas Y, G, and GY throughout the stages of the colour design experiment. As for blackness and colourfulness of colours selected by all designers, these are scattered more widely in the colour triangles. Table 6.16 summarises the ranges of both preferred and less-preferred colours by each group of designers across the application and modification stages of the experiment.

This section has looked at 'what' sorts of colours designers use in order to examine general tendencies of colour use by designer groups. Also, differences in use of colours by individuals and at the designer group level were investigated. In the following section, 'what' types of colour information designers believe are useful, and the actual sources of information they used during the colour modification task will be explored, along with 'how' they feel and think about such colour information. This will be done by analysing data collected from the web-based survey.

Table 6.15 Participant codes for those who modified colours during the colour modification tasks.

Designer Group	Medical Product Case	Commercial Product Case
Student	S1, S3, S7	S1, S3, S7
Novice	N1, N2, N6	N3, N6, N7, N10
Expert	E2, E5, E6, E8	E2, E3, E5, E6, E7, E8

Table 6.16 Preferred and less-preferred colours for the medical and commercial product cases for whole experiment.

Designer Group	Preferred Colour		Less-preferred Colour	
	Medical	Commercial	Medical	Commercial
Student	B, R	B, R	GY, Y	G, Y
Novice	B, R, YR	B, RB	G	G, Y
Expert	B, R	B, RB, R	G, Y	G, Y

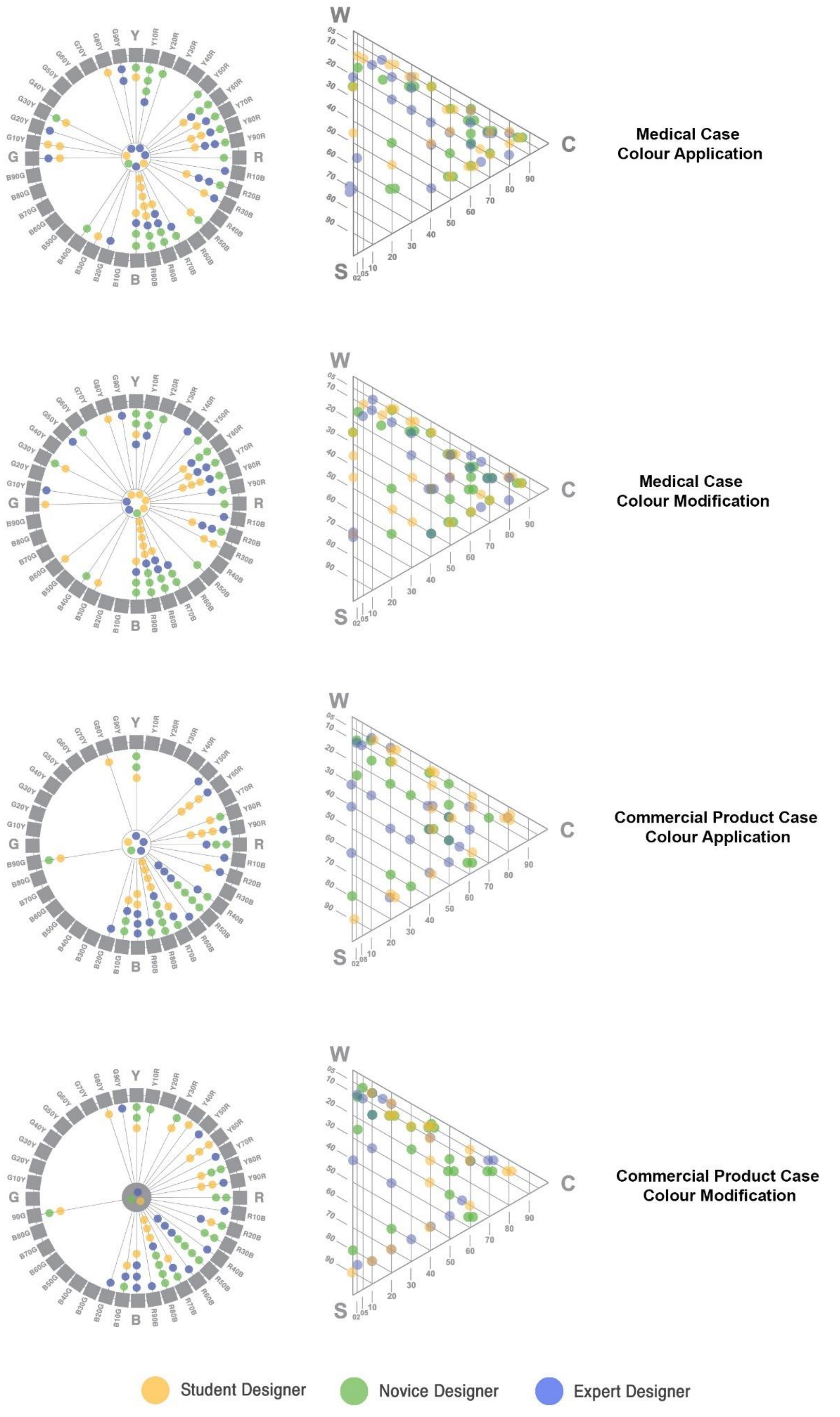

Figure 6.20 General tendency of colour use throughout the colour design experiment by thirty designers.

6.3.3 Web-based Survey with Designers

In this part of the study, descriptive data analysis was carried out using Jamovi statistical software on responses from the closed-ended questions (S1 to S7). The responses to the open-ended question (S8) were dealt with using QSR NVivo.

6.3.3.1 Binary Perceptions on Colour Information Use

After the colour modification task was completed (or during the task), individual designers were required to access an online survey form. There were three parts in the survey containing eight questions in total (see Table 6.6 in section 6.2.4.3). In the first part, there were two questions, as below:

> **S1.** What was your **overall positive perception** of the information you found during this colour application task? (Please tick (✓) as many boxes as you like for statements you agree with)
>
> **S2.** What was your **overall negative perception** of the information you found during this colour application task? (Please tick (✓) as many boxes as you like for statements you agree with)

Table 6.17 lists a breakdown of various characteristics leading to positive and negative perceptions of colour information provision that designers used (ticked) during the colour modification task. On the side of positive value, the most repeated first three terms ticked by all designer participants (*n*=30) were 'relevant' (10.20%), 'visual' (9%), and 'trustworthy' (7.80%). In terms of negative perceptions, the most frequently selected terms by all groups together were 'difficult to find' (10.40%), 'difficult to understand' (9.60%), and 'too abstract' (9.60%). Thus, these terms represent the overall positive and negative perceptions of colour information that designers highlighted while searching for information to aid colours selection for older people during the colour modification task.

Table 6.18 shows the ranking order of positive and negative perception from each designer group separately. The word 'visual' was the most frequently rated by the student (7 out of 10) and novice (6 out of 10) designers. However, it was not highly selected by those in the expert group (2 out of 10). This may suggest that student and novice designers rely on (or prefer to use) more intuitive information forms while searching for user-related colour information more than the expert designers. The words that were selected most frequently by expert designers were 'trustworthy' and 'relevant'. This is probably due to their higher level of personal confidence in their own task related information searching abilities.

Regarding negative perceptions about colour information, different characteristics were ranked most negatively by each designer group (Table 6.18). For example, expert designers (6 out of 10) reacted most negatively to 'small numbers of images' while 'difficult to find' was selected by novice designers (7 out of 10). Student designers (5 out of 10) were most likely to tick 'difficult to understand' for negative experiences during the colour modification task.

Table 6.17 Output for survey questions S1 and S2: positive and negative characteristics of colour information selected by designers as a whole.

Characteristics (positive)	Responses		Percent of Cases	Characteristics (negative)	Responses		Percent of Cases
	Frequency	Percentile			Frequency	Percentile	
Relevant	17	10.2%	56.7%	Difficult to find	13	10.4%	43.3%
Visual	15	9.0%	50.0%	Difficult to understand	12	9.6%	40.0%
Trustworthy	13	7.8%	43.3%	Too abstract (too broad)	12	9.6%	40.0%
Clear	11	6.6%	36.7%	Too much text	11	8.8%	36.7%
Accessible	11	6.6%	36.7%	Small number of images	11	8.8%	36.7%
Stimulating my insights	11	6.6%	36.7%	Too academic	10	8.0%	33.3%
Quick and easy to use	11	6.6%	36.7%	Does not fit with the design process	9	7.2%	30.0%
Up to date	11	6.6%	36.7%	Unreliable	8	6.4%	26.7%
Useful	10	6.0%	33.3%	Out of date	8	6.4%	26.7%
Experimental	9	5.4%	30.0%	Confusing	6	4.8%	20.0%
Concise	8	4.8%	26.7%	Inaccurate	6	4.8%	20.0%
Tangible	8	4.8%	26.7%	Irrelevant	6	4.8%	20.0%
Open-ended	8	4.8%	26.7%	Inaccessible	5	4.0%	16.7%
Specific	6	3.6%	20.0%	Dull	3	2.4%	10.0%
Accurate	5	3.0%	16.7%	Inapplicable	2	1.6%	6.7%
Exploratory	5	3.0%	16.7%	Not useful	2	1.6%	6.7%
Flexible	4	2.4%	13.3%	Complicated	1	0.8%	3.3%
Inspiring	3	1.8%	10.0%	-	-	-	-
Total	166	100.0%	553.3%	Total	125	100.0%	416.7%

Table 6.18 Output for survey question S1 and S2: positive and negative perceptions of colour information selected during the design modification task by groups.

	POSITIVE Characteristics	Level of design			Total		NEGATIVE Characteristics	Level of design			Total
		Student	Novice	Expert				Student	Novice	Expert	
		Frequency (%)						Frequency (%)			
S1	Relevant	5 (29.4)	5 (29.4)	7 (41.2)	17	S2	Difficult to find	2 (15.4)	7 (53.8)	4 (30.8)	13
	Visual	7 (46.7)	6 (40)	2 (13.3)	15		Difficult to understand	5 (41.7)	4 (33.3)	3 (25)	12
	Trustworthy	3 (23.1)	4 (30.8)	6 (46.2)	13		Too abstract (too broad)	3 (25)	4 (33.3)	5 (41.7)	12
	Quick and easy to use	3 (27.3)	5 (45.5)	3 (27.3)	11		Too much text	2 (18.2)	6 (54.5)	3 (27.3)	11
	Up to date	4 (36.4)	2 (18.2)	5 (45.5)	11		Small number of images	2 (18.2)	3 (27.3)	6 (54.5)	11
	Stimulating my insights	3 (27.3)	5 (45.5)	3 (27.3)	11		Too academic	4 (40)	2 (20)	4 (40)	10
	Accessible	3 (27.3)	4 (36.4)	4 (36.4)	11		Does not fit with the design process	3 (33.3)	3 (33.3)	3 (33.3)	9
	Clear	2 (18.2)	5 (45.5)	4 (36.4)	11		Out of date	4 (50)	4 (50)	0 (0)	8
	Useful	3 (30)	5 (50)	2 (20)	10		Unreliable	3 (37.5)	4 (50)	1 (12.5)	8
	Experimental	4 (44.4)	4 (44.4)	1 (11.1)	9		Confusing	2 (33.3)	4 (66.7)	0 (0)	6
	Open ended	5 (62.5)	2 (25)	1 (12.5)	8		Irrelevant	3 (50)	1 (16.7)	2 (33.3)	6
	Tangible	6 (75)	2 (25)	0 (0)	8		Inaccurate	1 (16.7)	3 (50)	2 (33.3)	6
	Concise	2 (25)	4 (50)	2 (25)	8		Inaccessible	2 (40)	1 (20)	2 (40)	5
	Specific	2 (33.3)	1 (16.7)	3 (50)	6		Dull	2 (66.7)	1 (33.3)	0 (0)	3
	Exploratory	3 (60)	1 (20)	1 (20)	5		Inapplicable	0 (0)	1 (50)	1 (50)	2
	Accurate	2 (40)	2 (40)	1 (20)	5		Not useful	0 (0)	2 (100)	0 (0)	2
	Flexible	2 (50)	1 (25)	1 (25)	4		Complicated	0 (0)	1 (100)	0 (0)	1
	Inspiring	1 (33.3)	2 (66.7)	0 (0)	3		-	-	-	-	-
Total		10	10	10	30	Total		10	10	10	30

6.3.3.2 Types of Useful Information for Designers

The types and sources of information that designers believe are useful for gathering colour information with information users in mind were examined. For this purpose, there were three categories: paper-based information [PI], online and digital information [ODI], and people information [PPI]. A symmetric Likert-type scale was used with four possible answers: not useful, somewhat, useful, and very useful.

> S3. **Paper-based Information.** What types of information sources would be useful for designers when they find colour information in relation to information users?
>
> S4. **Online and Digital Information**. What types of information sources would be useful for designers when they find colour information in relation to information users?
>
> S5. **People Information.** What types of information sources would be useful for designers when they find colour information in relation to information users?

Tables 6.19, 6.20, and 6.21 rank types of information sources in each of the three categories (PI, ODI, and PPI). The most popular are discussed here. In terms of PI, of all thirty designers, ninety percent of them believe that information gained from survey research is either very useful or useful, while ten percent answered somewhat. As for ODI, almost all designers (97%) agreed that searching for colour information using the internet is either very useful or useful. In the case of PPI, both interview experts and interview users were rated same value.

A total of twenty-seven information types are listed in ranked order [RO] in Table 6.22. The first five most popular information sources by each designer group are shown in Table 6.23. Regardless of level of designer, the internet is the most useful type for them. However, designers are likely to find or receive information from various types of sources as well. Mixing different types of information sources may need to be taken into account when it comes to discussing effective and efficient information forms for designers.

Table 6.19 Output of descriptive statistics for survey question S3.

Types of Paper-based Information (PI)	Frequency (n=30)			
	Not useful	Some-what	Useful	Very useful
Survey research	0	3	13	14
Journal articles	3	3	14	10
Photographs	3	8	10	9
Government document	4	6	11	9
Theses and dissertations	2	11	9	8
Annual reports	4	8	11	7
Proceedings of meetings and conferences and symposia	5	7	12	6
Leaflets	4	13	8	5
Patents	6	10	13	1
Transcripts	7	10	10	3
Newspaper articles	7	10	11	2
Diaries	8	15	6	1
Letters	12	12	4	2

Table 6.20 Output of descriptive statistics for survey question S4.

Types of Online and Digital Information (ODI)	Frequency (n=30)			
	Not useful	Some-what	Useful	Very useful
Internet	0	1	10	19
Video recordings	2	9	15	4
Communication through social network (Facebook, Instagram etc)	3	11	10	6
Personal blogs	3	12	11	4
Email communication	5	12	7	6
CDs or DVDs	8	13	7	2
Audio recordings	8	18	4	0

Table 6.21 Output of descriptive statistics for survey question S5.

People Information (PPI)	Frequency (n=30)			
	Not useful	Some-what	Useful	Very useful
Interview experts	1	3	11	15
Interview users	0	5	10	15
Working with users	2	5	9	14
Asking clients	0	8	11	11
Asking colleague	0	14	13	3
Asking friends	4	19	5	2
Asking family members	7	17	5	1

Table 6.22 List of information types favoured by designers as a whole (*n*=30).

Ranked Order (RO)	Category	Types of Information
1	ODI	Internet
2	PI	Survey research
3	PPI	Interview experts
3		Interview users
5		Working with users
6		Asking clients
7	PI	Journal articles
8		Photographs
8		Government document
10		Theses and dissertations
11		Annual reports
11	ODI	Video recordings
13		Communication through social network (Facebook, Instagram etc)
13	PI	Proceedings of meetings and conferences and symposia
13	PPI	Asking colleague
16	ODI	Personal blogs
17		Email communication
17	PI	Leaflets
19		Patents
19		Transcripts
21		Newspaper articles
22	PPI	Asking friends
23	ODI	CDs or DVDs
24	PI	Diaries
24	PPI	Asking family members
26	PI	Letters
26	ODI	Audio recordings

Table 6.23 The first five most popular information types for each designer group.

Student designer	RO	Novice designer	RO	Expert designer	RO
Internet	1	Internet	1	Internet	1
Interview experts	1	Survey research	2	Interview users	1
Survey research	3	Interview experts	3	Survey research	3
Asking clients	4	Working with users	3	Interview experts	3
Interview users	4	Photographs	3	Working with users	5
-	-	-	-	Journal articles	5

6.3.3.3 Ease of Information Accessibility and Overall Satisfaction

Designers were required to recall their experiences to rate ease of access to available information and overall satisfaction at the quality of information during the colour modification task. Responses to survey questions (S6 and S7) were gained through ratings on five possible answer Liker-type scales.

> **S6.** Overall, was it **easy to find information** that you tried to use for the colour application (modification) test?
>
> **S7.** What is your **overall satisfaction** with the quality of colour information you found and used during this task?

With regard to ease of information access (Table 6.24), almost half (47%) of all designers recorded neither easy nor difficult. Around one third (30%) of them answered negatively (either strongly disagree or disagree). The rest of the designers (23%) expressed positive experiences in terms of ease of searching for colour information during the colour design task. Nevertheless, it can be seen that designers hold neither strong positive nor strong negative views in terms of ease of accessing information that they searched for.

Table 6.24 Results for survey question S6 by designer group.

		Ease of Information Accessibility (S6)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Level of design	Student (*n*=10)	0	1	5	3	1
	Novice (*n*=10)	0	5	4	1	0
	Expert (*n*=10)	1	2	5	2	0
Total	(*n*=30)	1	8	14	6	1

The results presented in Table 6.25 are indicative of overall satisfaction with the information found and used throughout the colour design experimentation. Approximately half of those who answered the survey question S7 reported that they were neither satisfied nor dissatisfied (43%). Only a small number of respondents (7%) indicated that they were highly satisfied with information found and used. However, the numbers of designers who positively answered (either very satisfied or somewhat satisfied – 33%) are higher than negative answers (23%).

Table 6.25 Results for survey question S7 by designer group.

		Overall Satisfaction of the Colour Information use (S7)				
		Very dissatisfied	Somewhat dissatisfied	Neutral	Somewhat satisfied	Very satisfied
Level of design	Student (*n*=10)	0	1	2	6	1
	Novice (*n*=10)	0	2	7	1	0
	Expert (*n*=10)	0	4	4	1	1
Total	(*n*=30)	0	7	13	8	2

6.3.3.4 Emotional Experience of Using Information for Older Information Users

At the end of the survey questionnaire, an open-ended question was asked. The question is given below.

> **S8.** Can you tell me your overall **feelings** or **experience** while finding and using information about colour modification for older people and **why**?

In order to explore the feelings and thoughts of designer participants during the colour information search for the modification task, emotion codes were generated from the responses of designers. The emotion code is an affective coding method which is a "combination of In Vivo Codes and emotional states and reactions" (Saldaña, 2016, p.125). Terms which showed the emotional experiences of designers were extracted then coded from their statements. In other words, the emotion codes reflect terms actually used by participants.

Five emotion codes were generated (Table 6.26). These were *confused, frustrated, interested, excited*, and *inspired*. There were negative emotions. Some of the participants felt *confused* because of topic unfamiliarity. Plus, difficulties in accessing information made participant S10 *frustrated*. Although other participants did not express their negative feelings and emotions directly as shown in Table 6.26, which is based on emotion codes, similar experiences were expressed in other ways. This phenomenon is observed in all levels of designers (Table 6.27). However, as noted, positive emotions also arose such as *interested*, *excited*, and *inspired* (Table 6.26). Designers seemed to have positive experiences while taking part in solving a design task aimed at helping people. The design tasks that were conducted in this part of the thesis were likely to provoke a sense of responsibility or inspire designers (Participants S8 and S9).

Table 6.26 Emotion codes generated from responses to survey question S8.

	Emotion Code	Empirical Indicators
Negative Responses	Confused	"It's a new topic for me, I felt a bit confused at the beginning" (Participant N6). "Since it is actually my first time to find such information for this kind of groups of people. I felt a little bit confused" (Participant N9).
	Frustrated	"Frustrating because there is not much information easily available" (Participant S10).
Positive Responses	Interested	"It is interesting because I can solve the problems and improve packaging designs for older people" (Participant E2). "After I got some basic knowledge from the google, I start to feel it is perhaps interested me" (Participant N9).
	Excited	"Exciting, because it will be useful and helpful to old person, and also it can give a guideline to designers what to do" (Participant S8).
	Inspired	"Feel responsible and inspired because my grandparents stay with us. We do have this problem" (Participant S9).

Table 6.27 Emotional responses of designer participants to survey question S8.

Participant Code	Empirical Indicators
E8	"I tried to look up reliable information for the design task, but I could not find useful references that could be used in this task. I access the design reference sites. These sites showed brilliant visual information, I do not feel it is trusty. The information-driven sites do not contain image references".
E9	"I found it difficult to find information on colour applications for the elderly. Because there was not much data on this".
N2	"Limited information can be found. And somehow it seems a little bit academic".
N5	"I'm not sure because I didn't find enough information about older people such as age range, their problem and etc".
S4	"I found it difficult to find information for colour application for older people as there is not enough reliable sources that available out there and it is hard to find".
S6	"It can be hard to distinguish whether sources are useful or not. And since I'm not older people I don't know what they need and want exactly".

6.3.4 Email interviews with Design Educators

Comprehensive qualitative data elicited in the email interviews from six design education experts were analysed using content analysis [CA] in this section to meet the aim and objectives (see Table 6.1). Eight questions (see Table 6.5) were asked broadly covering three main issues: (1) perception, experience, and challenges in teaching user-centred inclusive visual communication design, (2) evaluations of a set of Affective Imaginary Information [AII] formats, and (3) suggestions for the future development of the AII formats. Findings will be addressed in the following sections.

6.3.4.1 Results of Email Interviews

6.3.4.1.1 Perception, Experience, and Challenges in Teaching User-centred Inclusive Visual Communication Design

All participants agreed on the importance of user-centred approaches in design projects in general. They all talked about design being for others instead of designers themselves during the interviews.

> Designers are not designing for 'themselves' but 'others', therefore, 'empathy', 'objectivity' and 'context' should be brought before personal preferences and self-indulgence (Participant L1).

> Students need to be drawn to a user centred approach in order to find and develop relevant working approaches and methodologies for their life beyond university (Participant L3).

> Essentially design is for someone else, not for the designer (Participant L4).

> The end user/target audience should always be a key consideration (Participant L5).

In terms of experience of teaching to encourage user-centred approaches, in particular, techniques they apply are varied. Participants L1, L2, L3, and L4 mentioned specific types of techniques they use with design students such as market research, writing briefs, profiling the user, creating user scenarios, tasks of designing for others, peer review, interviews, observation, and norm creativity. In contrast to the others, participant L6 approached the same question in general: "*focus on identifying the user in lots of detail - produce a full picture of the user and their fit in society. Also, to continue to evaluate the success of a problem in progress against the description of the user*".

The statement of L6 can be summarised using two terms: “identifying the user” and “continue to evaluate the success of a problem in progress”. Thus, so far, responses of the participants in this stage prove that all of them hold user-centred problem-solving approaches in design and have knowledge about techniques which help to understand users. The responses of the participants confirm that they are suitable to participate in discussion of the topic of user-centred inclusive design that is dealt with throughout this research project.

With regard to answer to the questions about difficulties and challenges in terms of encouraging student designers to think about users first, eleven codes and four themes were generated (Table 6.28). There are four main themes: (1) lack of confidence and learning background, (2) level of awareness about users, (3) ignoring a step-by-step design process, and (4) a subjective outlook.

In the case of the first theme above, ‘lack of confidence and learning background’, it should be recalled that a similar theme of ‘lack of education and experience about design inclusion’ were revealed as reasons behind the creation of inaccessible design outcomes by designers during the designer study in Chapter Five (see section 5.6.1). In terms of the second theme ‘level of awareness about users’, this can be matched to the theme of ‘difficulties in empathising’ from Chapter Five. The third theme above ‘ignoring a step-by-step design process’ can be related to a point mentioned by participant L5: “*they are often fixated on a shiny and polished final outcome and rush to get to that stage without going through the primary and secondary research needed to really make a project work*”.

Two design educators (participants L1 and L4) said that a difficulty is that design students are likely to focus on themselves rather than the audience of the design project. This might be discussed as part of the issue of the subjective approach of designers. This might suggest there could be difficulty in getting student designers to empathise with users. A similar issue arose during the designer studies in Chapters Four, Five, and Six regardless of the level of experience of the designers. However, it was also revealed that designers often have an emotional approach too, if we remember the results of Chapters Four and Five, because of subjectivity, emotion, and creativity, while looking at facial expressions of the users in the AII formats, designers tended to imagine users’ emotions due to the situation that the user might be facing. Using an emotional approach based on user needs may help to take advantage of the emotional qualities of designers when we try to give them information. These results taken together may provide support for the use of

AII formats. The evaluation of the AII formats will be addressed in the following section 6.3.4.1.2.

Table 6.28 Difficulties and challenges in terms of making student designers consider users first in design.

Meaning Unit (example quotation)	Code(s)	Theme
"Students relying on their intuitions and personal preferences – as being self-indulgent and self-centred, therefore unable to think for or from 'others' perspective" (Participant L1).	▪ Intuitions ▪ Personal preferences ▪ Self-indulgence ▪ Self-centred approach	Subjective outlook
"A main issue is often confidence and at the same time the learning background they bring along from secondary pre-university education" (Participant L3).	▪ Confidence and learning background from previous education.	Lack of confidence and learning background
"It is a change of mindset and perspective shift from the student most of all, as they are used to and think almost exclusively about making something which appeases and looks good for them only. They are also more focussed on making things which look good instead of functioning well or doing a good job" (Participant L4).	▪ Looking good instead of function ▪ Looking good for themselves	Subjective outlook
"Our students have grown up in a very digital and visual world, and they are constantly consuming image-based material through their smartphones. Part of the outcome of this is that they are often fixated on a shiny & polished final outcome and rush to get to that stage without going through the primary and secondary research needed to really make a project work" (Participant L5).	▪ Ignoring research stage ▪ Rushing to final outcomes	Ignoring a step-by-step design process
"An awareness of a specific user, the specific details of a user and how to continue to analyse a work for a specified user through the duration of a project" (Participant L6).	▪ Need for awareness of a specific user ▪ Need to analyse a piece of work for a specified user	Level of awareness about users

6.3.4.1.2 Evaluations of a Set of Affective Imaginary Information Formats

In the second part of the email interviews, the set of AII formats was evaluated in terms of four aspects of their design as below. A five-point Likert-type scale was used for the first three aspects:

- **Evaluation of pictures**: please indicate whether you agree that the picture of the facial expression successfully relates to the question on each card. Please tick (✓) to give your answer in the table and provide brief reasons for your answer.
- **Evaluation of text**: please indicate whether you agree that the answer on the back side of each card would provide an appropriate amount of information to encourage designers in general to consider information users? Please tick (✓) to give your answer in the table and provide brief reasons for your answer.
- **Amount of Information**: please indicate whether you agree that the amount of information on both sides of each card is appropriate? Please tick (✓) to give your answer in the table and provide brief reasons for your answer**.**
- **Usefulness**: overall, do you think the AII formats (see above) would be useful to encourage designers in general to have a user-centred approach in mind when designing information? If your answer is yes or no, please give reasons.

For the evaluation, the set of AII formats (see Figure 5.11 in section 5.4.5.2.5) was presented on a single page onscreen first. Subsequently, each card was presented on a separate page onscreen. To evaluate the first three aspects, as noted, participants were asked to measure each card on a five-point Likert-type scale. They also gave brief reasons for their answers. Responses about the usefulness of the AII formats were written also by each participant. The results of the evaluation of each aspect will be described below.

In terms of the evaluation of the pictures on each card (Figure 6.21), all responses about card 1 were in either the neutral category, or positive categories (agree or strongly agree). As for cards 2, 3, and 4, each received one disagree score from participant L5, each card also received neutral or positive scores from the other five participants. As shown in Figure 6.21, card 4 received four neutral ratings. Participant L4 offered a reason for giving a neutral rating, and seemed to feel it was too vague. Thus, participant L4 said "*slightly improved in the sense that the elderly woman is wearing sunglasses – that denote travel, and the lifted off the face and facial expression of surprise* *'what is this?' expression suggest a vague reference to being in an unfamiliar place".* Participant L6 said *"expression not linked to the idea".* From the responses of these participants, two issues may be revealed that need to be consider for future development. These are careful consideration of the most appropriate facial expressions, and also careful consideration of the items on the image.

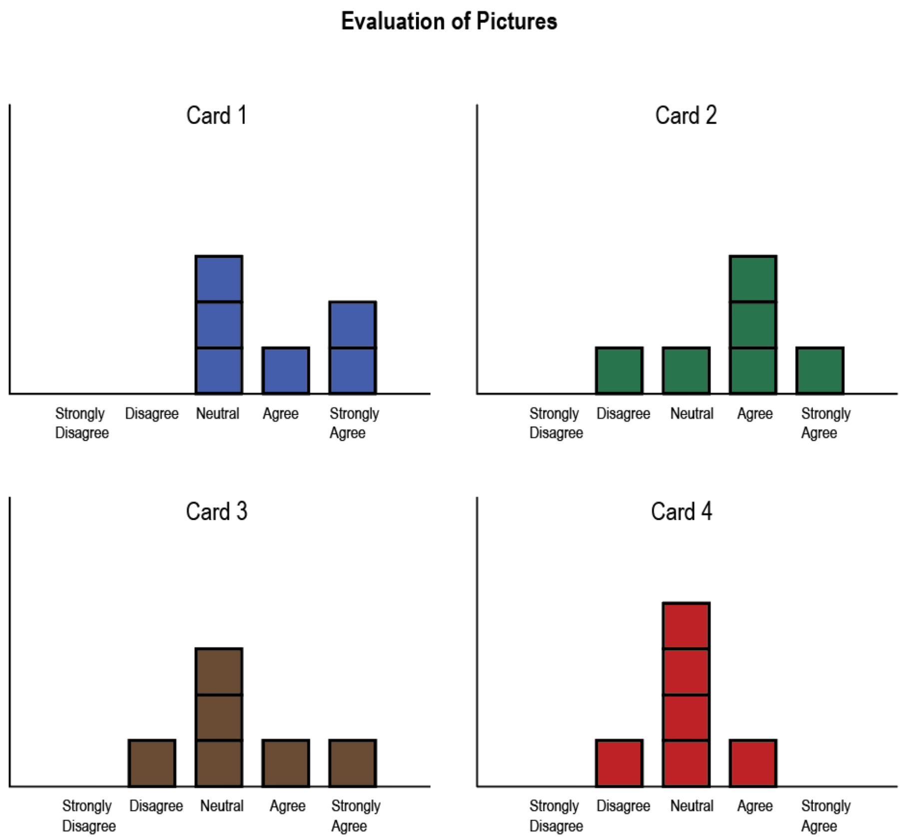

Figure 6.21 Evaluation of pictures on each of the AII card formats by design educators.

In terms of evaluation of text, Figure 6.22 illustrates that all participants agree or strongly agree that the text on card 1 provides an appropriate amount of information to encourage designers in general to consider information users. The reasons for the positive ratings were provided by participants. For example, participant L4 said it showed "*very succinct and clear problems based on reading text for elderly people, also, the age of the person helps to define the target audience more*". In addition to this, participant L6 mentioned that *"It is a clear problem".* Also, participant L5 provided the reason that "*it would definitely help in terms of things to consider, but it doesn't give indication of exactly how to change things e.g. 'Font size 20 is the best for people with sight loss' – just an example*". The opinions of these participants can be summarised as suggesting that (1) using direct quotations of what the users' actually say would be helpful, (2) it would help to indicate the problem clearly, and (3) detailed information or guidelines should be given. This provides useful insights about what needs to be considered to create tools for designers, which might help them to consider the central position of users.

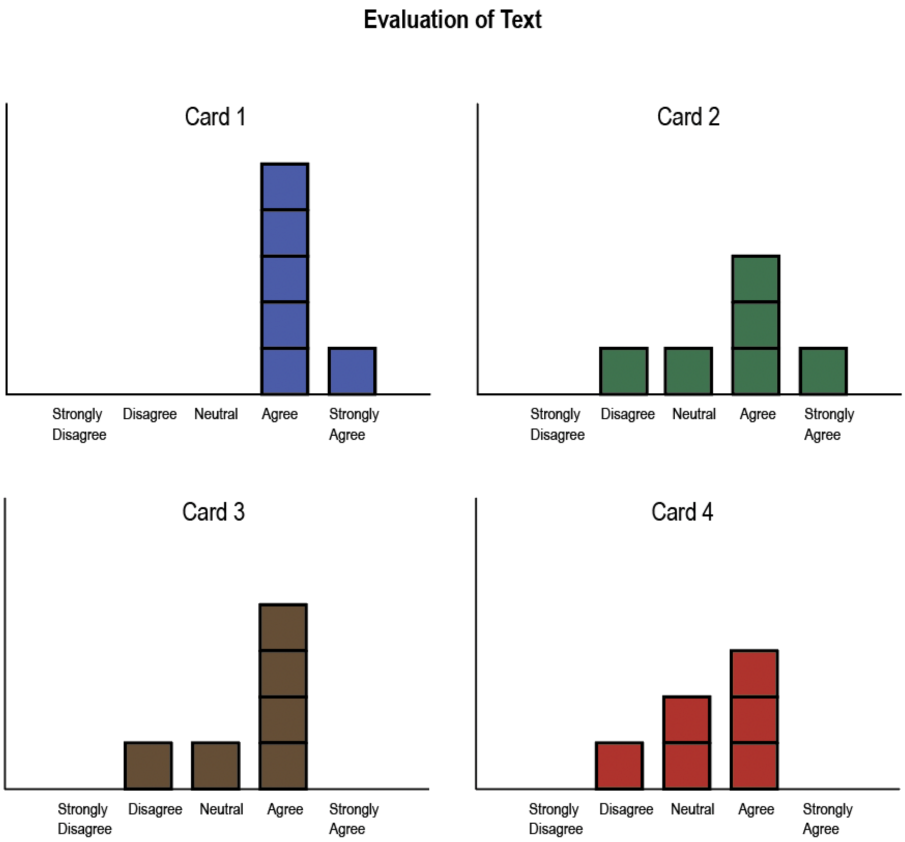

Figure 6.22 Evaluation of text on each of the AII card formats by design educators.

In term of cards 2, 3, and 4 (see Figure 6.22), each received one disagree score from a same participant. Although each card also received neutral, four in six participants rated either agree or strongly agree. Thus, the set of AII cards could be regarded as a useful tool in terms of contents (textual information) with in a context of colour information use for older information users.

As regarding card 2, there are debating opinions between participants L5 (Disagree) and L3 (Agree). On the one hand, participant L5 provided the reasons for disagreement: "*Useful information but some of it is unclear. For example, 'yellow and brownish' – what does this mean? Does it mean those with cataracts see things as yellow and brownish or does it mean those* *colours should be avoided? As with the first card, more information would be helpful here".* On the other hand, participant L3 rated agree: *"Again, it is helpful as a starting point for designers to consider different colour related issues".* As we will see in the last part of the AII evaluation, participant 5 seemed to wish to read more information on card or use textual information forms such as leaflets. However, due to the main purpose of the AII format is to provoke designers' emotion, creativity, and empathy by using their emotional and creative characteristics to make them consider user first with a small amount of information based on the findings from literature and Chapter Five.

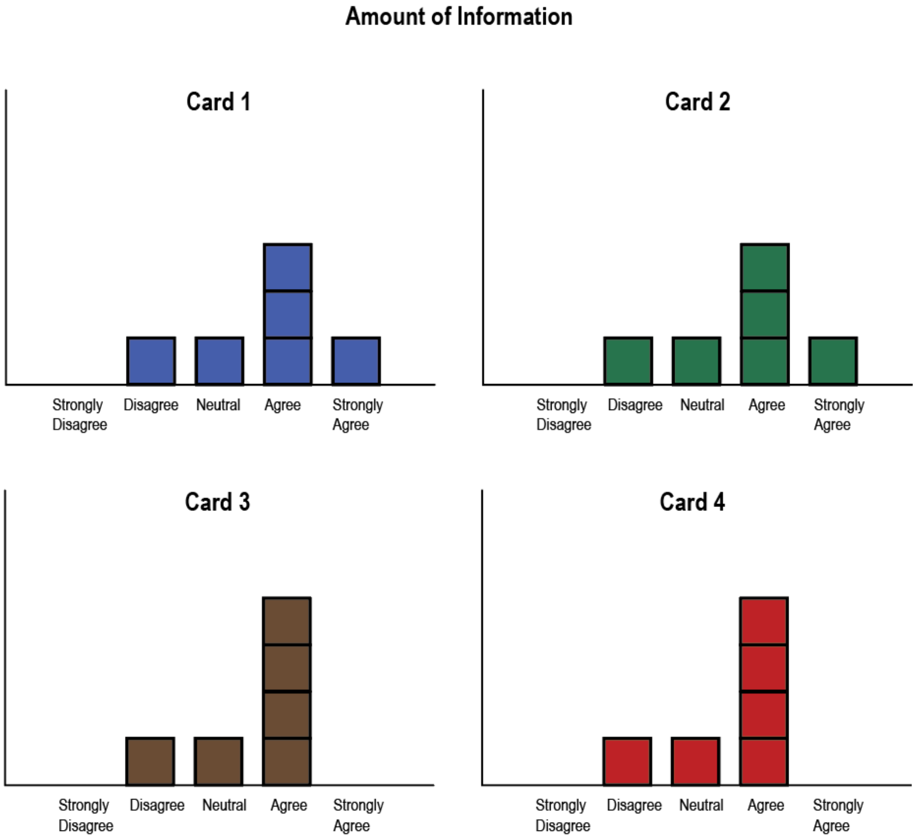

Figure 6.23 Evaluation of the amount of information on each of the AII card formats by design educators.

As Figure 6.23 shows, four in six participants agree or strongly agree that the amount of information on both sides of each card is appropriate. Participant L5 rated disagree for four cards giving the same reason for each:

> While the information provided is interesting, it only relates to one specific context and also does not provide any tangible indication of how the design could be improved for these users – it only explains their difficulties. Perhaps some suggestions would be helpful here (Participant L5, evaluating for each of the four cards).

It seems that participant L5 believes that more information would be useful. In the same vein, this participant also provided similar feedback for the further development of the formats in terms of evaluation of text. This is quoted again here for ease:

> It would definitely help in terms of things to consider, but it doesn't give indication of exactly how to change things e.g. 'Font size 20 is the best for people with sight loss' – just an example (Participant L5).

However, most of the participants measured each card positively (either agree or strongly agree) and gave reasons. Examples are below:

> It makes sense to have more contrast to better distinguish colours (Participant L1, evaluating card 2).
>
> Very specific and defined issues (Participant L4, evaluating card 2).
>
> I suppose we could learn a little more about the problems specifically here (Participant L4, evaluating card 4).

The amount of information to give is a major issue when considering providing information to most designers. This is because, based on the findings in Chapter Five, they often seem to prefer images to reading information. Based on the results of the evaluation of the AII formats in this section, the amount of information on each card here seems to be appropriate in general. The results here seem to provide guidance in terms of consideration of the amount of information to give designers.

In relation to the usefulness of the AII formats, five in six design educators (not including L5) agreed that the AII formats would be useful to encourage all designers to have a user-centred approach in mind when designing information. The reasons for agreement about the usefulness of the AII formats by the participants are illustrated in Table 6.29 with key terms provided by the researcher.

On the other hand, participant L5 disagreed about the usefulness of the formats and gave the following reasons:

> I <u>wonder</u> if the format of a card is appropriate as <u>a learning/design resource</u>. Cards are good for things such as business cards, used to convey <u>a small amount of information</u> and then sometimes discarded. If it is intended for a designer or student to refer to when starting a project, would it not make more sense to use a book/leaflet/online format? This would allow <u>a lot more</u>

> information to be included and it would also mean all could be kept in one place and referred back to when needed. Cards may be easily lost (Participant L5).

Participant L5 continues to suggest there is an issue with the amount of information provided. It seems that participant L5 prefers to use textually rich information/data rather than images with short descriptions. However, the latter are shown as preferred by most designers throughout the current research project, and this is supported by other scholars (e.g. Frascara, 2004; Goodman *et al*., 2007). The usefulness of the card tool has been proven and researched by various scholars in the design area (e.g. Beck *et al*., 2008; Arrasvuori *et al*., 2011; Yoon *et al*., 2016; Lundqvist *et al*., 2018; Lee *et al*., 2020). Thus, it is certainly a popular area of research and it is suggested cards are helpful. However, participant L5 wondered about the usefulness of the card tool as a learning resource. This participant's comments are still interesting because these preferences may provide new angles of research to find better suggestions and solutions to providing information in a designer friendly way including formats, context, the amount of information and so on.

Table 6.29 Reasons given for usefulness of the AII formats by design educators.

Empirical Indicator (evidence)	Key Terms
"Yes, seeing how poorly the general design is could encourage designers with conscience to want to improve it" (Participant L1).	▪ Making designers see poor design ▪ Encouraging designers to improve
"Yes – a good reminder and not only for designer, but these professionals are also often the last decision makers" (Participant L2).	▪ Good reminder for designers and others
"As said as a starting point and encouragement these cards are helpful" (Participant L3).	▪ Starting point ▪ Encouraging designers ▪ Helpful
"Yes- specific ages need specific design problems solved. The problems can be overcome easily by a good design" (Participant L6).	▪ Specific design problems highlighted [in the card format].

6.3.4.1.3 Suggestions for the Future Development of the AII Formats

In the last section of the interviews, design educator participants were asked the following:

- Please also provide suggestions for further development in general for the AII formats, in terms of design elements, contents and so on which should be added or deleted.

Based on the responses of the participants, the suggestions for further development can be summarised as follows: (1) using blocks of images, (2) using more straightforward elements and contents, (3) involving older designers to create contents, and (4) providing follow-up points and weblinks to further information. Relevant example quotations are underlined in Table 6.30. These suggestions may be helpful points to consider for the future development of the AII formats in order to make them more designer friendly and to encourage designers to take into account information users.

Table 6.30 Suggestions for improvement of the AII formats given by design educators.

Participant Code	Empirical Indicator (evidence)
L1	Only relevant and straightforward elements and contents should be included. The less important and redundant ones should be deleted to avoid further confusion. I think finding designers in the age group of 40-50 would help, because they will be facing the crisis soon and would be more empathetic when designing.
L3	As in contrast to elderly public transport users, designers are able to access web-based information a webpage with more in-depth information/follow up points to the card's initial points made and related weblink could be helpful.
L4	The cards could be presented like blocks of images rather than singular imagery, as one image to capture all these issues is not easier e.g. the person with cataract issue – this could be enhanced with colour field or pantone yellows to signify these sight related experiences for the user.

6.4 Conclusions

This Chapter has offered an exploration of actual colour use and the colour information use behaviour of designers under a controlled design situation. The research in this chapter was developed from reviews of literature as well as earlier Designer Studies in this thesis. Based on findings from Chapter Four, the AII formats were developed in Chapter Five and applied in Chapter Six during the designer study. The AII formats were evaluated by professional design educators in HE in the UK in the present chapter. Due to the complex nature of colour as well as difficulty in defining the abilities of designers, diverse data collection and analysis techniques were adopted.

The main findings of this chapter are below.

Findings from email interviews with designers:

- Colour seems to be regarded as the most fundamental factor in design elements/principles in the everyday design tasks of designers irrespective of the experience level of these individuals as well as their area of design.
- Affirmative and negative attitudes toward colour information use were revealed by designers. However, these do not seem to relate to the experience level of designers but rather relate to personal factors.
- There were four factors that influence designers in colour information use: attitudes, guidelines and instructions, knowledge and experience, and Information accessibility.

Findings from colour design experimentation with designers:

- Personal attributes seemed to be influential in the colour changes during the colour modification task rather than the experience level of designers. There was no significant difference in terms of numbers of designers who tried to change colours during the colour modification tasks among designer groups. However, expert designers did try to modify colours more than other groups of designers.
- Designers preferred to use colours in a range of Blue and Red. They seemed to disfavour Green and Yellow in the case of medical and commercial product cases. These phenomena are common in the three designer groups.
- Designers seemed to consider hue differences between colours more than blackness or colourfulness in contrast.
- The expert designer group were more likely to consider intensive contrast in colour compared to other groups of designers.

Findings from web-based survey with designers:

- Perceptions on colour information were as follows: positive (relevant, visual, and trustworthy) and negative (difficult to find, difficult to understand, and too abstract).

- Designers believed that various types of information sources would be useful for providing colour information in relation to information users: internet, interview/working with experts or users, and survey research and journal articles.
- Ease of information accessibility and overall satisfaction at the colour information used have a positive correlation with each other.
- Difficulties in finding reliable colour information were the main issues that were reported by all groups of designers.
- Designers are likely to be inspired, excited, and interested in a new subject when they believe they can help others by solving a problem in a designerly way.

Findings from email interviews with design educators:

- Design educators who were involved in this research all agreed that design is for others and part of a problem-solving approach.
- Design educators pointed out four issues relating to problems in making designers think about users. Lack of confidence and learning background, lack of awareness of users, ignoring a step-by-step design process, and having a subjective outlook.
- Each element, in other words, texts, pictures, and amount of information on each of the AII card formats, and their usefulness were positively evaluated by the professional design educators.
- Suggestions for future directions of the AII formats were provided by professional design educators. These were providing blocks of images, having more straightforward elements and contents, involving older designers to create contents, and providing follow-up points and weblinks.

6.5 Summary

A comprehensive set of data was collected and analysed in this chapter to answer one of the overarching research questions of this thesis. The findings in this chapter offer specific perspectives on how we approach research into designer in the area of colour information design from an inclusive user-centred angle. In the next chapter, findings from each of the main designer studies in the thesis (Chapters Four, Five, and Six) will be discussed in synthesised and carefully considered to establish their implications.

*** Note.** Related Publications to Chapter 6.

Conference paper

Lee, G., Cheung, V., Tang, T., Westland, S. 2020. Designers' experience and use of colour information. In: *Proceedings of the International Colour Association (AIC) Conference 2019. AIC 2019 Color and Landscape, 14-17 Oct 2019, Buenos Aires, Argentina*. International Colour Association (AIC), pp.162-167.

Lee G., Cheung V., Tang T. 2021. The role of colour designers in the design process. In: *Proceedings of the 14th International Colour Association (AIC) Congress. The 14th International Colour Association (AIC) Congress, 30 Aug - 03 Sep 2021, Milan, Italy*. pp. 861-866. (Winner of a best paper award)

Chapter 7 DISCUSSION

7.1 Introduction

In this chapter, the research questions will be re-examined and the findings from the research project will be discussed and related to existing studies. In addition, the implications of the most significant findings from the research will be described. For this purpose, the findings of previous chapters are reconsidered together to explore interconnections between them.

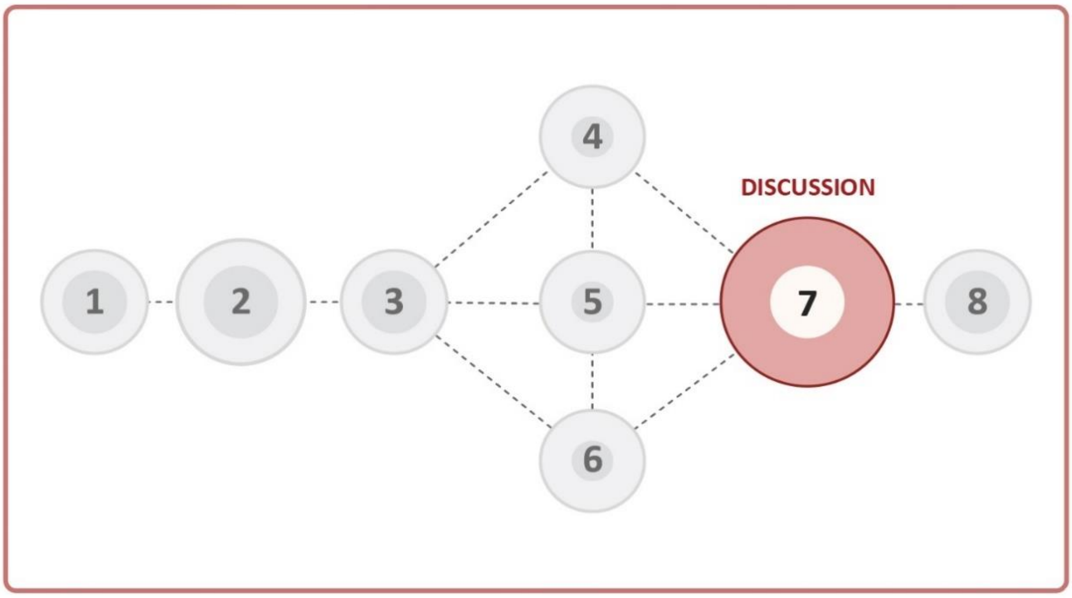

Figure 7.1 Position and context of Chapter Seven within the whole research process.

The overall aim of this research was to explore fundamental reasons behind designers producing inaccessible information design; ultimately to consider more effective ways of offering user-related colour information to designers from a perspective of inclusive design. This has been fulfilled and the findings throughout this research have been used to create and evaluate a set of Affective Imaginary Information [AII] formats by taking into account behaviour and characteristics of designers.

Considering the research as a whole, it is possible to identify two main area of focus:

1. Exploration of new approaches to explore fundamental characteristics of designers by applying linguistic theories and analysis and by analysing the behaviour of these individuals in use of colour and information in design practice.

2. Discussion of effective ways of providing colour information formats to designers by considering the characteristics of designers themselves, in order to encourage them to consider information users from an inclusive viewpoint.

Discussion relating to theory and practice in design and to bringing about behaviour change for designers based on an inclusive philosophy is continued below.

7.2 A Problem-Solving Paradox

As outlined in Chapter Two (section 2.2.1), the meaning of design has been expanding over the past decade. This can be understood when we consider that the responsibilities and influence of designers in our society have also been changing. Contemporary designers may be described as practical problem solvers whose role is to solve contradictions (Sparke, 1983; Wong, 1993, Cross, 2001; Frascara, 2002).

For example, according to Allen (2013 cited in Çetin and Aryana, 2015, p.4),

> Contemporary designers are required to concentrate on relations between design and society and power of design to transform our environment and society rather than a pursuit for form and function.

The topic of designers and designing behaviour is a source of fascination for design researchers. For this reason, levels and types of problem-solving ability between designers with different levels of experience have long been explored (see section 2.2.2.3.2). Wynn and Clarkson (2005) argue that designers tend to prefer more creative solutions to problems in comparison to scientists. From an inclusive design context, Dong *et al*. (2015) claim that designers are engaged in promoting and delivering design solutions. The researcher of this thesis agrees with the statements mentioned above by other scholars, these support the present designer-driven research project. However, although designers can be problem improvers, there are still unsolved social issues of exclusion caused by designers in our society from an inclusive design perspective. Based on this background, a fundamental leading overarching research question (RQ 2-1) arose.

RQ 2-1 Why do designers consistently continue to create inaccessible communication materials even though scholars have identified the problems that arise from them doing so?

This leading research question led to the whole research project, encompassing the other four overarching research questions (RQs 2-2, 2-3, 2-4, and 2-5) as well as an extra overarching research question RQ 4-1 which was generated based on findings in Chapter Four (see Figure 2.31 in section 2.4 and Table 4.14 in section 4.4.2). The overarching questions will be given again, and discussed along with implications of the findings that arose from them in the following section. Table 7.1 illustrates the relationship between overarching research questions and how they reflect a systematic problem-solving approach in design.

Table 7.1 Overarching research questions and relevant chapters, reflecting the problem-solving process adopted in the thesis.

Overarching Research Question	Problem Solving Process	Relevant Chapter
RQ 2-1	Identify the problem	CH 2. Literature review
RQ 2-2 RQ 2-3 RQ 2-5	Investigate the reasons behind the phenomenon	CH 4. Exploration of how designers perceive tasks from colour description experiment.
		CH 5. Investigation of use by designers of information formats for colours and of how designers utilise user colour information.
		CH 6. Actual colour and colour information use behaviour (by designers with different levels of design experience) for real world product cases in a problem-solving design situation.
RQ 2-4 RQ 4-1	Generate potential solutions and tests	CH 5. Creation of a set of AII formats and initial test by designers.
		CH 6. Use by designers of the AII formats while doing colour and colour information design tasks.
	Evaluate results and suggest solutions.	CH 6. Evaluation of the usefulness of the AII formats by professional design educators with practical experience in the design area.

7.2.1 Influential Factors

7.2.1.1 Conflict between Subjectivity of Designers and Objectivity Needed in Design Problem Solving

As mentioned above, although various scholars agree that designers are problem solvers, problematic design artefacts are commonplace. However, there has been little discussion regarding the fundamental reasons behind such problematic design created by designers. In order to explore the reasons for these ineffective designs arising, problematic situations (colour description tasks) were given to design and non-design groups in Chapter Four. This addressed the overarching research question RQ 2-2:

> **RQ 2-2** How do designers perceive and communicate about colours?

The findings for this research question indicate how designers may perceive colours and design tasks in a real-world situation. The responses of two different groups were compared with each other in order to explore characteristics of design participants while doing a design task (a problem-solving situation). This was based on their use of language and adopted a sociolinguistic theoretical background with a constructivist perspective (e.g. Eckert, 2005; Bucholtz, 2009; Wales, 2011; Ballard, 2013; Matthews, 2014). A number of contrastive characteristics were revealed. The characteristics of the design participants were categorised linguistically and behaviourally.

In the case of the linguistic characteristics of the design group, it was found that the language that design participants used could be explained with four adjectives: *associative*, *evocative*, *emotive*, and *imaginative*. There are representative examples of language falling under these four key adjectives in the excerpts from transcription below.

> **Associative.** Tomato, can I say the brand like McDonald. Hot I mean like chilli. Blood. Like an old traditional, like Chinese culture. Positive as well, like passion (Participant D2).

> **Evocative.** You know the warm colour always reminds me of food. (Participant D2).

> **Emotive.** It makes me think about the autumn, especially leaves down, so it makes me feel uncomfortable (Participant D8).

> **Imaginative.** If I see this colour everywhere I feel die, yes, I mean I am just dying naturally (Participant D5).

The linguistic characteristics addressed above were only found among participants who held a design degree in their higher education. However, the boundaries of the responses under the four key adjectives appear to be ambiguous. For this reason, in order to investigate any linkages between them and see contexts after and before these four key adjectives, a text search query was utilised to generate word trees (using QSR Nvivo12 Plus) from the data collected for the whole of Chapter Four (Figure 7.2). Root terms were *associative*, *evocative*, *emotional*, and *imaginatively*. The criteria for producing the word trees are generalisations (level five – words with a more general meaning), alphabetical (branch order) and five (words).

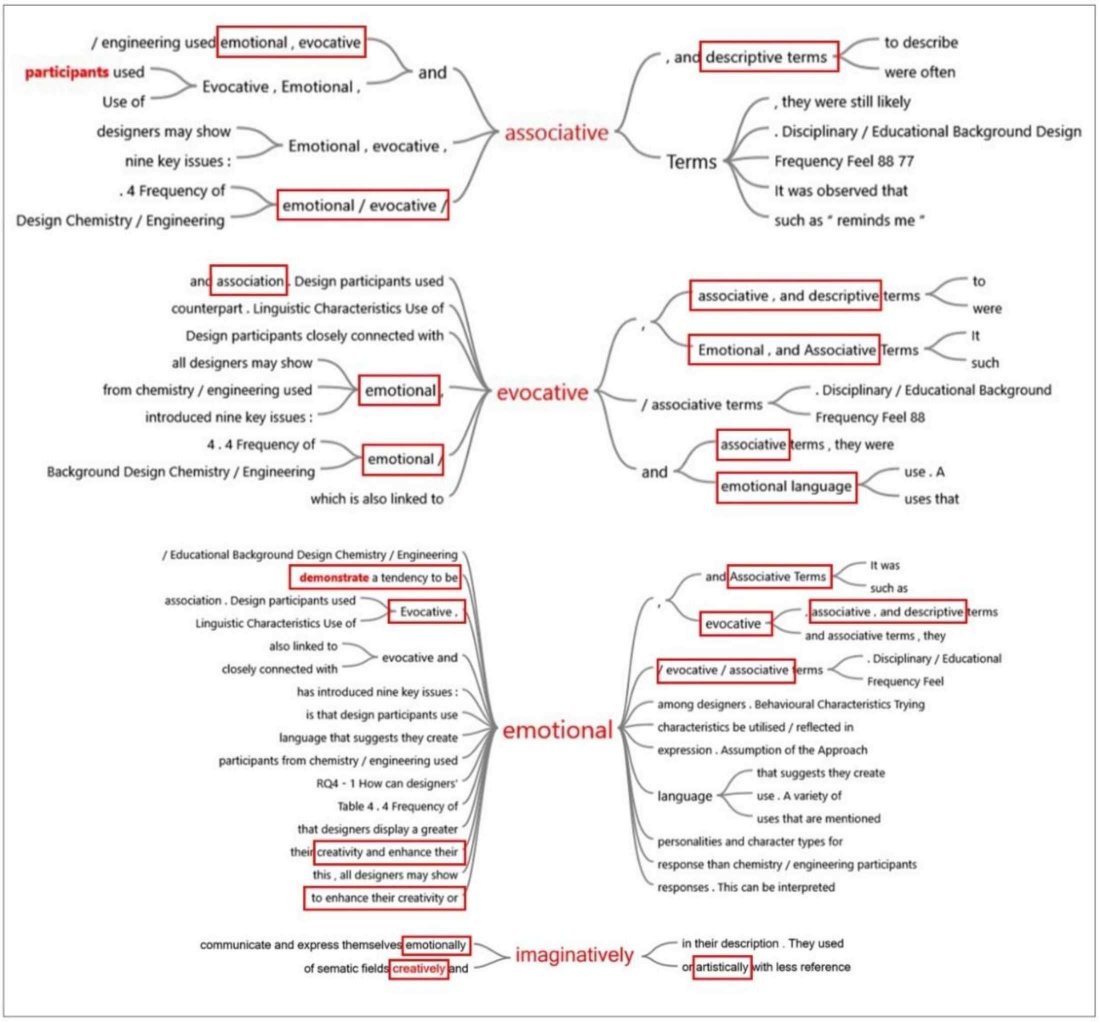

Figure 7.2 Word trees generated from the participants responses based on four key terms in the data collected during designer study one (source: Chapter Four – Designer Study One).

In the word tree, it is clearly shown that these four key root terms are used together in the data collected in Chapter Four. For example, the key adjective *associative* was used with *emotional*, *evocative*, *descriptive*. In addition, *evocative* was used with *emotional*, *associative* (*association*), and *descriptive*. Moreover, the adverb *imaginativ*ely was used with three other adverbs such as *emotionally*, *artistically*, and *creatively*.

This can be interpreted as suggesting that the adverbs (*emotionally*, *artistically*, and *creatively*) closely relate to each other. Because the four key adjectives (*associative*, *evocative*, *emotive*, and *imaginative*) have no hard boundary, these three adverbs can be linked also to all of the four key adjectives. In sum, there are four primary terms (adjectives – *associative, evocative, emotive,* and *imaginative*) and three secondary terms (adverbs – *artistically, emotionally,* and *creatively*) which represent how characteristics of designers have been described. Such primary and secondary terms which represent characteristics of design participants do not seem to closely relate to objectivity.

The results are suggestive of a link between using language, behaviour, and ways of thinking in the area of design. Professional language in various disciplines has been studied within applied linguistics (e.g. Bhatia and Bremner, 2014), in communication studies (e.g. Ulijn *et al*., 2000), in business (e.g. Vuorela, 2005) and so on. These studies show how language shapes identities and ways of thinking for professionals. However, little research has been done for designers and yet designers have a real impact on people's quality of life. These findings from sociolinguistics and about professional language, behaviour and identity have important implications for understanding designers' practice and ways of thinking.

7.2.1.2 Emotional Effects on Information Use Behaviour

The overarching question RQ 2-3 sought to explore features of types and sources of user-related colour information that designers searched for and used.

> **RQ 2-3** What are the features of user-related colour information provision that designers actually access, and how do they talk about the features?

The answers to this question can be provided based on the findings in Chapters Five and Six. It was found that the information sources that designers accessed during the colour modification tasks were heavily image-based and from photo sharing online platforms. These results are similar to those reported by various other scholars (e.g. Lofthouse, 2006; Goodman *et al*., 2007, Gonçalves *et al*., 2014). Although student designers are likely to prefer to use images over objects in comparison to professional designers, all are less likely to prefer text as an inspiration source regardless of level of design experience (Gonçalves *et al*., 2014). Similar findings were revealed during the current research project showing designers preferred simpler information instead of searching for textual (perhaps more detailed) information telling them what they should or should not do. It is not very surprising that designers are unlikely to read detailed written guidance or simply may not have awareness about guidelines according to Pettersson (2015c). Designers seem to consider visual aesthetics more than functional aspects of information.

The fact that designers are, nevertheless, inspired consciously by actively searching for information or unconsciously by what surrounds them (Goldschmidt and Sever, 2011), does raise questions about how we can inspire designers in order to engage them to change their behaviour toward more user-centred design.

In terms of possible implications for design formats/tools in practice, the findings here indicate that designers are bounded to a limited range of inspirational stimuli in terms of using colour information when designing for information users. It seems obvious that information formats provided for designers need to be developed and used based on the preference of designers themselves. However, issues could arise relating to the amount of necessary information given if we use images with less text. It may not be easy to provide detailed guidelines that designers should be aware of using images. Thus, research on the combination of use of textual information with images as inspirational information formats may be needed in the future.

It was also discovered in Chapter 5 that positive and negative emotions seem to affect designers' use of information formats (conventional or online) and sources (textual or image-based). The findings of the current research consistently prove that designers react emotionally toward design tasks, but also feel emotional empathy perhaps because of their own emotional attributes. A considerable amount of literature has grown up around the theme of design and emotion. However, most studies have investigated the emotional functions (responses, engagement, and interaction) from users to design outcomes or services (e.g. Desmet *et al*., 2001; Demirbilek and Sener, 2003; Mao *et al*., 2017; Jourabchi Amirkhizi *et al*., 2022; Özmen *et al*., 2022). On the other hand, few studies have been conducted to investigate the emotional characteristics of designers and their impact on the behaviour of designers themselves. This is true in the case of the use of user-related colour information and actual colour use by designers. This is rather surprising. Although it is necessary to understand the behaviour of designers when we investigate how they go about problem identification and providing solutions, emotion and empathy seem to be overlooked. It may be important to consider how such a dominant characteristic of design participants could be utilised to make a positive impact on designing behaviour. Indeed, it may be that this could be used to urge designers to consider diverse types of users by empathising with the emotions of those users. This might also provide some answers to how we can make designers think more inclusively.

7.2.1.3 Tacit Knowledge, Intuition, Conjecture, and Design Sensitivities

The overarching research question RQ 2-5 sought to examine how colours and colour information are dealt with by different levels of designers (in terms of level of experience) in real world design contexts.

> **RQ 2-5** Are any distinguishing characteristics between different levels of designers revealed in a problem-solving design task in terms of use of colours and colour information?

Based upon a review of around thirty published scholarly outputs from non-colour design areas (see section 2.2.2.3 and Table 2.9), it was hypothesised that unique differences would be discovered under a problem-solving situation related to colour (a design task) between less-experienced and more-experienced designers, irrespective of field of design. It was also expected that different levels of knowledge and skills would be found in terms of colour information use and colour design in the task given because they are acquired with certain levels of design experience. In Chapter Six, to test these hypotheses, three designer groups (student, novice, and expert) were invited for a colour design experiment (application and modification) and a user-related colour information search task.

When it comes to the colour information search task during the colour modification activity (colour selection for older people), the results show rather unanticipated findings. These are that there are few differences between different levels of designer groups by experience. It was found that most of the designers (19 in 30) relied on tacit or subjective resources. These are intuition, more subjective previous experiences and knowledge, conjecture, and design sensibilities. These results reflect those of Forlizzi and Lebbon

(2002) who state that designers are likely to rely on their personal insight in the context of user-centred communicative design.

Tacit knowledge in design would be associated with prior design experience and education to some degree. However, this could be a problematic issue in some cases based on the previous investigation in Chapter Five (section 5.6.1). While caution is needed because of a small sample size in Chapter Five, the ten doctoral design students who participated had little design education, project or research experience in terms of design inclusion and different ranges of users. The findings in Chapters Five and Six therefore prove a need to enhance education, research, or design projects for people who study or work in the field of design to keep various users who have different levels of cognition in mind while designing.

Even though levels of education and design experience, age, and nationality vary among designers, there is no significant difference at a group level in terms of actual colour use. Instead, a common tendency in colour use was revealed by all groups of designers. Designers preferred to use colours in the shade of red, blue, and red-blue. In contrast, they did not favour colours in a shade of yellow, green, or yellow-green. Another important common feature was that designers seemed to consider mainly hue differences when they tried to make contrasts between colours while doing the colour modification task. This phenomenon was only slightly clearer among the student and novice designer groups than for the group of expert designers. These findings in the current study do not correlate with previous research, which clearly indicates that the ability of designers in terms of dealing with design tasks in non-colour design contexts is influenced by levels of design experience or education. The results suggest the need for further research. This may involve exploring whether links exist between colour and intuitive choice more broadly. It may be necessary to ask whether colour choice in particular arises from personal choice or dominant cultural influences in comparison to other disciplines in design.

7.3 Possible Approaches to Bringing about Behaviour Changes among Designers

7.3.1 Facilitating Touchability to Enhance Engagement

Researchers in various disciplines seem to focus on emotional reactions of users or customers to services or design artefacts. Of course, understanding the emotional experience of users could help designers to create better user experience and build long-lasting bonds between users and design artefacts. However, it is also important to consider whether designers' emotional experience while using information formats and searching for information, and their emotional characteristics could be utilised to create designer friendly forms of information. Here, colour information has been the focus in this study, as mentioned. This is because little research has been done in the area of colour and colour information within a user-centred perspective.

> **RQ 2-4** How should colour information be offered to designers in an effective and efficient way?

The findings from Chapters Four and Five were intended to offer answers to the overarching research question RQ 2-4. The outcomes for the question can be divided into two parts. They deal with formats (physical or digital taking into account the emotional characteristics of designers) and contents (amount of information and images). In Chapter Four, it was observed that some of design participants tried to touch colour samples or described them as if they had touched them in their imagination. Such characteristics were discovered in the design group only – not the non-designer group. The findings in Chapter Four offered an inspiration to develop a set of AII formats both in a tactile conventional form (p-cards) and online form (i-cards) for the following chapter (Chapter Five).

Thus, in terms of formats for information, the AII formats were created and tested in Chapter Five. Design participants showed positive emotional attitudes toward the usefulness of the AII card formats. In particular, they prefer to use p-cards rather than i-cards (see Table 5.14). Designers mentioned that although online and digital information formats (i-cards) are convenient to be used, they were less preferred because of negative emotional experiences (e.g. a lack of ownership and feeling distance). With respect to the positive emotional responses to the p-cards, the words *attractiveness, aesthetic, comfortable, personal, familiarity, reliability, touchability*, and *exclusivity* were coded from the responses of design participants during focus groups. It was also observed that design participants continuously rubbed physical information formats (p-cards) with their hands while thinking and speaking during the time when both types of the AII formats were evaluated during focus groups. Such preferences for tactile forms seemed to make design participants deeply engage with a given task.

Nowadays, a lot of information can be used digitally using electronic devices. It is often easier and quicker to find information by accessing the internet. Participants who were involved in this research (Chapters Five and Six) were all in the UK at the time when the research was done without internet issues. However, the results in this part of the thesis show that emotional aspects of what designers feel need to be taken into account rather than practical or economic aspects of forms of information. Being able to touch seems to be an important factor that might help designers engage with information material and design tasks.

Based on literature and findings from Chapter Five, limited textual information was applied alongside images. Taking into account emotional and imaginative characteristics of design participants (Chapters Four and Five), a sketch of the emotional face of a user (older person) was presented on each of the AII card formats. The set of AII card formats was evaluated by professional design educators in Chapter Six. Text, pictures, and amount of information on each of the AII formats as well as usefulness were evaluated positively by the professional design educators in Higher Education in the UK. These educators offered a series of recommendations or new approaches for designing information formats or tools for designers. These may in turn aid methods for seeking information and alter behaviour of designers.

We now stand in the better position to explore more about what designers look for when they are searching for inspiration from sources in terms of colour information for users. Moreover, the way in which fundamental characteristics of designers can be applied to create effective information formats or tools has been discussed and evaluated. These findings have important implications for developing formats/tools for effective ways of providing information for designers to encourage them to consider user needs.

7.3.2 Promoting Imagination and Creativity through Emotion-based Information

Based upon the findings stated above from Chapter Four, it was hypothesised that information presented emotionally and artistically using emotion-based images would be beneficial for designers to attract their attention and stimulate their imagination. Thus, a set of Affective Imaginary Information [AII] formats was created by the researcher then tested during the focus group interviews in Chapter Five. It was shown that when design participants described the pictures on the AII formats they tended to imagine the situation that possible information users (old people on the AII formats) might be faced with, as well as the emotions of those information users. The findings here were intended to give answers to RQ 4-1.

> **RQ 4-1** How can designers' emotional characteristics be utilised/reflected in providing colour information to them?

Taken together some of the findings from Chapters Four and Five indicate that designers' emotional and subjective attitudes seem to cause a negative impact on making things more user-centred or inclusive. This is because such attitudes may cause designers to focus on their feelings, preferences, and experience while insufficiently focusing on design tasks. It seems that encouraging designers to make their design behaviour more inclusive and more user-centred may be a challenging task. Nevertheless, this is of both concern and interest because emotional characteristics of designers also offer positive opportunities in terms of their ability to imagine the emotional situations of information users. This was demonstrated in Chapter Five (see section 5.6.4 and Table 5.22). Imaginative and emotional attributes of designers may enhance feelings of empathy towards users. These findings seem rather contradictory but ultimately could be useful.

7.4 Conclusions

This chapter has discussed the issues and implications of the main research findings by addressing outcomes for the overarching research questions of this thesis. Answers to the overarching research questions were addressed with reference to specific chapters and it was shown how the central aims of the research project were fulfilled.

Whilst conducting this research project, a number of designer studies have been reviewed and analysed to identify the characteristics of designers in general, as well as more specific abilities of designers in terms of level of practical experience or design degree. It seems to be clear that previous authors have been focused specifically on design skills. However, the current research was conducted in order to address the following issues:

- Why designers produce inaccessible information design outcomes with inadequate consideration of users.
- What designers say about information they are using while doing design tasks, and what they say about new forms of information (the set of AII formats) within the user-centred inclusive perspective.
- How the characteristics of designers and their information use behaviour can be utilised to encourage them to change their design behaviour and give more consideration to users.

This research started with a question asking why designers continue to produce inaccessible information or design artefacts. To answer the questions, the fundamental characteristics of designers were explored by applying linguistic theory and analysis in light of four key adjectives (*associative, evocative, emotive*, and *imaginative*). These indicate why designers continue to produce inaccessible design artefacts. Three adverbs (*artistically, emotionally,* and *creatively*) may indicate ways to provide information for designers to motivate them to think about users of design artefacts.

Based on these findings, a new question arose as to how we can apply and use fundamental characteristics of designers to encourage their designing behaviour to change towards a more user-centred inclusive perspective. This helped the author of this thesis to create the effective formats for providing information for designers to encourage them to consider information users. Thus, both physical and digital types of Affective Imaginary Information [AII] format cards for designers were created. While testing the AII formats, what designers said about the use of information within the user-centred design context were revealed. It was revealed that characteristics already discussed influenced the use of information formats. This indicates that although design participants understand the benefits of seeking information online, they seem to prefer to use physical forms of information because of positive emotions toward the format itself. Due to the emotional and creative characteristics of designers, when looking at the AII formats, they tend to imagine an older person's situation and create a story when they look at the facial emotion. The AII card formats were developed, and they were tested by designers with different levels of experience, and positively evaluated by professional design educators.

Undoubtedly, designers prefer to use image-based information with less text. However, as designers do need to understand and follow guidelines, methods for combining use of textual information with images as a source of inspiration is a topic for further research. It seems clear that simply providing detailed textual information to designers telling them what they need to do to make information more accessible would lead to them not engaging with it enough.

This research offers new approaches for understanding designers and how to use their observable characteristics to make a tangible information format for them. It also suggests further research regarding how to create designer friendly information combining a proper amount of textual information alongside images to inspire designers, as well as change designing behaviour towards a more user-centred inclusive standpoint.

7.5 Summary

Significant findings and fresh insights from the research have been described in this chapter in light of a consideration of the overarching research questions. In the next chapter, the aims and objectives of the research will be reflected upon in order to confirm that they have been fulfilled throughout the whole research project. The contributions and limitations of the research will be stated together with recommendations for future work.

Chapter 8 CONCLUSION

This final chapter summarises and reflects on the current doctoral research project as a whole. In addition, contributions to new knowledge and limitations of the research are addressed. The chapter ends with some recommendations, which are directed toward further development of research.

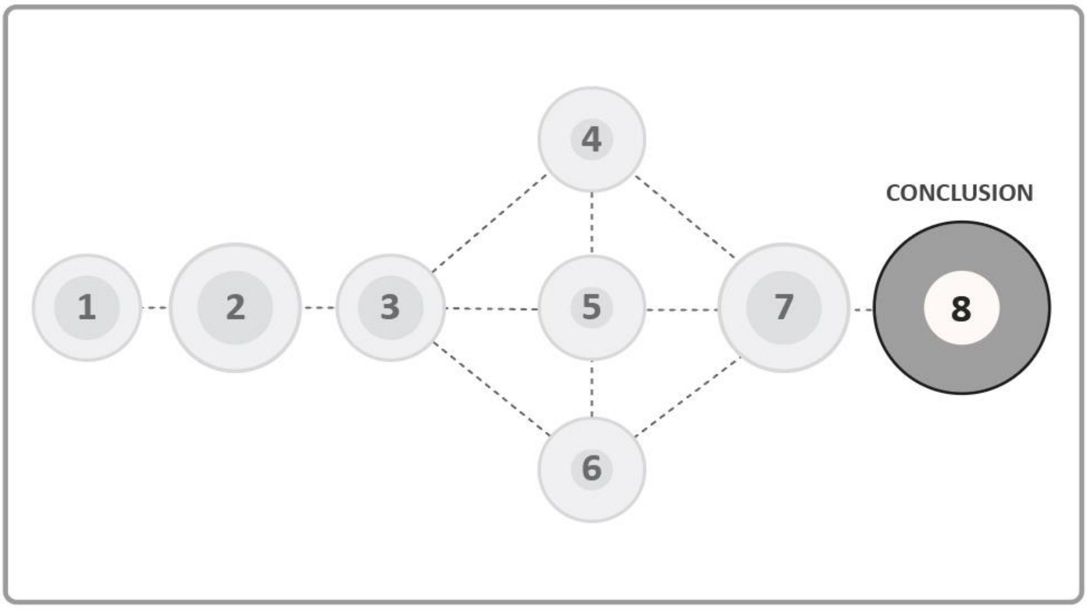

Figure 8.1 Position and context of Chapter Eight within the whole research process.

It is recognised in the area of inclusive design that although there are already identified reasons for the production of inaccessible artefacts across the design field, this phenomenon continues to occur regularly. For this reason, this research makes in-depth efforts to discover fundamental but also concrete factors and causes behind the present phenomenon in real-world design contexts focusing specifically on designers. This is because the researcher believes that designers are among the main agents who cause inaccessible artefacts to be created across diverse design areas. Specifically, from an inclusive design philosophy, colour and information have been focused upon in this project based on the educational and work background of the researcher. In short, this research project aimed to explore the fundamental causes of a certain design phenomenon (design exclusion) in our society occurring due to the behaviour of designers and consideration of how to encourage designers to change their designing behaviour and consider users from a more inclusive standpoint.

This research project is made up longitudinally of three main design studies (Chapters Four, Five, and Six). Qualitative open-ended responses from designers were coded inductively in those chapters, and organised logically to generate categories and themes to gain a holistic understanding of the behaviour of designers.

8.1 Conclusions of the Research Project

Several overarching conclusions are listed below.

- Attention to issues of how designers perceive design tasks should be fundamentally important to not only designers, but also academic design researchers who are interested in the behaviour of designers and design practice to make positive changes in our society through design.

- When design tasks were dealt with by designers, their emotional characteristics, subjective outlook, and use of personal factors (design sensibilities, previous subjective experiences, imagination, intuition, perceptions of common sense, and conjecture) along with their effect on design tasks were uncovered throughout the main designer studies (Chapters Four, Five, and Six).

- Neglecting design tasks probably arose from emotional and subjective-attributes of designers. In many cases, designers were likely to forget the design situation that they were engaged in at a given moment. Rather they tended to focus on expressing their personal feelings, experiences, or preferences.

- Use of colour information types (PI, ODI, and PPI), formats (conventional and online), and other sources (image and text based) seem to be influenced by emotional and subjective features of designers. The reasons behind the preference (or disfavour) of designers towards design formats seemed to depend mainly on formats causing positive emotions (e.g. through exclusivity and familiarity) or negative emotions (e.g. through a lack of ownership). Although most of the design participants in Chapter Five (*n*=10, PhD design students) would want to use conventional (paper-based) types of information, in Chapter Six, designers (*n*=30) used information online, because of the ease of use of the internet. Designers actually used a range of information types (PI, ODI, and PPI), while the design tasks were carried out (Chapter Six). However, all of them prefer to use image-based information (Chapters Five and Six).

- It would not be appropriate to speculate about whether designers' emotional behaviour and subjective tendency emerged specifically from personality, life experience, education, or career at this stage. Further investigation is needed about what makes designers heavily react emotionally and subjectively to design tasks and the positive or negative impact of this on design and our society.

- This thesis has shown that designers display emotion and subjectivity toward design tasks. It is likely that AII formats with use of facial expressions would be useful in communicating user experiences to designers. In Chapter Five, for example, it was demonstrated that providing facial representations of the emotions of older people on the AII formats seemed to lead design participants to imagine the emotions and situations of possible older information users. Such emotional imaginary information formats seemed to enhance the empathy of designers. The effectiveness of the AII formats communicating emotions to designers through the use of facial expression needs to be further explored in the future. This could allow us to investigate how we could utilise designers' emotional characteristics in a positive way.
- The AII formats (image-based information formats with only a small amount of text) were tested by thirty designers and evaluated positively by six professional design educators. However, the appropriate amount of text in combination with appropriate images for designers as a source of information and inspiration is yet to be researched fully.
- It does not seem that there are huge differences between designers in terms of level of experience in relation to actual colour use and colour information use. This result does not confirm the hypotheses that arose from prior literature (see section 6.2.2). This is a rather unexpected but interesting point for further research into why different levels of experience in design do not appear to influence colour design, whether in actual colour use or colour information searches during design tasks in inclusive design contexts.

It seems that various factors are intricately intertwined when discussing design exclusion related to behaviour of designers. However, such factors can be explained through the terms 'emotion' and 'subjective-centred attributes' in many cases. There is a need for research on how fundamental characteristics of designers can be positively utilised to provide information contents and formats to encourage them to consider the user more carefully while designing.

8.2 Reflection on Research Aims and Objectives

The overarching aim of this research project has been to explore fundamental issues behind the production of inaccessible information provision arising from designers, in order ultimately to identify effective ways forward to provide colour information to designers in an inclusive design context. This has been achieved through various methods, such as think-aloud protocol, focus group interviews, surveys, colour design experiments, and email interviews, during the research process.

In order to achieve the research goal, there are divisions of two sub aims and four objectives, as shown in Table 8.1. The relationship between sub aims, objectives, and overarching research questions are listed in Table 8.2. Because the answers to each of the six overarching research questions have been discussed already in sections 7.2 and 7.3, the objectives of the research are addressed here to confirm that the research aims are fulfilled.

Through the colour description research in Chapter Four, objective 1-1 was satisfied. Based on theoretical background from sociolinguistics, characteristics of design participants were comparatively and contrastively analysed alongside non-design participants. Unique characteristics of design participants were revealed from the detailed data analysis. These characteristics are categorised into two types: verbal and behavioural (see section 4.3 in Chapter Four).

The fulfilling of objectives 1-2 and 1-3 were demonstrated through the colour information search tasks in Chapters Five and Six respectively. In Chapter Five, ten PhD design students were involved in the focus group interviews. They were asked to search for user-related colour and colour information in order to make more accessible information formats for older users. They seemed to ignore searching textual information, preferring inspiration from image-based information or existing design outputs. Similar findings were revealed in Chapter Six in which three designer groups were asked to search for colour information to select colours in order to make information on product cases more accessible to older people. The responses from designers collected by email interviews and surveys show that designers would want to use various types of colour information. However, irrespective of designer group, image-based information or existing designs of physical products were favoured by designers, instead of searching textual and detailed information. Similar results have been found already by other authors (e.g. Lofthouse, 2006; Goodman *et al*., 2007; Gonçalves *et al*., 2014). Thus, they have come to similar conclusions

The findings during the colour information search task also show that designers seemed to rely heavily on implicit knowledge and personal factors (preference, their own decisions, common sense, conjecture, and so on) in order to complete the colour modification task.

Table 8.1 Aims and objectives of the research project.

Overarching Aim (OA)	The overall aim of this research is to explore fundamental issues lying behind the production of inaccessible information by designers, in order ultimately to identify effective ways forward to provide information to designers themselves within an inclusive design context.	
Sub-Aim (SA)	Sub-aim 1. To reveal how situations and problem are perceived and understood by designers in the context of colour and information design.	Sub-aim 2. To discuss appropriate formats and their contents for providing user-related colour information to designers based on the characteristics of designers themselves, in order to encourage them to take a user-first approach.
Objective(s)	• Objective 1-1. To compare responses to colour between participants from design and non-design backgrounds and identify differences between them. • Objective 1-2 To examine features of various types of information sources that are preferred for use by different designer groups, specifically user-related colour information. • Objective 1-3. To show how colours and information about colour are dealt with by designers with different levels of experience in real-world design contexts.	Objective 2-1. To investigate effective ways of providing colour information to designers by reflecting on the emotional characteristics of designers.

Table 8.2 Matrix of sub aims and objectives of the research project with overarching research questions.

Sub-aim	Objective	Overarching Research Question
SA 1	O.1-1	RQs 2-1 and 2-2
	To compare responses to colour between participants from design and non-design backgrounds and identify differences between them.	RQ 2-1 Why do designers consistently continue to create inaccessible communication materials even though scholars have identified the problems that arise from them doing so? RQ 2-2 How do designers perceive and communicate about colours?
	O.1-2	RQ 2-3
	To examine features of various types of information sources that are preferred for use by different designer groups, specifically user-related colour information.	RQ 2-3 What are the features of user-related colour information provision that designers actually access, and how do they talk about the features?
	O.1-3	RQ 2-5
	To show how colours and information about colour are dealt with by designers with different levels of experience in real-world design contexts.	RQ 2-5 Are any distinguishing characteristics between different levels of designers revealed in a problem-solving design task in terms of use of colours and colour information?
SA 2	O.2-1	RQs 2-4 and 4-1
	To investigate effective ways of providing colour information to designers by reflecting on the emotional characteristics of designers.	RQ 2-4 How should colour information be offered to designers in an effective and efficient way? RQ 4-1 How can designers' emotional characteristics be utilised/reflected in providing colour information to them?

By undertaking colour design experiments (application and modification of colours) in Chapter Six, objective 1-3, was met. The findings of prior designer studies reviewed in Chapter two (see section 2.2.2.3.1) have shown consistently that there are different abilities among designers under problem solving design contexts by level of either education or employment experience. It is commonly believed that more experienced designers can be regarded as problem solvers (or improvers) and “reliable information sources about a topic” (Baxter *et al*., 2015, p.108) with various design skills (Hubka and Eder, 1996).

Based on previous research and such arguments, it was hypothesised that distinguishing designing behaviours (problem solving abilities) between designer groups would be shown in a colour and information design context with an inclusive design focus. However, in Chapter Six, the hypothesis seemed to be rejected. This is because there was no strong distinction in terms of use of colours between designer groups during the colour design experiments. It also cannot be judged which colour combinations for the contrast for the product cases are better than others at this stage. Therefore, further research is needed. The recommendations for further work will be addressed in sections 8.4 and 8.5.

Objective 2-1 was achieved in Chapter Five. The idea of objective 2-1 emerged from Chapter Four. Based on one of the main findings in Chapter Four (the emotive, evocative, associative, and imaginative characteristics of design participants), a new overarching research question (RQ 4-1) and a hypothesis (H4-1) were generated which influenced the construction of Chapter Five. In order to test the hypothesis (H4-1), a set of Affective Imaginary Information [AII] formats (including facial representations of emotion) was created with two types: online (i-cards) and physical (p-cards). These were used to examine how design participants would respond to images (the facial emotion of older information users) on cards, and talk about these two different types of AII formats. It was discovered that design participants tended to imagine users' feelings and situations when they looked at a persons' face on the AII cards. The responses of designers seem to show that use of facial images would allow designers to empathise with people who have different physical and cognitive levels. In addition, the usefulness of the AII formats was positively evaluated by professional design educators in HE in the UK in Chapter Six.

8.3 Contribution to the Body of Knowledge

The data collection methods used in this research (face-to-face interviews, email interviews, focus group interviews, surveys, colour design experiments, and think-aloud protocols) are traditional. So also are the analysis techniques (linguistic analysis, thematic analysis, content analysis, and descriptive statistical analysis). However, this research project has offered a unique approach to data analysis in the design area by adopting the sociolinguistic theories of linguistic relativity and the community of practice, and the linguistic concept of semantic fields.

This is a new theoretical and methodological contribution to the area of design research which broadens our way of approaching, analysing, and understanding the behaviour of designers.

In addition, as demonstrated throughout the main designer studies, emotional and subjective-centred attributes of designers toward a given design situation were repeatedly revealed. Because of such characteristics of designers, the researcher assumed that even if enough user data and relevant guidance could be offered to designers, this might not bring about much difference and change in terms of making more accessible design artefacts. A new attempt at providing information was made by creating a set of AII formats in two forms (online and conventional) in order to test whether such characteristics of designers could be utilised positively. The formats were then tested by ten doctoral design students in Chapter Five as well as being provided to thirty designers during the inclusive colour design experiment (colour for older people) in Chapter Six. Further, the usefulness of the AII formats was evaluated by professional design educators in HE in the UK in Chapter Six.

The novelty and appeal of the AII formats has been demonstrated through the responses of design participants (Chapter Five) and tested by designers with different levels of experience (Chapter Six) and evaluated by professional design educators (Chapter Six). Design participants imagined particular situations that users (older people here) might encounter and described the emotional experiences of users under these situations. These findings imply that designers emotional, imaginative, and subjective outlooks could help the designers themselves to empathise with other people and their feelings. The results here would suggest further research areas.

It was also found that designers would prefer to use physical forms of information because of positive emotional reasons. However, they still believe that use of various types of information sources would be useful for them. This suggests further research topics into the combination and balance of use of different forms and types of information for designers in order to give them inspiration, and encourage them to consider information users more carefully.

8.4 Research Limitations

There may be some limitations in this research project. As previously demonstrated in Chapter Three, this research project was stipulated as qualitatively driven mixed methods research. Although a quantitative method (a web-based survey) was adopted at one stage, qualitative data collection (focus groups, email interviews, and think-aloud protocols) and qualitative analysis techniques (linguistic analysis, thematic analysis, conventional content analysis, and visual content analysis) were the main approaches throughout the research process. Additional quantitative elements might have made the project stronger. However, the researcher maintains that those methods used are adequate.

According to Morse *et al*. (2002, p.15), “ensuring rigour” is an issue along with "trustworthiness" in a qualitative methodological approach. As demonstrated in Chapter Three (see section 3.5 and Table 3.14), ten techniques were utilised to improve research trustworthiness which ensure the solidity and reliability of the research. In addition, previous literature confirmed that adoption of qualitative research methods is appropriate for the topic of behaviour of designers in a problem-solving design context across the fields of design (see section 2.2.2.3.3 and Table 2.18). However, due to the inherent nature of qualitative research, it is almost impossible to remove the subjectivity and bias of a researcher completely. Hence, introducing quantitative research techniques might have reduced some limitations of the current research. For example, colour data collected from colour design experiments can be analysed either with qualitative or quantitative techniques (this is relevant to Chapter Six). In addition, narrative data collected from think-aloud protocols (Chapter Four) and email interviews (Chapter Six) can be dealt with also by adopting quantitative content analysis. However, such data was analysed in a qualitative form in this research project. If the data had been analysed closely quantitatively and this compared to qualitative results, this could have helped to strengthen the reliability and rigour of the current research. Nevertheless, as noted, other safeguards to ensure reliability have been implemented.

The AII card formats were created based on fundamental characteristics of designers. The initial AII formats were created with collaboration from information and graphic design experts. In order to test and evaluate the AII formats, design doctoral students from the University of Leeds were involved in focus groups (see section 5.4.2 and Table 5.5). It is acknowledged that these doctoral students may not represent designers generally, and this may cause the issue of sampling bias. Sampling bias was described in detail (see pp.121-124) in Chapter 3. However, the AII card formats were refined based on their opinions and in collaboration with a professional graphic designer and an information design researcher again. Subsequently, the AII formats were tested by designers with different levels of experience while doing colour design experiments, and were evaluated by expert design educators in higher education in the UK. All these processes enhanced the reliability of the research and suggest the strength of the AII formats. Although it cannot be said that the AII format is perfect, it suggests a series of recommendations are possible for designing information in terms of both formats and contents to encourage change in designer behaviour towards considering information users more carefully.

The constructivist viewpoint taken in this thesis creates some degree of bias in the interpretation of data. One way to avoid this would be to request a researcher taking a positivist perspective to read and analyse data. Time constraints did not permit this in the current project. This could be a potential avenue for research in the future.

8.5 Recommendations for Future Work

Based upon the findings and implications of the current study, suggestions have been identified for future research.

- Research regarding how to create designer friendly information combining a proper amount of textual information alongside images to inspire designers, as well as change designing behaviour towards a more user-centred inclusive standpoint.
- More design participants need to be involved to test the AII formats. This would enhance the validation of the results.

Overall, further investigation of existing information providing tools or formats for designers is required. The existing tools and formats need to be tested and compared with each other in terms of usability and utility from a designers' point of view. This will offer new insights and ideas for further development of research and resources.

The research in Chapter Six combines three design areas (information, colour, and inclusive design) to investigate distinguishing problem-solving behaviour between designer groups (student, novice, and expert designers) from any design field. As no significant differences have been detected, it may be valuable to conduct research on the three design areas separately to see if such differences exist in problems solving behaviour within these specific areas of design.

Finally, this research was designed and conducted by an individual researcher. For this reason, the researcher's worldview, values, and experience have had a great impact on overall research development. Thus, in the future it might be beneficial to collaborate with other specialists working in other areas such as usability, information, inclusivity and so on. This would offer wider perspectives.

All of the recommendations mentioned above would strengthen future research. At the same time, they would compensate for any limitations in the current research project.

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List of Abbreviations

A	AI	Adobe Illustrator Artwork
	AIC	International Colour Association
	AII	Affective Imaginary Information
	APA	American Psychological Association
B	BDC	British Design Council
	BSI	British Standards Institution
C	CA	Content analysis
	CCT	Correlated colour temperature
	CIE	International Commission on Illumination
	CL	Colour literacy
	CT	Convergent thinking
	CUDO	Colour Universal Design Organisation
D	DIN	Deutsche Institut für Normung
	DT	Divergent thinking
E	EEG	Electro-encephalography
	EPS	Encapsulated PostScript
F	FGI	Focus group interview
G	GD	Graphic design
H	HE	Higher Education
I	ID	Information design
	ISCC	Inter-Society Colour Council
	ISO	International Organisation for Standardisation
L	LCCA	London College of Contemporary Arts
M	MCS	Munsell Colour System
N	NCS	Natural Colour System
	NHS	National Health Service
O	ODI	Online and digital information
	OECD	The United Nations Educational, Scientific and Cultural Organisation
	OED	Oxford English dictionary
P	PF	Problem formulation
	PI	Paper-based information
	PPI	People information
Q	QCA	Qualitative content analysis

(continued)

R	RAL	Reichs-Ausschuss für Lieferbedingungen
	RNIB	Royal National Institute of Blind People
	RO	Ranked Order
S	SL	Scientific literacy
	SRD	Socially responsible design
T	TA	Thematic analysis
U	UKAAF	UK Association for Accessible Formats
	UNESCO	The United Nations Educational, Scientific and Cultural Organisation
V	VA	Visual analysis
	VC	Visual communication design
	VCA	Visual content analysis
	VL	Visual literacy
	VSTM	Visual short-term memory
	VT	Visual thinking
W	WCAG	Web Content Accessibility Guidelines
	WHO	World Health Organization

List of Appendices

Appendix A

Word lists (Chapter Four)

Sample A-1

	D1	D2	D3	D4	D5	D6	D7	D8
	**bent orange,** frame, square highlight	Sunny, warm , fashion, honey, food, positive, sports fashion	**orange,** very warm, bright, very easy to noticeable	very warm, full of energy, not very clear, **red connected with yellow,** healthy	active, energy, carrot	**orange** paper, thin, not thick soft, square	**orange,** very bright, bright, very familiar, favourite	warm, cozy, food, hungry, enthusiastic
	C1	C2	C3	C4	C5	C6	C7	C8
	orange, bright orange, cadmium, orange, matte	**orange,** not very light, matte, not reflective, not stand out	**orange colour with red** on the side, made from pulp	**orange,** plain orange, without shiny, without rough, plain surface	**orange,** square	**orange, orange red,** matte, opaque orange, covering the card	neon, neon light, **orange,** matte, bright, modern, sign, outstanding	my nails, **vibrant orange,** traffic cones, very saturated

Sample A-2

	D1	D2	D3	D4	D5	D6	D7	D8
	not bright, **between bit of red and orange,** card, square, shape	classic, traditional, food, tomato, McDonald, chilli	a bit redder than A1, warm, not that as brighter than A1, low key	not as light as A1, dim	darker than A1, sunset, mature, girl, older than A1	**dark orange,** darker and thicker than A1, more dirty	**bright orange**	gloomy comparing with A1, bit dirty, not very comfortable, fail, unfortunate
	C1	C2	C3	C4	C5	C6	C7	C8
	more red, **redder orange,** **still orange**	matte, **red,** **not pure red,** chroma, mixed red and black, not so saturated	similar dimension to A1, **little bit more hint of red,** from pulp duller	similar to A1, **plain orange,** brightness is different	slightly **redder,** **orange red**	**orange,** a lot more **red orange,** closer to red, quite matte, deep, opaque	wet, big, matte, **orange** lipstick, brick	more of a **red orange,** same saturation as A1, little bit of a different hue

Sample B-1

	D1	D2	D3	D4	D5	D6	D7	D8
	too busy, texture in the card, texture from lines, touch me, embossed, interlocking lines, texture going across, crossing texture	**dark white,** **light grey,** dirty snow, not main, sub, popular and be easy by used designers and artists	**white,** **yellower,** very normal paper	**grey,** patterns on it, surface of water, wind go through the surface	concrete, road, snow, **not white,** peaceful	tissue, being wet, being dried, easy to be destroyed by the water, **grey**	**bright grey,** similar with the desk, city	nature, boring, rough, nothing
	C1	C2	C3	C4	C5	C6	C7	C8
	white, **blue tinge,** indentations, thicker, **off white**	not flat, texture, not reflective	nice texture, spunbonded material, quite flexible, cardboard feel, probably made out of pulp	quite rough, similar to D2	**off white,** slightly grey, matte, texture	**very pale grey blue,** texture of the card, matte	**light grey,** toilet paper, cheap, man-made	wall paper, **off white,** **white,** **white with a grey tint,** **really grey,** **closer to white but not white,** **not a perfect white,** rice paper, crinkly texture, slightly textured

Sample B-2

	D1	D2	D3	D4	D5	D6	D7	D8
	**strong grey,** still calming, not loud, not coming out texture, lines, cut cross, formation of texture	just a little bit dark than B-1, same as B-1	very normal grey, **light grey**	same pattern as B-1, darker colour	peaceful, texture, distracted, water, surface of water, lake, not sea and other things	thicker than B-1, this is made by two or three pieces of B-1	darker than B- 1, pigeon	calm, comfortable, nature, very common, nothing special
	C1	C2	C3	C4	C5	C6	C7	C8
	light grey **more grey**	not flat, **white,** **grey**	**duller grey,** textured	**grey,** similar to B1, rough, some patterns	**grey,** matte, slight texture	**grey,** **light grey,** matte, texture of the card	**35% black,** rough, wallpaper, office	**grey,** **shade of grey,** a rice paper, texture, crinkles

Sample C-1

	D1	D2	D3	D4	D5	D6	D7	D8
	hard on surface, **burgundy,** smooth texture	women, female, lip, blueberry milkshake, ice cream	**reddish purple,** grape, luxury, very expensive	**purple,** symbol of royalty, middle age of western history, Japan, traditional, very mysterious	Mature, a matthiola incana, **violet,** elegant	thick, **purple,** rough	brick, not vivid	not bad, bit dull, very boring, not very smooth, romantic, **purple,** old things, old furniture, 1960's, India
	C1	C2	C3	C4	C5	C6	C7	C8
	maroon purple, purple, more purple	matte, **dark purple**	quite a dull, matte, **burgundy,** thick, fairly rigid, robust but smooth	mangosteen, **purple, purple maroon,** smooth, no rough surface	**mauve purple,** plum, matte, fairly smooth, not much texture	matte, dark, **burgundy,** very opaque, not reflect	matte, **purple,** fabric, royal	maroon, wine, texture, **purple**

Sample C-2

	D1	D2	D3	D4	D5	D6	D7	D8
	natural, earthy, blend with environment, calmness, smooth, made of card, wood paper pulp	chocolate, coffee, forest, feel Africa, cosmetic, foundation, hair	wood, fence, good for clothes	out of fashion, elder people like, earth	wall, building in the Lisbon, Lisbon city	same as C1 just colour different	buildings, house wall	boring, autumn sadness, old style, old building, rough, very cheap
	C1	C2	C3	C4	C5	C6	C7	C8
	burnt umber	**brown,** soil, leather, bricks	similar to C1, robust, rigid, matte **black finish**	**brownish,** smooth	matte, **brownish red,** earthy, pottery, smooth looking, **browny beige**	**brown,** tan, **between brown and orange,** **more brown side**, not reflect, quite opaque	wood, natural, soft, **brown,** matte	cognac, rust, **orange,** **slight orange,** **mostly brown,** shoes

Sample D-1

	D1	D2	D3	D4	D5	D6	D7	D8
	bling-bling, attract attention, shiny, expensive, don't touch me, look at me, glossy surface, texture	mirror, big influenced by the light, bling-bling, reflection, earring, necklace, jewellery, **silver necklace**, metal	**bluey grey** original, **blue and grey,** give a layer, **silver,** **blue-grey-silver,** metal things, metal	under the light, looks like white, cool, temperature of material is low, iron, winter, cheap	mirror, like a water reflect the light, fog, milky way, mystery, sparkle	shiny, **silver,** sharp	**silver,** Jewellery	boring, confused, darkness
	C1	C2	C3	C4	C5	C6	C7	C8
	silver very shiny, mirror, reflection, opaque, not transparent, quite thick, quite smooth, opaque	**silver,** very reflective, different angle, lighter, darker	**silver,** square, quite dull, not the shiniest, not like a mirror	aluminium foil, shiny, smooth, mirror	reflective, **silver**	**silver,** metallic, reflecting, opaque	metallic, **silver,** mirror, smooth, metal can	glossy, reflects light, **silver or grey,** **light greyish**

Sample D-2

	D1	D2	D3	D4	D5	D6	D7	D8
	wet, matte, smooth, calm, not bling-bling	frosted, blurry, aeronautic, plastic, materials and texture	a bit **bright silver,** more brighter, not very reflective	similar feeling as D-1, reflect less light, warm, more expensive	foggy, peaceful, going to die, feel die, dying naturally	metal, harder than D1, metal for kitchen stuff, pot	silver, not bright, not reflect	bright, modern, cutting-edge, technology, business, business website, efficient, good
	C1	C2	C3	C4	C5	C6	C7	C8
	lighter silver, not pewter, matte, opaque, almost transparent, mirror, same thickness as D1	very smooth, **white,** not reflective, very even	more of an even pigment , a lot brighter, **brighter silver,** more matte	glossy, **white mixed with grey,** not shiny, mirror	reflective, **silver,** matte, less clear	**silver,** metallic, matte, opaque, fogginess	velvet coat, nail polish effect, mirror, matte, **metallic silver** paint, car	reflective, doesn’t have a mirror effect, matte, **gradient light grey,** jewellery, kitchen stainless steel

Sample E-1

	D1	D2	D3	D4	D5	D6	D7	D8
	natural, texture, invite a hand to feel, matte, shiny, not too busy, subtle, bring calmness	desert, cookies, pancake, tan, animal fur, skin, nature	wood, natural, paper, a bit comfortable, book	earth, yellow earth, village, some mountains, trees, good, environment, close to nature	old, long time, history, comfortable, grandpa, grandpa's clothes	hard, hard paper, **brown,** square, rough	confusing, skin, unhealthy, people's face	dirty, warm, uncomfortable, poor places, not well organised places, dirty underground, dirty village, autumn, leaves down
	C1	C2	C3	C4	C5	C6	C7	C8
	yellow ocher, more brown, light brown, yellow tinge	board, box, package	paper pulp with a **beige pigment**, quite rigid	**yellowish,** rough, square, some lines	natural looking, **browny beige,** texture	thin card, **a browny beige**, matte, not shiny, texture	wood, **gold,** dry, natural, rough, pure, hand-made, textured	a rice paper, texture , snakeskin, a shade of tan, matte, sand, desert

Sample E-2

	D1	D2	D3	D4	D5	D6	D7	D8
	high class, a bit expensive, nice texture, smooth, **gold,** expensive	rich, luxury, soft, hair, golden hair	**gold,** a bit luxury, expensive	**golden,** less emotional, artificial, materials, something about nature, smooth material	a kind of fashion, modern, vintage, old fashion, becomes new fashion	shiny, more light, more smooth, water on my hands, sweat	brighter than E1 glitter, Jewellery	fortune, **gold,** a high-lever, upper class, Trump tower, Trump himself, enthusiastic, royal, good, bright, excited, everything, all positive
	C1	C2	C3	C4	C5	C6	C7	C8
	not mottled, smooth, iridescent, slightly thicker	**gold,** golden foil, smooth, lighter	glossy, **more gold,** more polished, more rigid	**gold,** shining, smooth	matte, reflective, **gold,** very smooth, no texture	more golden, not shiny, opposite of matte, metallic, golden metallic, **light yellowy,** **gold**	metallic, smooth, **gold,** artificial, man-made, luxury	gloss, reflective, metallic, metallic sand, shine like jewellery

Sample F-1

	D1	D2	D3	D4	D5	D6	D7	D8
	warm, warmth, **dark grey,** silver, glitters, expensive, high-profile, greyish	**dark grey,** rational, not active, still, not move, strong, heavy	**black,** **navy,** a bit refractable, still luxury, reflection	square, **black,** very cheap, patterns on it	starry night, light, some dot, small dot, adjusting old TV, soy sauce, mineral	cardboard, **grey,** unique, pattern, dots, texture, thick, very sharp,	very dark, **black,** glitter	expensive, business, factory, industrial, comfortable, metal, very strong, stubborn, safe
	C1	C2	C3	C4	C5	C6	C7	C8
	pewter, an iridescent shine , underlying blue tone	**black,** a bit reflective, brighter	nice colour, **black** **infused with** **a little** **something** **shiny,** not matte	**shining** **black,** smooth, some patterns, rough, not smooth, shiny	**black,** square, matte, slight silver, specks	**black,** sparkly bits, matte, texture	fine sparkle, metallic, modern, well paper, **grey,** matte, male	**charcoal,** **black or dark,** **grey ,** bit shiny, glistens, subtle glitter, highlight (make up), speckles

Sample F-2

	D1	D2	D3	D4	D5	D6	D7	D8
	**gold,** glossy, texture, stripes gown down, stripe like pattern	luxury, **gold,** gradually varied, metal, rich, Egyptian culture	straight line, luxury, expensive gold, decorate my home	very light, **golden,** horizontal lines, a bit expensive, popular among Asian people	metal, desert	**gold,** very hard, package for the wine, shiny, elegant	luxury, **gold,** Hungary, Hungarian decoration	all the positive, **gold,** fortune, everything, too much lines, very comfortable, very high level royal, not very smooth
	C1	C2	C3	C4	C5	C6	C7	C8
	gold, **slightly golder,** incredibly shiny, very iridescent, lines across, horizontal lines, metal, shiny, matte, red tinge	very reflective, very bright, **bright gold,** golden foil	**gold,** glossy, shiny, streaky in a vertical, direction, quite reflective	smooth, **gold,** shining, shadow	**gold,** reflective, metallic, horizontal lines	**golden,** metallic, shiny, reflect light, lines cross, quite opaque	glossy, **gold,** luxury, mobile phone, scratched, metallic, expensive	**mix between gold and bronze,** **not a yellow gold,** **more of a like bronzy gold,** **not quite rose gold,** horizontal, little lines, vibrancy, saturation, **darker gold,** **brown**

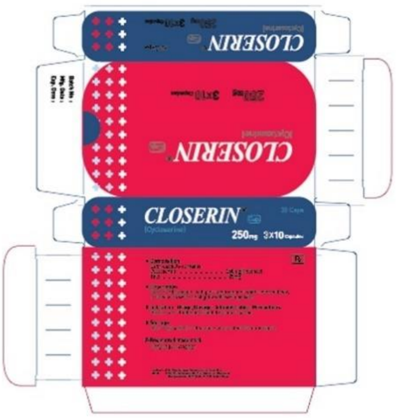
Appendix B

Colour Design Experiment by Student Designers

(Chapter Six)

Participant code		S1
Age		23
Years of work experience		0
Job title		Design student
Education	BA	Visual communication design
	MA	Information design

Colour Application



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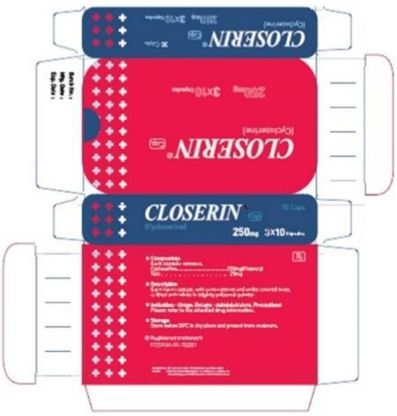
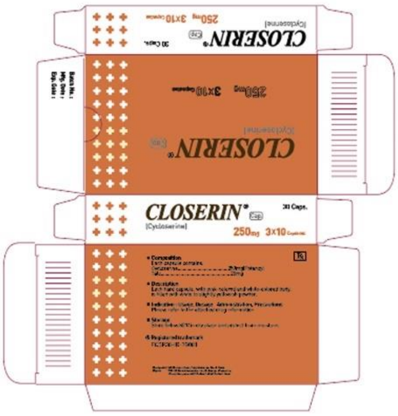


Participant code		**S2**
Age		23
Years of work experience		0
Job title		Design student
Education	BA	Visual communication design
	MA	Visual communication design

Colour Application



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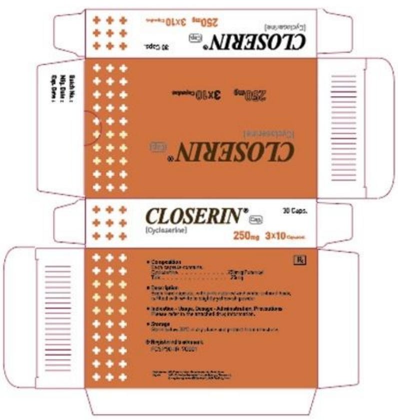
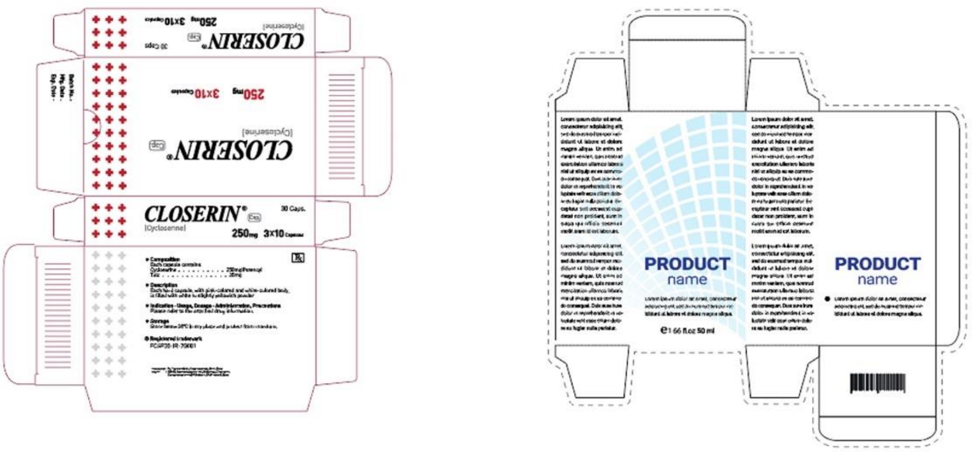


Participant code		S3
Age		27
Years of work experience		0
Job title		Design student
Education	BA	Graphic design
	MA	Graphic design
	PhD	Information design

Colour Application



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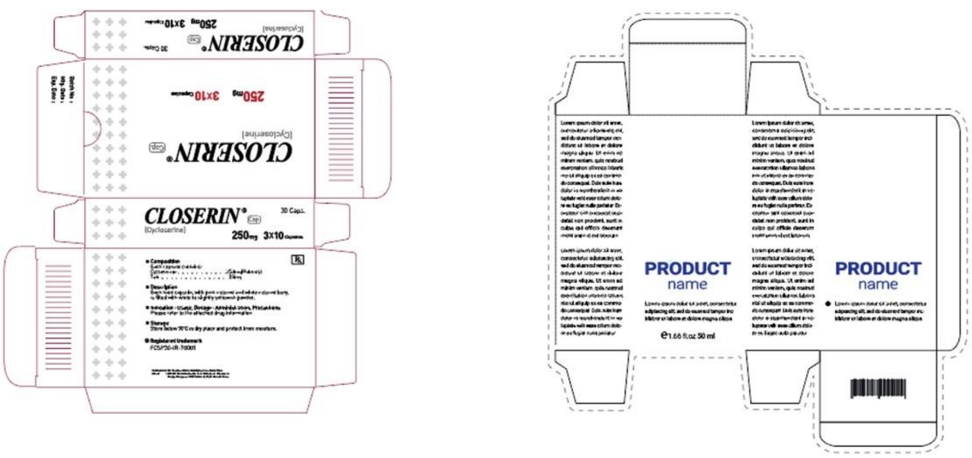
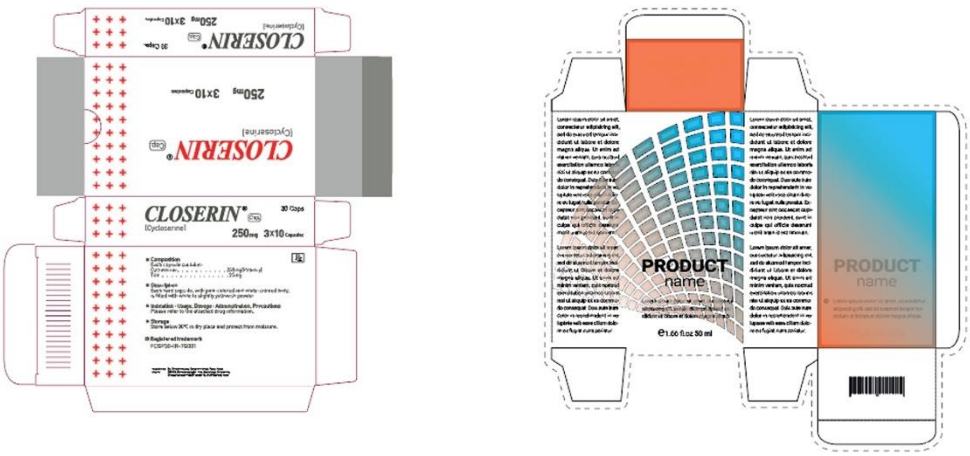


Participant code		**S4**
Age		20
Years of work experience		0
Job title		Design student
Education	BA	Industrial design and technology

Colour Application



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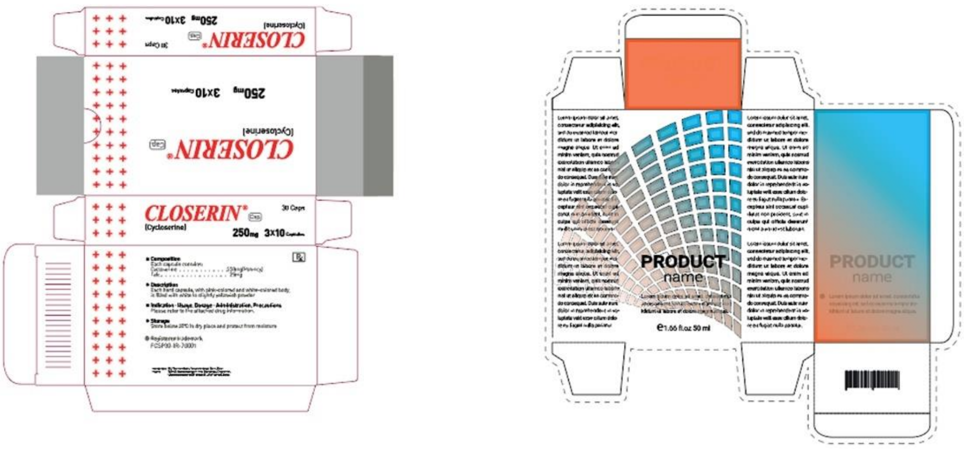

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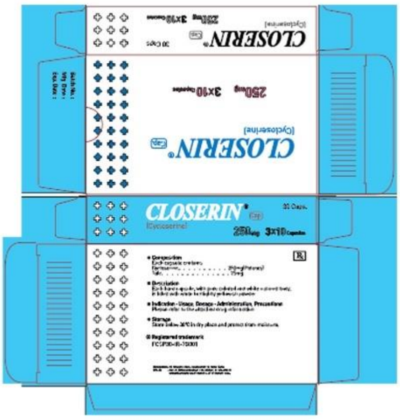

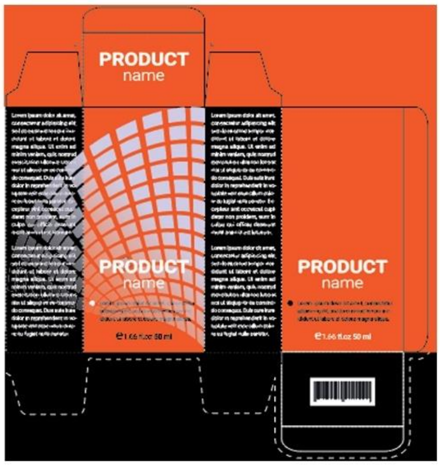

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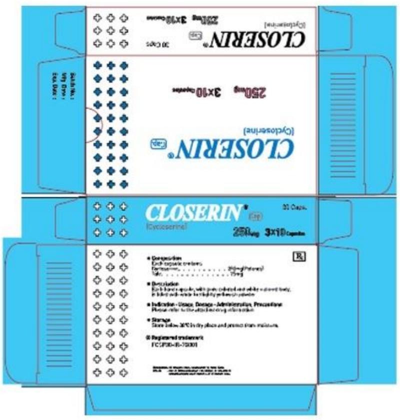
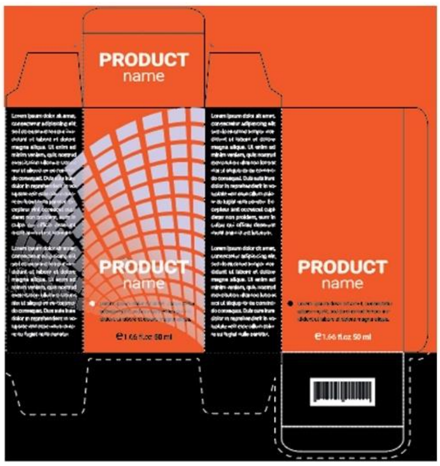
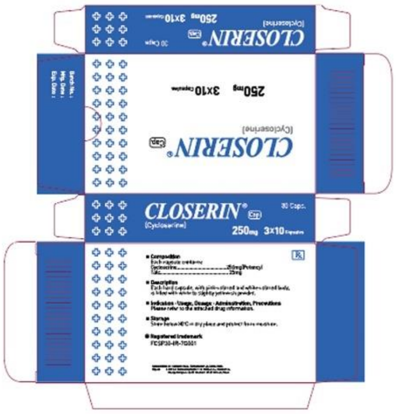
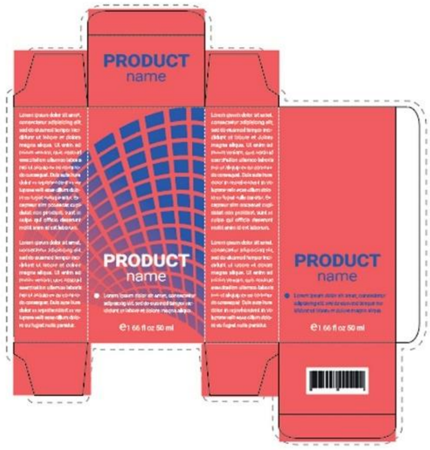




Participant code		S6
Age		22
Years of work experience		Less than a year
Job title		Design student
Education	BA	Finance
	MA	Information design

Colour Application





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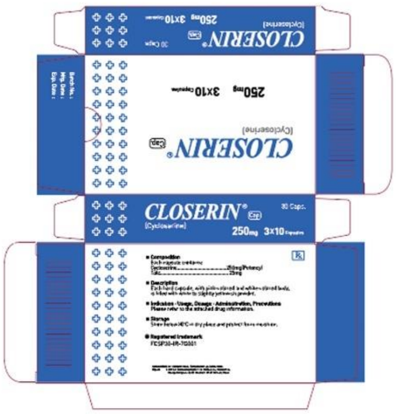
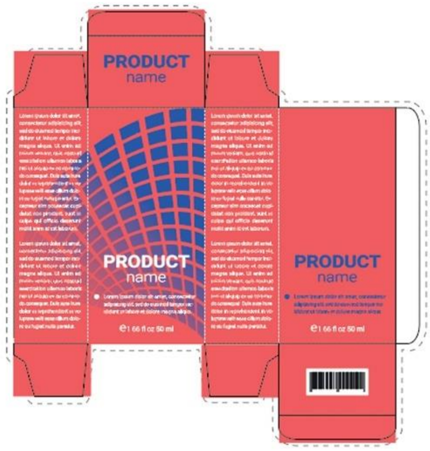
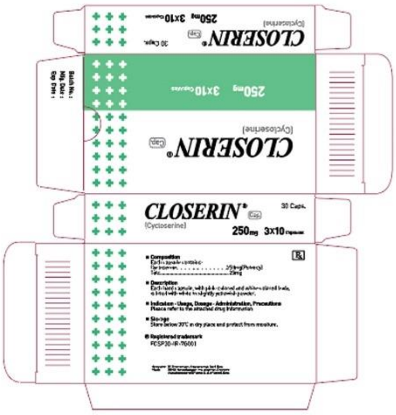




Participant code		S7
Age		23
Years of work experience		0
Job title		Design student
Education	BA	Fine art
	MA	Information design
	PhD	Information design

Colour Application



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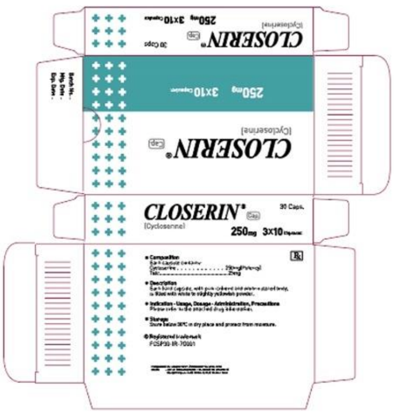
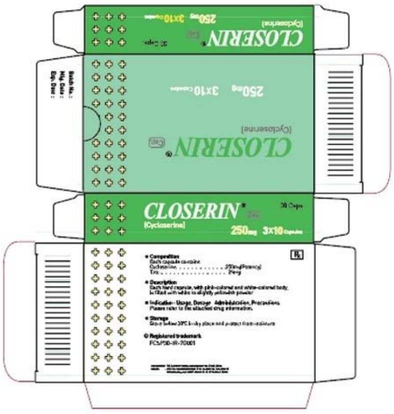
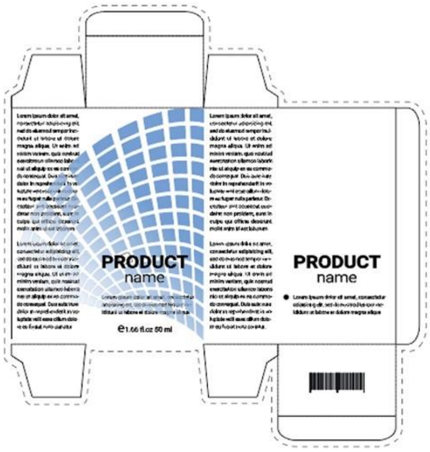


Participant code		S8
Age		24
Years of work experience		Less than a year
Job title		Design student
Education	BA	Fine art
	MA	Information design

Colour Application





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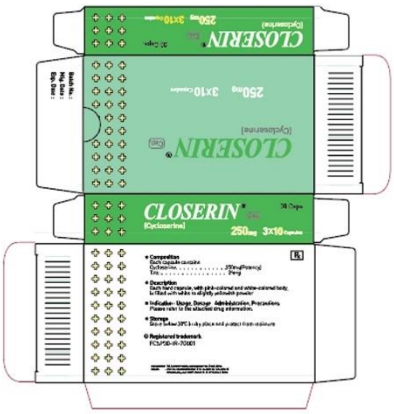
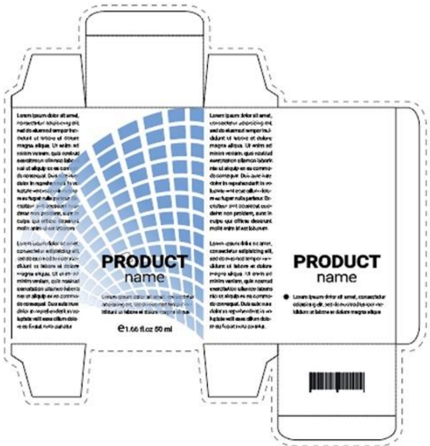
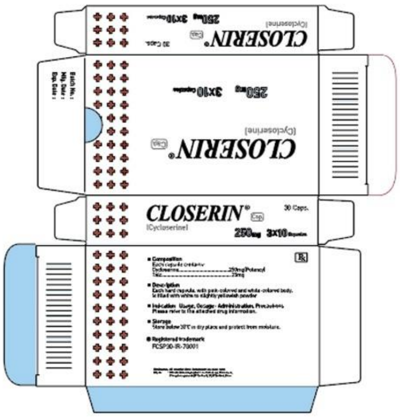
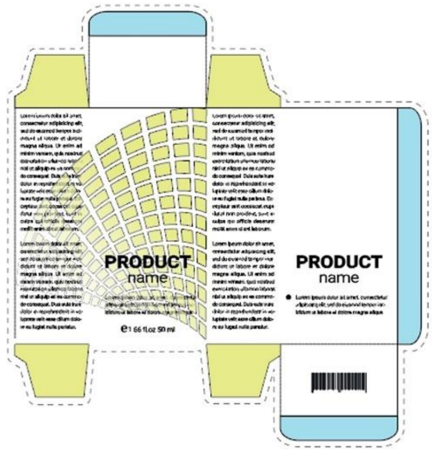




Participant code		**S9**
Age		23
Years of work experience		0
Job title		Design student
Education	BA	Psychology
	MA	Information design
	PhD	Colour design

Colour Application





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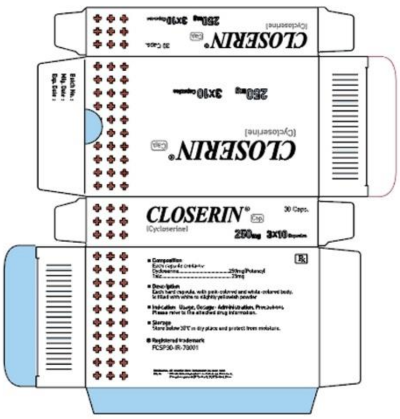
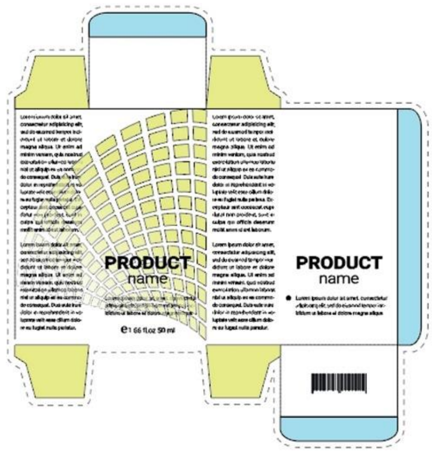
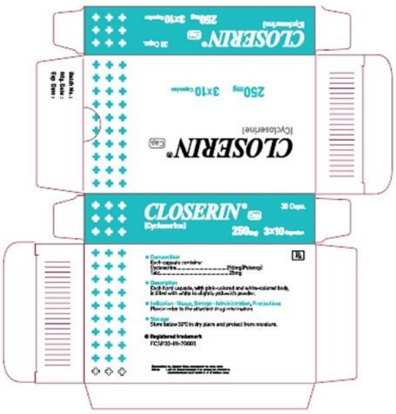
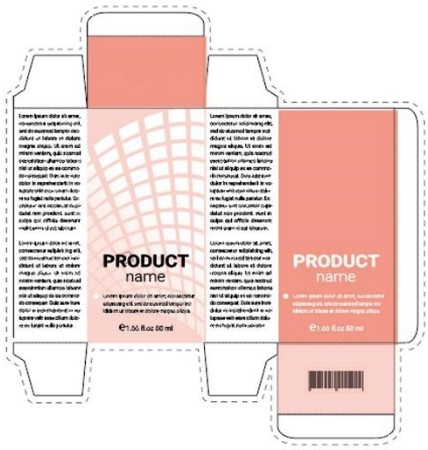




Participant code		S10
Age		23
Years of work experience		0
Job title		Design student
Education	BA	Zoology
	MA	Information design
	PhD	Information design

Colour Application





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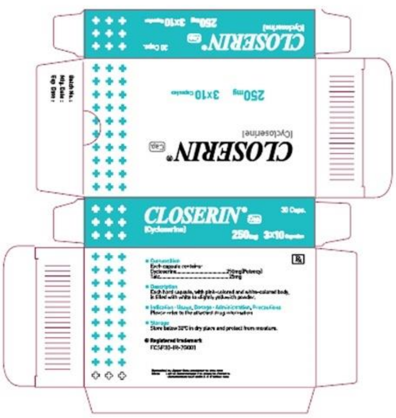


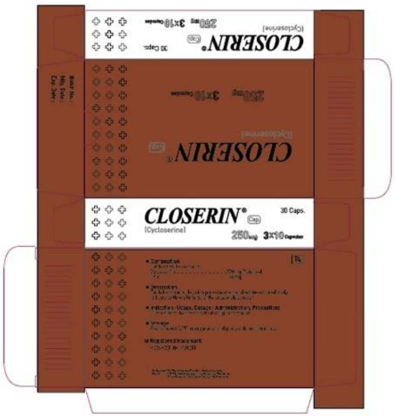
Appendix C

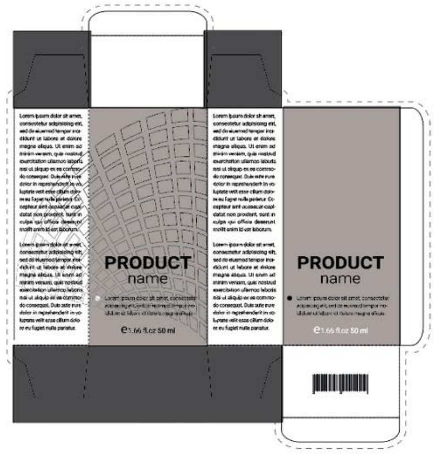
Colour Design Experiment by Novice Designers

(Chapter Six)

Participant code		N1
Age		25
Years of work experience		1.5
Job title		Graphic designer
Education	BA	Graphic design
	MA	Information design

Colour Application





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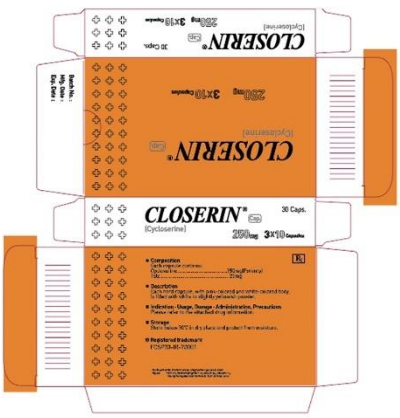
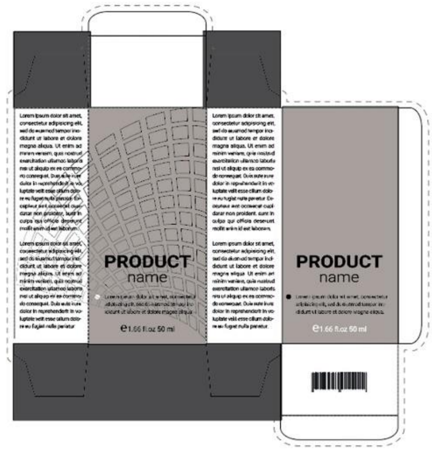
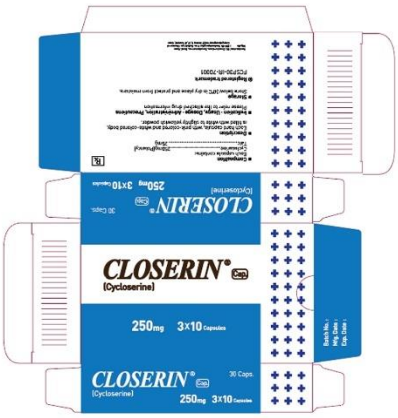




Participant code		N2
Age		26
Years of work experience		3
Job title		Product manager
Education	BA	Industrial design
	MA	Product design

Colour Application

Colour Modification



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<tr><td colspan="2">Job title</td><td>Art tutor</td></tr>
<tr><td rowspan="3">Education</td><td>BA</td><td>Fashion design</td></tr>
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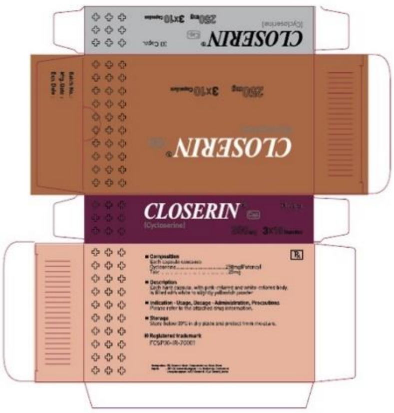
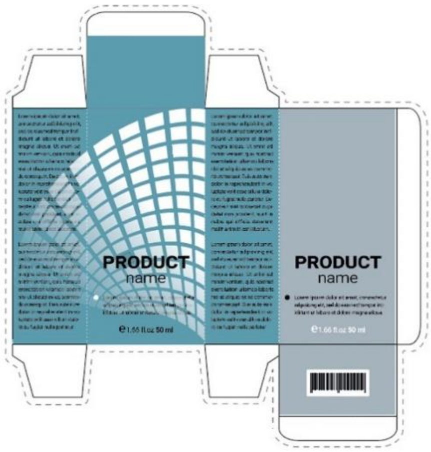
Colour Application





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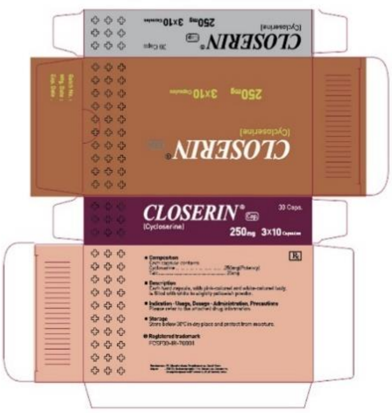
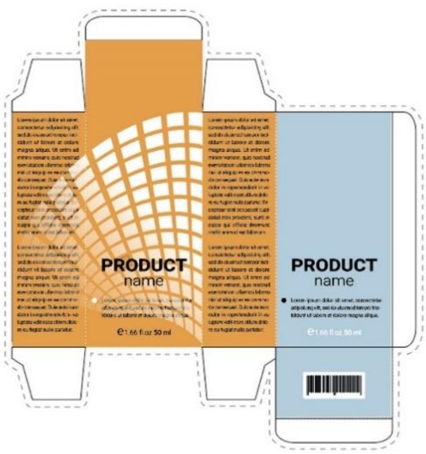
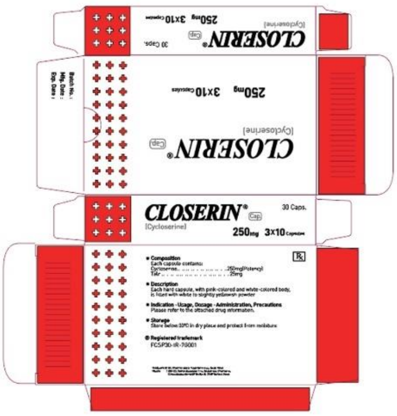
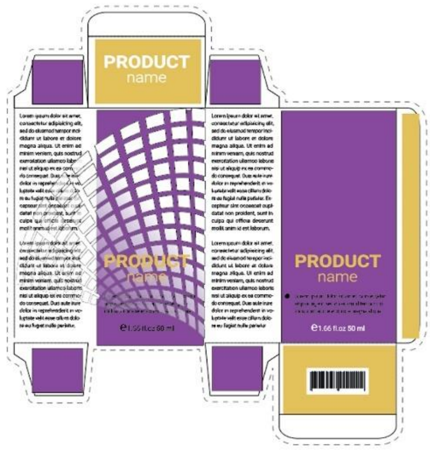




Participant code		N4
Age		30
Years of work experience		4
Job title		Art director in film making
Education	BA	Fine arts and photography
	MA	Communication design
	PhD	Advertising and sustainable development

Colour Application





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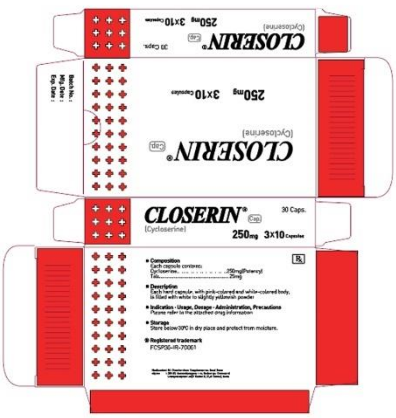
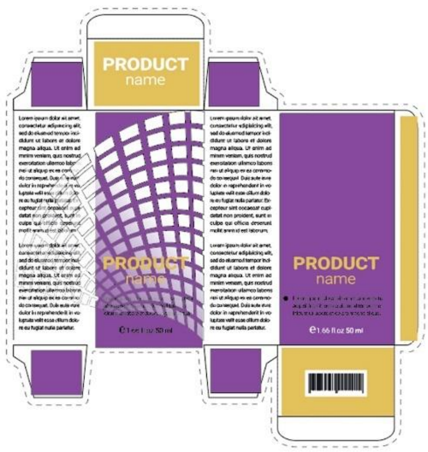
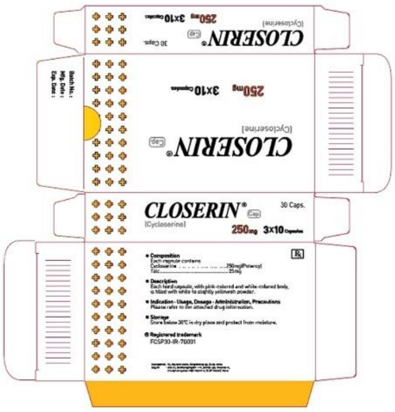
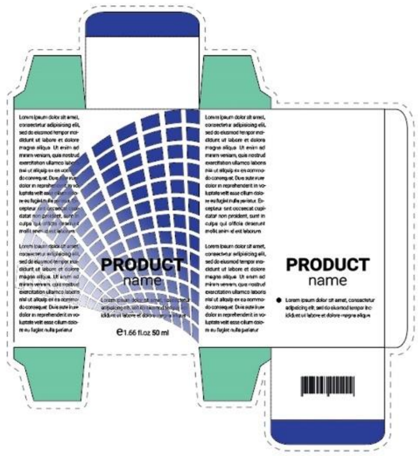




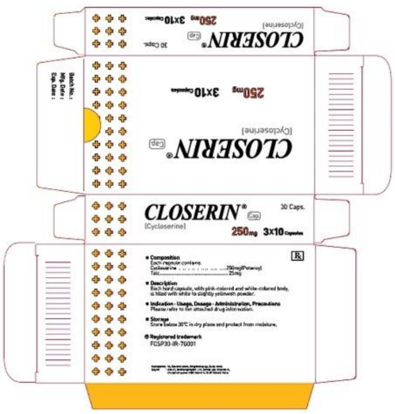
Participant code		**N5**
Age		32
Years of work experience		2
Job title		Fashion researcher and designer
Education	BA	Fashion design
	MA	Fashion design
	PhD	Fashion and textile design

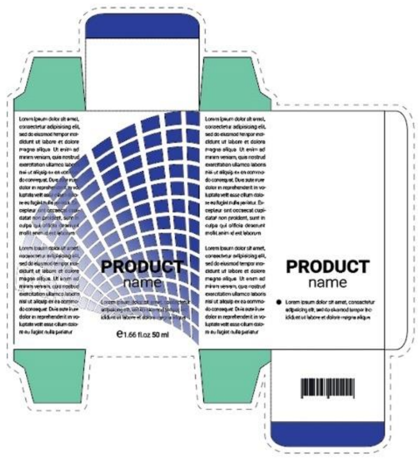
Colour Application





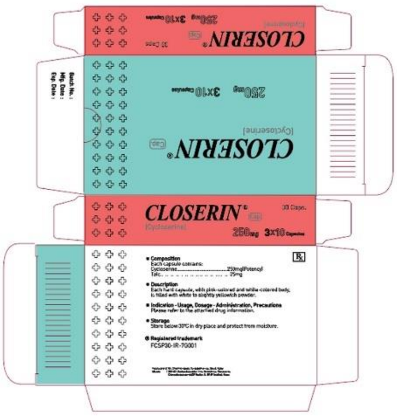
Colour Modification



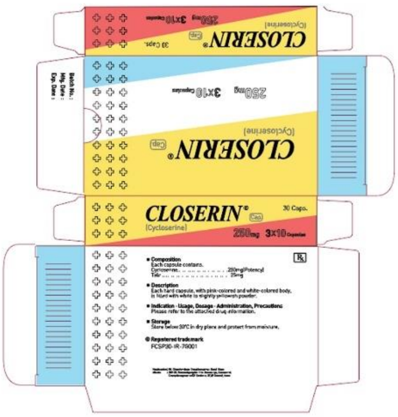


Participant code		N6
Age		25
Years of work experience		1
Job title		Graphic designer
Education	BA	Oil painting
	MA	Graphic design
	PhD	Information design

Colour Application

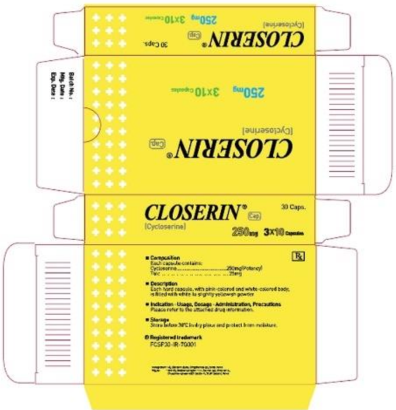


Colour Modification

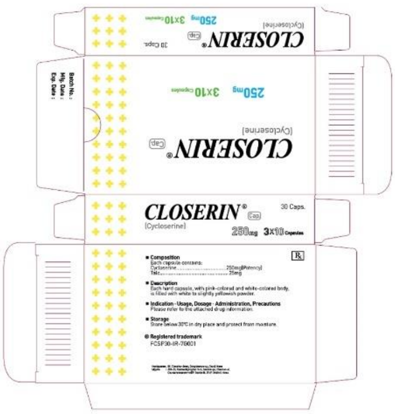


Participant code		N7
Age		30
Years of work experience		3
Job title		Service designer
Education	BA	Digital content design
	MA	Interaction design

Colour Application

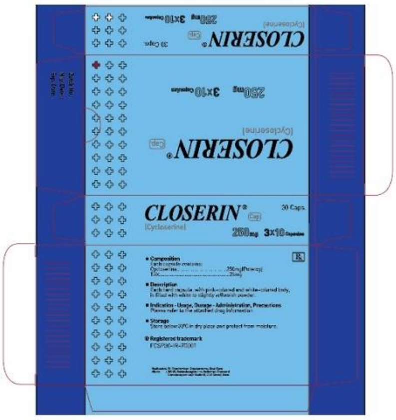


Colour Modification



Participant code		N8
Age		36
Years of work experience		2
Job title		Book designer
Education	BA	Korean painting
	MA	Korean painting
	PhD	Korean painting

Colour Application



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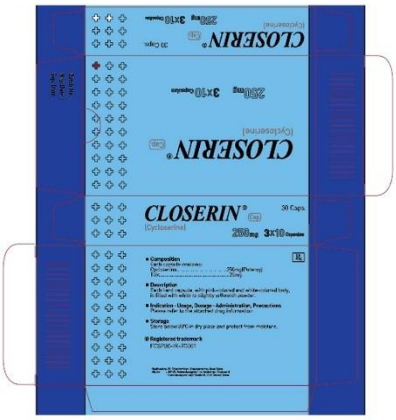
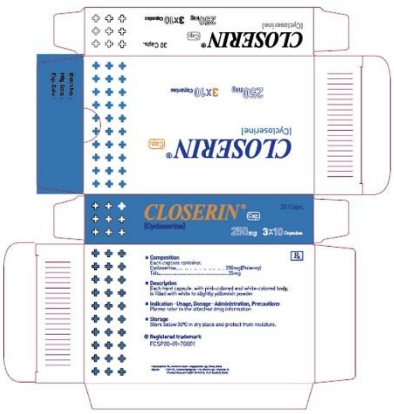
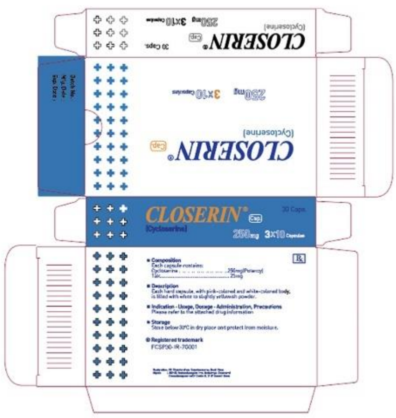


Participant code		**N9**
Age		25
Years of work experience		3
Job title		Graphic designer
Education	BA	Animation
	MA	Design and digital media
	PhD	VR

Colour Application

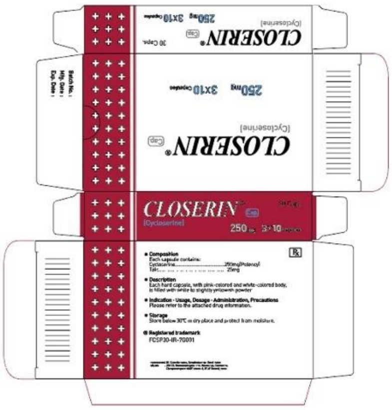


Colour Modification



Participant code		N10
Age		28
Years of work experience		4
Job title		Textile designer
Education	BA	Fashion design

Colour Application



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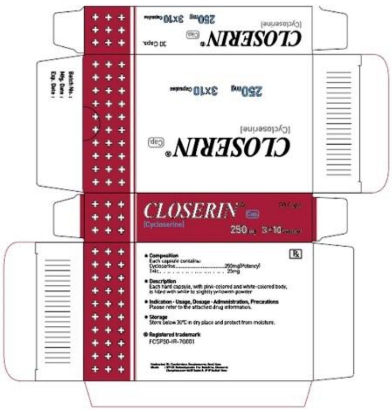


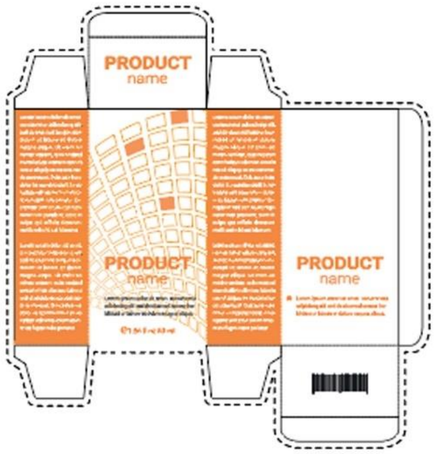
Appendix D

Colour Design Experiment by Expert Designers

(Chapter Six)

Participant code		**E1**
Age		29
Years of work experience		9
Job title		Creative director
Education	BA	Fashion design

Colour Application



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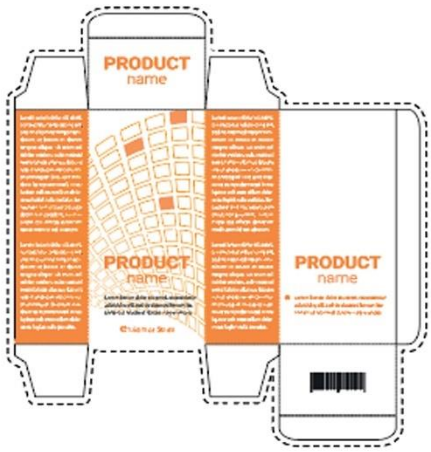
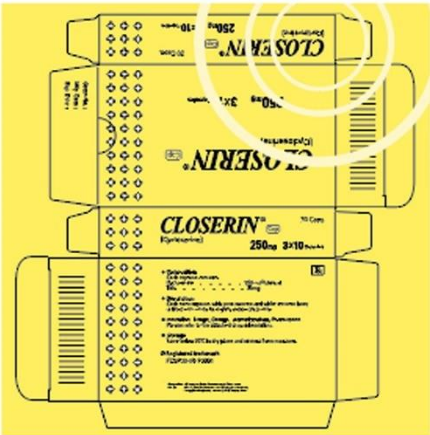


Participant code		E2
Age		34
Years of work experience		7
Job title		Graphic designer
Education	BA	Graphic design

Colour Application



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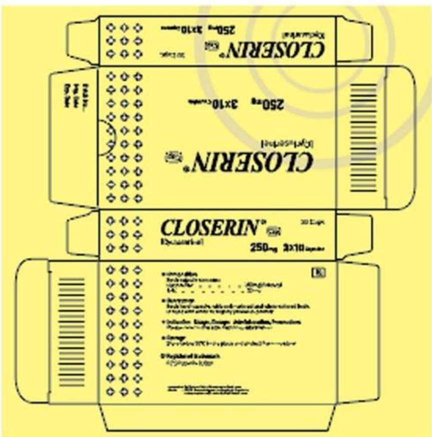
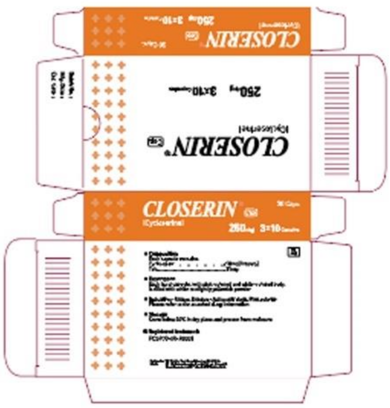
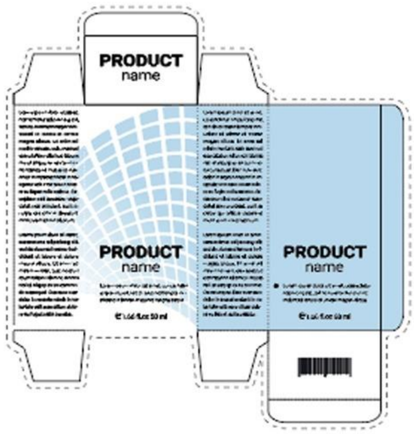


Participant code		**E3**
Age		34
Years of work experience		12
Job title		Graphic design manager
Education	BA	Contemporary lens media and interactive screen-based graphics

Colour Application

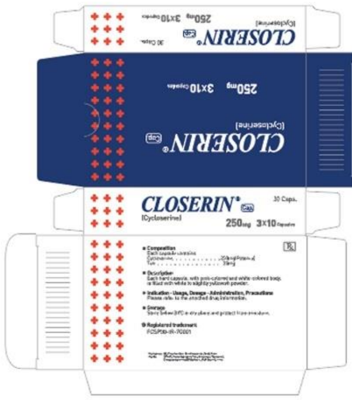
Colour Modification





Participant code		**E4**
Age		30
Years of work experience		7
Job title		Graphic designer
Education	BA	Environmental design

Colour Application



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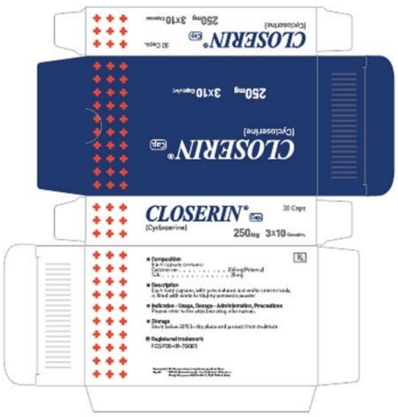
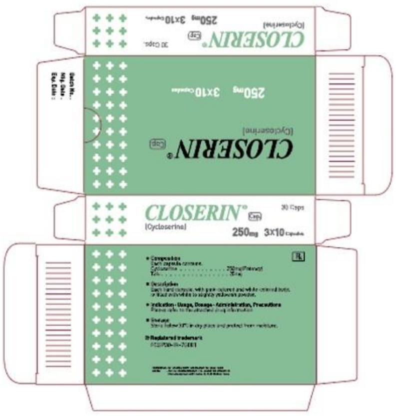


Participant code		**E5**
Age		35
Years of work experience		8
Job title		Environmental colour designer
Education	BA	Fibre arts
	MA	Space design

Colour Application



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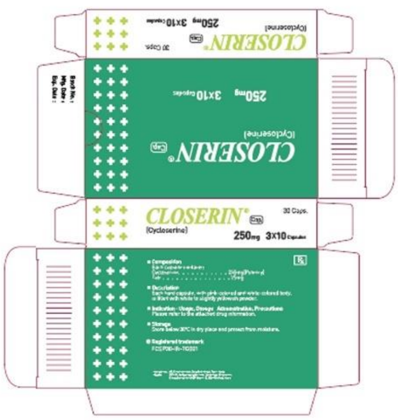
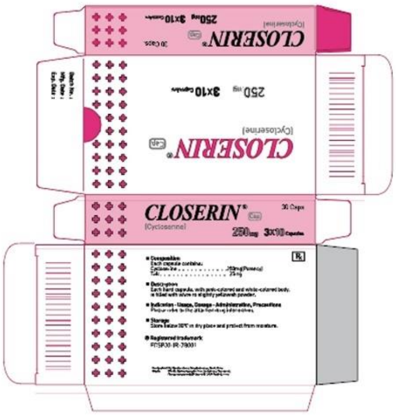
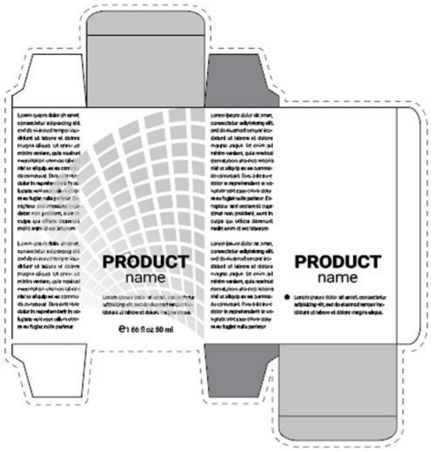


Participant code		E6
Age		36
Years of work experience		13
Job title		UX designer
Education	BA	Korean painting

Colour Application





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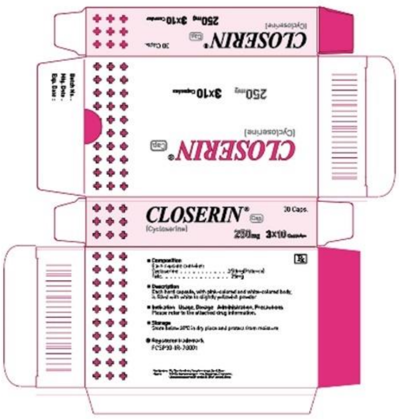
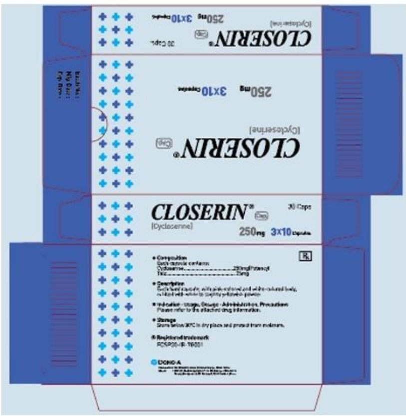


Participant code		E7
Age		36
Years of work experience		14
Job title		Graphic designer
Education	BA	Industrial design

Colour Application



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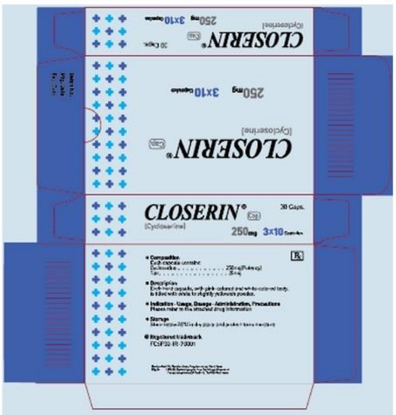
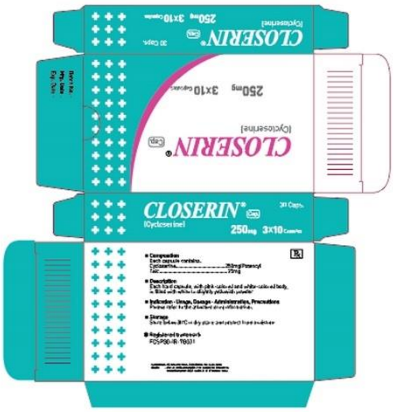


Participant code		**E8**
Age		36
Years of work experience		8
Job title		Graphic designer
Education	BA	Visual design

Colour Application



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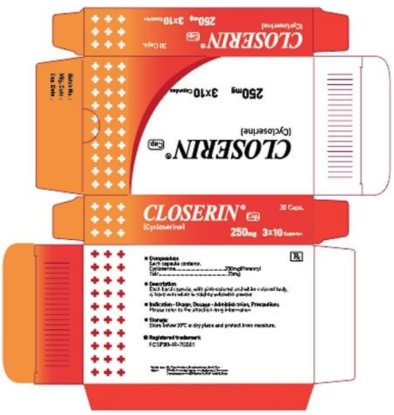
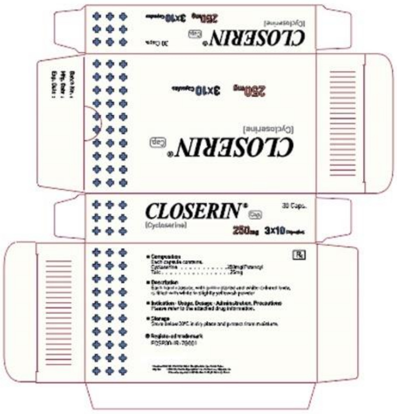
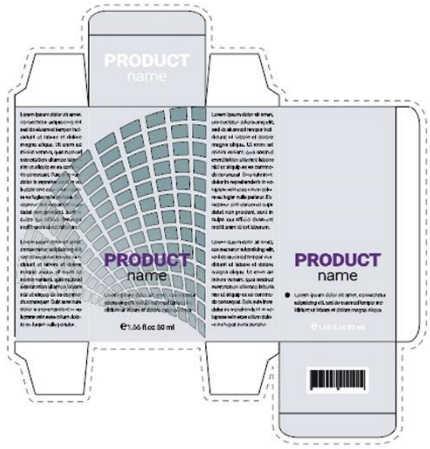


Participant code		**E9**
Age		32
Years of work experience		10
Job title		Interior designer
Education	BA	Interior design
	MA	Information design

Colour Application





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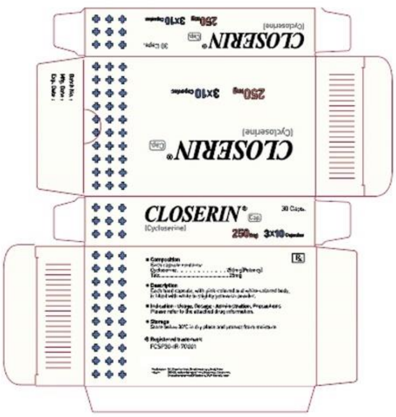
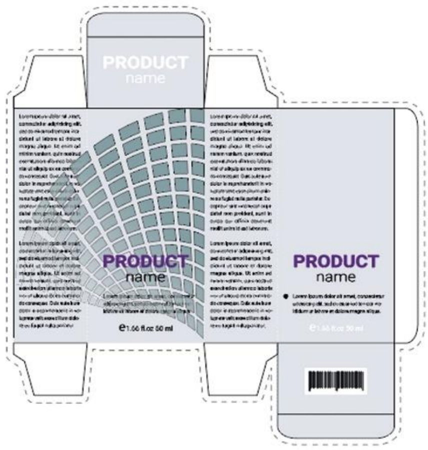
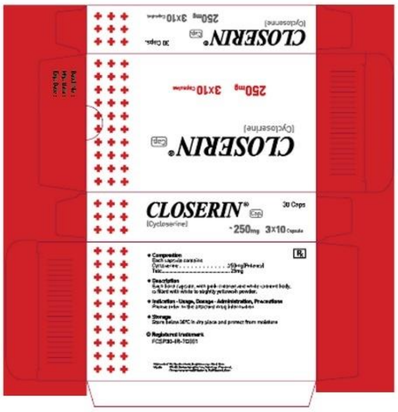




Participant code		**E10**
Age		31
Years of work experience		7
Job title		Character designer
Education	BA	Animation design

Colour Application



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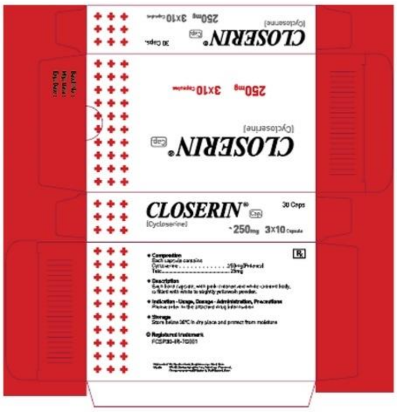

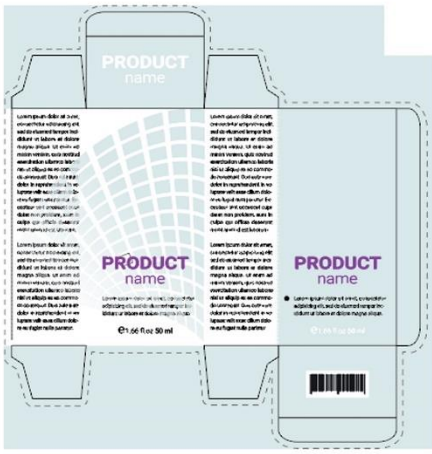

Appendix E

Certificate of Award

International Colour Association
Internationale Vereinigung für die Farbe
Association Internationale de la Couleur

12 September 2018

Dear Gyeonghwa Lee

Thank you for your AIC 2018 full-paper submission, entitled "Effective colour communication", to the AIC Student Paper Awards 2018. The AIC Student Paper Awards Panel has reviewed all the submissions and we are delighted to inform you that your submission has been selected as the Second Runner-up Prize of the Awards.

The goal of the AIC Student Paper Awards scheme is to encourage students to present their work at the AIC conferences and to benefit from interaction with the international colour community. We will look forward to meeting you and hearing about your work in Lisbon.

You are invited to attend the AIC 2018 conference gala dinner on Wednesday 26th September and you will be presented a Second Runner-up Prize certificate at the Student and Poster Awards ceremony on Friday 28th September.

A financial award of AUD400 will be given to you. Please confirm your PayPal or bank account details to the AIC Secretary/Treasurer by emailing treasurer@aic-color.org.

An extended version of your awarded paper will be published in a special issue of the JAIC. You will be contacted by the JAIC Associate Editor after the AIC 2018 conference on the manuscript submission details.

Congratulations on your award. We wish you all the best for your research.

Yours sincerely

Nick Harkness

Nick Harkness
Past President

Vien Cheung
Chair
Student Paper Awards Panel

Robert Hirschler
Chair
Study Group on Colour Education

Best Paper Selected for special issues on International Journals

보낸 사람: info@aic2021.org <info@aic2021.org>
보낸 날짜: 토요일, 10월 23, 2021 12:54 오전
받는 사람: Gyeonghwa Lee [ml13g3l] <ml13g3l@leeds.ac.uk>
참조: editorCCSJ <editorCCSJ@gruppodelcolore.it>; marco.gaiani <marco.gaiani@unibo.it>
제목: Best papers selected for special issues on International Journals

Dear Author(s),
The Congress of the International Color Association (AIC) 2021 has been a success, also due to the presentation of valuable contributions like yours. Thus, we are more than glad to inform you that your paper has been selected to be invited and hopefully published, in a more extended version, on **COLOR CULTURE AND SCIENCE JOURNAL** (http://jcolore.gruppodelcolore.it/)
Your paper (The role of colour designers in the design process) is one among the 30 out of 280 selected for a submission to **COLOR CULTURE AND SCIENCE JOURNAL.**
Please reply to this letter telling us if you will submit or not a revised version of your work, within 7 days, in order to prepare the formal proposal to the Journal.
The submission does not guarantee the publication, your paper will be reviewed anonymously to assess its final suitability for the journal.
Cultura e Scienza del Colore – Color Culture and Science (CCSJ) is a double blind peer-reviewed diamond open access journal published on-line by Associazione Italiana Colore.
Let us remind you that your paper will follow again a regular peer review process, according to the Journal's editorial rules, and your submission will have to follow the Journal's authors guidelines.
Deadlines and other relevant information on your submission will be sent later, upon your acceptance.
Again, congratulation for your work and warm regards from the AIC2021 Publication Committee.

The Publication Committee.