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The Influence of Colour on Learning in University Libraries

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature:...

Date: 28/04/2015.....

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ABSTRACT

Colour can be utilised to evoke aesthetic responses and generate specified atmospheres in indoor spaces. Colour is recognised as an important element of interior design, playing an essential role in constructed interior space. It significantly affects the mood, emotion, performance and behaviour of the people who occupy the space. However, the influence of colour on the students' learning performance has until now remained under-examined. The main aim of this study is to identify the impact of colour on learning performance in study rooms for individual students within university libraries. Contemporary libraries are considered to be learning centres and they are places where new forms of knowledge may be generated. Although studies have been conducted to investigate the influence of different colours on performance and mood in work offices, very few studies have investigated the influence of colour on human performance in university learning environments such as libraries. Therefore, the main question of this thesis is: how does colour influence learning performance in the individual study rooms in university libraries?

Action research was used as the methodology in this thesis, integrating a series of research cycles involving various mixed methods to collect, describe and interpret the data. Both qualitative and quantitative methods were used (such as experiments, focus groups, a questionnaire and interviews). This study included four cycles. The first cycle (literature reviews) aimed to demonstrate how libraries became a place for learning and how colour schemes developed in relation to library design.

The second and fourth cycles consisted of a series of experiments that examined the impact of different colours (hues and nuances) on students' learning performance in a simulated study environment (individual study room). Participants were asked to sit at a desk facing a panel painted one of 12 colours (six colours for each study). In Cycle 2 the colours were vivid red, vivid blue, vivid yellow, light red, light blue and light yellow; and in Cycle 4 the colours were light yellow, light orange, pale yellow, pale purple, pale green-yellow and deep yellow. Participants were then assessed for their emotional response to colour, heart rate changes and a reading comprehension task (reading articles). The experiment took thirty minutes for each colour condition.

A Semantic Differential Scale (SD) was used in both cycles 2 and 4 to describe colour emotion, not the basic human emotions. SD was proposed by Osgood et al. (1957) and it has been used widely in colour emotion studies such as Gao and Xin (2006) and Xin et al. (2004). Adjectives were used to describe emotional response to one coloured wall in an interior environment while participants were seated directly in front of it. Heart rate was measured to examine the physiology of participants. A reading comprehension test was used to assess learning performance. The third cycle was designed to find suitable colours for individual study room in the library by asking university students in focus groups to select suitable colours that they thought appropriate.

85 students participated in all three studies; 48 participants were exposed to different colours in the second and fourth cycles, 37 participants participated in the third cycle: 17 of these took part in focus groups and 20 responded to a survey. The quantitative results of the second and fourth cycles showed that the nuance of the colour and not the hue had a significant impact on learning activity by influencing the reading comprehension task. It was found that when chromaticness increased, the reading comprehension task improved; this was clear in the second cycle. Qualitative data showed that colours with medium chromaticness (light colours), especially light yellow and light orange, could support the learning performance in the individual study room. Although participants' emotional response and heart rate were affected by colour conditions during the experiments, these influences did not mediate the relationship between colour and reading comprehension. It can be concluded that colour can directly impact on learning performance. In addition, it is proposed that light orange and light yellow can be suitable for learning activities particularly for reading comprehension tasks in the individual study room.

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1 CHAPTER 1: INTRODUCTION

1.1 Background and Rationale of the Study

For many years, people visited libraries to seek and find information, and also to find appropriate spaces for their reading. Nowadays, a library is a place of knowledge acquisition, for communication and to socialise with other people (Sufar, Talib and Hambali 2012). Libraries have changed and expanded to include a variety of types, such as the public library, national library, specialist library and university library (Edwards 2009). University libraries have been considered a hub of campus life, and central to learning and research, as they are deemed to be a repository for knowledge and reference texts, as well as a link between students and the information they require (Freeman 2005). The traditional library was a collection of sources and services, as well as the structure in which the information was housed. However, in its most elementary sense it was considered to be just a collection of books. In contrast, during the digital age, libraries have become much more than a collection of books; new forms of knowledge are generated and innovative technologies are creating new methods of storing and delivering information, and they have become a place for learning (Aina 2004).

This important transformation of university libraries into learning centres is due to shifts in modes of learning, and to learners becoming more diverse in age, ability and background. Learning can be defined as an active process of acquiring knowledge or information that occurs within different environments; and that learning is focused on connecting specialised information sets (Siemens 2004). Learning in university libraries takes different modes, including formal learning that is systematic and guided by instruction, such as listening to lectures. Another mode is informal learning that is intentional, but not structured or quantified in terms of instructor delivery and involvement; it occurs when control over the learning situation is given to the students either socially, experientially, or constructively (Jamieson 2003). According to Jamieson (2009), informal learning takes place in the library and is undertaken individually and collaboratively.

More specifically, the university library's role has changed from a quiet place to a modern place for meeting other people and sharing ideas in groups or individually in a variety of learning spaces to meet all students' requirements (Sufar, Talib and Hambali 2012). University libraries have become places to learn and have been changing their study space into learning spaces based on student's developing needs and their ways of learning, as the students become more independent and able to choose suitable ways of learning (McNamara 2012). Each person has a different learning style. This means that individuals perceive and process information differently (Cassidy 2004). According to Spencer-Waterman (2013), there are three basic learning styles: (1) visual learners who prefer viewing and reading to learn; (2) auditory learners who prefer listening to a lecture or audiotape; (3) tactile-kinesthetic learners who remember and understand better when they write or draw or undertake experiments in the laboratory. A modern university library provides various learning spaces, such as individual study rooms, group study areas, computer areas and training or seminar rooms, which cater for diverse learning styles (Jamieson 2003; Twait 2009). The interior design of future libraries should provide an appropriate environment for users to enhance their ability to learn effectively.

Library design has responded to the evolution in information technology in different ways to enable access to electronic material, services and training, and to make working in the library as easy as possible (Childs 2006). An appropriate interior design of a library can help to create a place that inspires and motivates the individual. As an academic and interior designer, I, as researcher am interested in colour studies, particularly in learning environments, and the relationship between colour and students. This study will help practitioners to apply the findings about colour use to learning spaces in university libraries and to develop their knowledge about colour design in the library, particularly in individual study spaces.

Library design is not only about exterior surroundings; it is also about practical and pleasing physical interior environments. One of the important areas of a university library is the individual study rooms. The study room is a place where the students spend their time for individual study (Jamieson 2009). The students move between quiet or private spaces to collaborative spaces and back to private spaces within the library building according to their specific requirements. It is recognised that individuals who work on complex tasks tend to prefer a private space because they need a quiet place to concentrate (Värlander 2012). This is so for students in the library; when the students want to study with more focus and concentration for tasks such as focused reading, they look for a private and quiet place to study (Jamieson 2003). Therefore, they prefer to choose the individual study room as it is isolated from other study areas in the library, thereby reducing the external factors that cause distractions for students.

An individual study space is one of the learning spaces in the library that needs a high level of design quality to create a suitable study atmosphere. The physical interior environment, including physical layout, furniture, colour and lighting, has an important impact on library users' performance (Brooks 2011; Kumi et al. 2013). Effective design of the physical environment of the library can attract users or students to come and use the learning spaces to study. Colour is deemed to be one of the factors which impacts human achievement in regard to learning. Colour works as a tool for communication between people and the objects surrounding them (Hard and Sivik 2001). It plays an important role with the components of environmental design such as theme, function, built form, location, and direction.

Colour is not only an important aspect in interior decoration; it is also a relatively easy tool to alter the atmosphere of an environment (Pressly and Heesacker 2001). Colour, as one of the most important elements of the physical environment, can impact on students' lives (Blackmore et al. 2011; Brooks 2011). The colour-person-environment relationship is an important theoretical concept not only for designers but also for environmental colour researchers. It is important to consider the way people exist in different forms of relationship with the built or physical environment when colouring the buildings and associated environments (Smith 2008). Colour can impact human psychology through emotions, moods, behaviours, and perceptions; and it can also impact human physiology through heart rate, blood presure and brain acivity (Abbas, Kumar and Mclachlan 2006; Küller, Mikellides and Janssens 2009; Wang and Russ 2008). Colour, as it affects the psychology and physiology of the learners, is one aspect of the physical environment that may impact on learning activity. Therefore, the correct use of colour can reinforce users' ability to interact with their environment effectively.

This research focuses on how colour influences learning in individual study rooms in the library. Indeed, very few studies have investigated the influence of colour on human performance in learning environments. One such study examines how environmental colour (blue, red or white) and other variables (study material, private study room) impact on adult students' mood, satisfaction, motivation, and performance (Stone 2001). In addition, a series of studies have been conducted to investigate the influence of different colours on performance and mood in work offices (Kwallek, Soon and Lewis 2007; Kwallek, Lewis, Lin-Hsiao and Woodson 1996; Küller, Ballal, Laike, Mikellides and Tonello 2006). Therefore, from these previous studies about the impact of colour on human performance in work offices, the research postulates that colours can impact on learning performance in a similar way in individual study spaces in the library.

Furthermore, many studies have investigated the relationship between human emotions and colours. These studies mostly focus on emotional responses to a specific colour sample, exploring positive and negative connotations by using defined adjectives to capture particular moods and emotions. In these studies, participants simply match the adjectives with different colours without any reference to interior space (Gao and Xin 2006; Manav 2007; Ou et al. 2004).

The impact of colour on learning space users' psychological and physiological state and performance is gaining greater attention. Although there are numerous studies about colour, psychology, physiology and learning environment, there is not a uniform set of findings to give a consistent perspective on the influence of colour on learning performance in the individual study space of a university library. Specifically, there is a lack of research combining the concepts of colour, psychology, physiology and learning performance in relation to individual study rooms in the library building.

1.2 Aim of Research

The aim of this study is to identify the impact of colour on learning performance within a university library. The intention is to provide an optimum choice of colour for individual study areas in the library that architects, interior designers and other professionals can utilise in their practice. Recently, the role of a university library as a learning centre has been an important focus in the contemporary learning sector. Architects and interior designers have made great efforts to create and design suitable learning environments to enhance users' performance and to motivate them to study by designing appropriate indoor spaces, attending to aspects such as lighting, colour, and furniture. Many studies in the field of colour have investigated the effect of colour on physiological and psychological states in different contexts. This study identifies links between the colour field and the learning experience, and between the colour field and the psychological field, in individual study rooms within university libraries. Accordingly, the main question of this thesis is: **How does colour influence learning performance in individual study rooms in university libraries?**

In order to answer the main research question, this research project's boundaries were identified. Firstly, different colours (hues and nuances) were examined to ascertain their effects on learning performance. Secondly, to assess learning performance, it was decided that a reading comprehension task is a suitable example of learning, because the participants were visual learners. A reading comprehension task was done by participants while they were exposed to different colours in a test room. Thirdly, the individual study room was chosen as the focus of this research, because as Jamieson (2003) states students spend a considerable time studying alone, particularly when they want to focus on their task.

Finally, the researcher expected that students' learning performance would be affected by colour psychologically (such as in their emotional response to colour) and physiologically (such as in their heart rate) (see Fig. 1-1). Accordingly, the main question is further articulated via the following sub-questions:

1. To what extent do hue and nuance influence reading comprehension in the individual study room?

2. To what extent do hue and nuance influence heart rate and emotional response to colour in the individual study room?

3. To what extent do emotional response to colour and heart rate mediate the relationship between colour and reading comprehension in the individual study room?

In light of the overall aim, the resultant findings and discussion will address the objectives of this particular study. The objectives are:

1. Investigate the role of colour in the individual study room.
2. Explore the impact of colour on reading comprehension in individual study spaces, through considering emotional responses to colour and the impact of colour on heart rate.
3. Investigate if colour can motivate students to engage in learning activities in individual study rooms in university libraries.

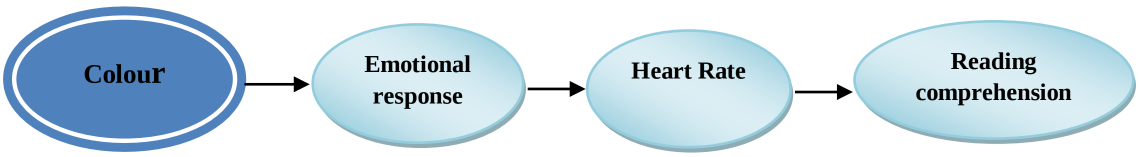


Figure 1-1: The predicted colour's effect on emotional response, heart rate and reading comprehension

1.3 Introduction to Research Methodology

The research methodology addresses on the aims and objectives by integrating theoretical and empirical research to address the research questions. Action research methodology was used to guide this research. Action research is usually cyclical in nature, and the methodology, methods and design for each cycle as they are applied within this study are described in detail in Chapters 3, 4 and 5. This thesis explores the role of colour in the indoor space of academic libraries and its impact on students' learning performance. The researcher believes that a pluralistic approach is needed to identify the impact of colour on learning performance in the individual study room. An experimental method was used to assess learning performance by asking participants to be in a full-scale room and exposed to different colour conditions to obtain valid results. In addition, to obtain more details about the impact of colour in the indoor spaces, qualitative methods such as focus groups, interviews and questionnaire have been used to consolidate the results and enrich the researcher's understanding of the situation.

1.3.1 Action Research

Action research is one approach within a range of critical methodologies that have a central interest in exploring the relationship between knowledge and action, where knowledge relates to power and the power of change. Stringer and Genat (2004, 4) define it thus: "Action research is a systematic, participatory approach to inquiry that enables people to extend their understanding of problems or issues and to formulate actions directed towards resolution of those problems or issues."

Action research is viewed as a spiral or cyclical process, starting with the research questions and ending with the application of the knowledge gained that leads to new questions (Johnson 2011; Kemmis and McTaggart 2000). Kemmis and McTaggart (2000) demonstrate a simple model of the cyclical nature of the typical action research process (Fig. 1-2). Each cycle begins with a *plan* identifying a problem or issue the researcher wants to explore, an *act* which means acting on the plan by designing the study and planning the methods of collecting data, *observation* (collecting data and evaluation), and *reflection* (reflecting on these processes and consequences) (Kemmis and McTaggart 2000).

This study required for a responsive approach that included both testing and understanding how colour can impact on reading comprehension and how it can motivate students to study and use an individual study area in the library; these requirements led the researcher to adopt the methodology of action research. This methodology was selected because of the need to provide in-depth, detailed understanding of colour's role in the learning environment in the individual study rooms. This method also enabled the researcher to do a series of studies, each study (cycle) dependent on the outcomes of the previous cycle.

The current study includes four action research cycles, which have been explained, followed the action research spiral: plan, act, observe and reflect. The *planning* step of each cycle involved an aim and the focus of this particular phase of the study. It was developed to explore the question which was identified for this study: to show how colour can impact on a learner's performance. In the *acting* step, the plan was implemented. For example, the experiments (cycles 2 and 4) and focus groups (cycle 3) which recorded people's responses to the colours being tested by recording emotional responses to colour and heart rate, and the reading comprehension task. In the *observe* step, the effects of action were observed and a summary of all the data obtained from each study completed. The *reflect* step involved discussing and analysing the data collected, and the implementation of actions was evaluated to form the basis for the next cycle of research (see Fig. 1-3). The outcomes of each cycle's reflection were essential for the researcher to devise a new plan to be implemented in the next cycle and thereby gain new insights and build knowledge.

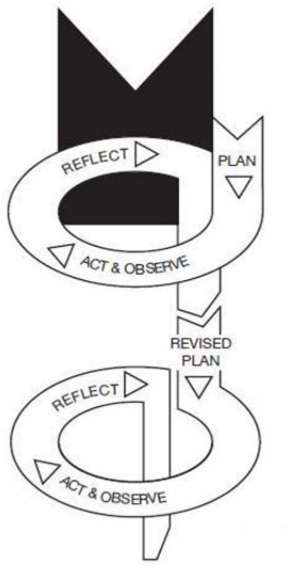


Figure 1-2: Simple Action Research Model
(Kemmis and McTaggart 2000, 564)

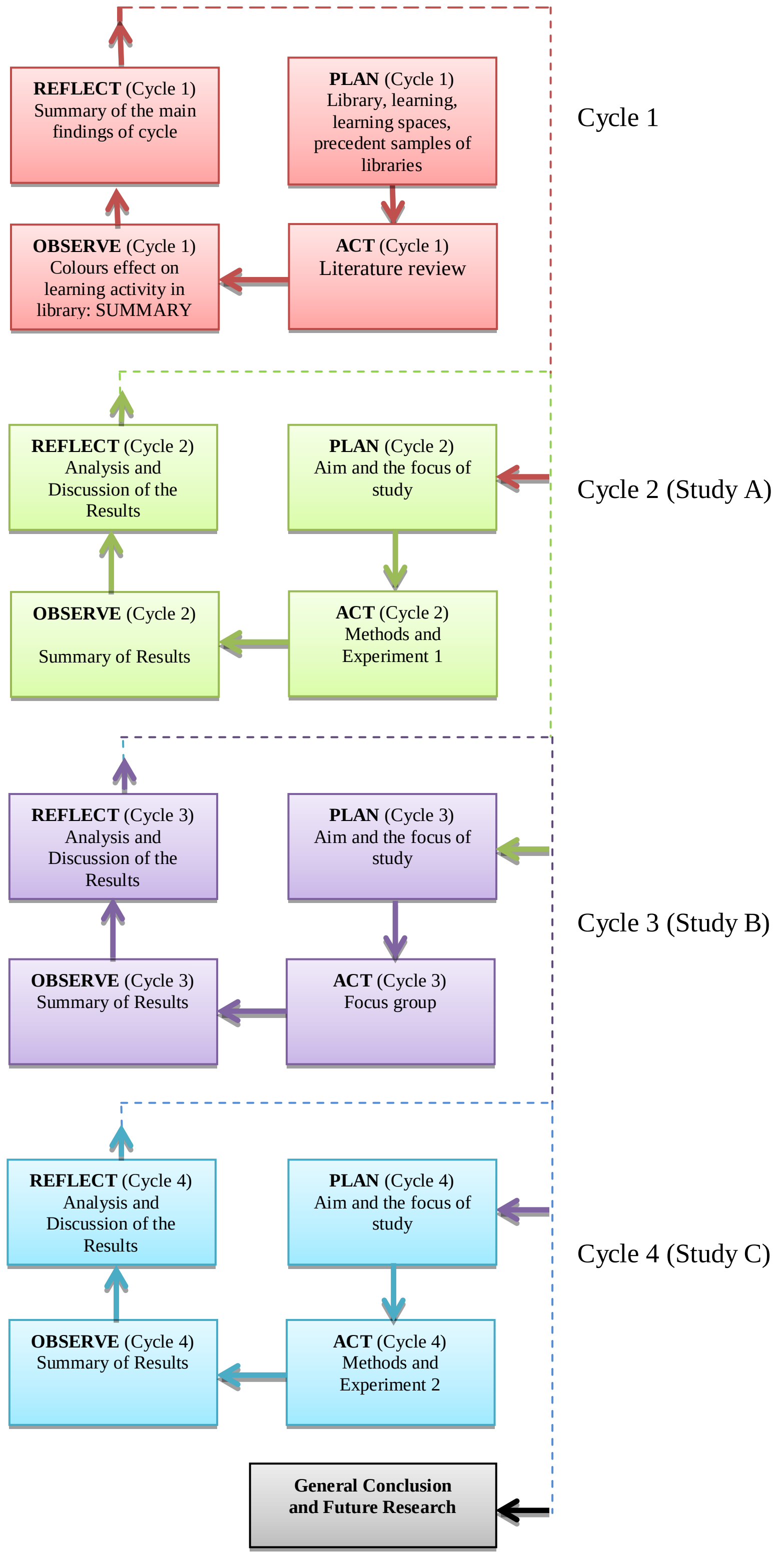


Figure 1-3: Mapping of the four cycles

(Al-Ayash 2012)

1.3.2 The Use of Mixed Methods

In action research methodology, there are different approaches, such as qualitative research methods, quantitative research methods, or mixed. The mixed methods could include more than one stage or a chain of studies. These studies can be connected to each other in order to establish accumulated or interactive knowledge (Hunter, Albert and Brewer 2003). Qualitative research is where the researcher depends on the views of participants, asks general questions, describes and analyses the data for themes, and conducts the inquiry in a biased and subjective manner (Creswell 2008). According to Mills (2007), qualitative research uses descriptive approaches to understand the data and what the research means from the perspective of the participants in the study. Qualitative methods include, for instance, observations, interviews or focus groups.

In a quantitative study, the researcher decides what to study, asks specific, narrow questions, collects measureable data from participants, uses statistical tests to analyse the data collected, and conducts the inquiry in an unbiased and objective manner (Efron and Ravid 2013; Todd et al. 2004). Before conducting the research, a quantitative researcher states the hypothesis to be tested and specifies the research procedure that will be used in the study. The researcher also takes control over appropriate factors that may interfere with the data collection, and identifies a sample of participants large enough to provide statistically meaningful data. The view of quantitative researchers is that the world is something predictable and can be understood by scientific research (Mills 2007).

Research that combines the collection of quantitative and qualitative data in one study is called mixed methods research design. Mixed methods research is where the researcher mixes or combines qualitative and quantitative research methods in the same study (Mills 2007). The researcher can use both qualitative and quantitative techniques; each method uses different types of strategies, and looks for different types of findings. Therefore, the nature and purposes of the study influence the choice of suitable approaches for the study.

This thesis utilised mixed methods that are qualitative and quantitative to collect, describe and interpret the data. This allowed a more comprehensive picture of the problem under investigation than would be possible using one method alone. According to Creswell (2008), using more than one method in one research project enables the researcher to obtain a more complete image of human experiences.

Qualitative and quantitative data is incorporated throughout the research to authenticate the project findings. In addition, Creswell (2008) states that there are several advantages of using mixed methods in a single study. Researchers in a mixed methods research approach are able to use all of the data available to support a research project, rather than being restricted to the types of data collection normally related to a qualitative or quantitative approach (Creswell 2008). It also helps to solve the research problems that cannot be solved by using either qualitative or quantitative research exclusively, and enhance the validity of research findings (Mills 2007; Todd et al. 2004).

According to Lewis (2011), the reasons for conducting mixed methods research are: firstly, to seek convergence and justification of outcomes from different methods that are studying the same phenomena; secondly, to elaborate, expand or enhance the outcome of one approach compared with the outcome of another approach. For example, interviews may yield contrary findings to those from the analysis of questionnaire data.

1.4 Data Collection Process

The data collection process focused on the aim and objectives of the research by integrating the theoretical and empirical research to address the research question. This data collection process helped to refine and expand the scope of understanding the research area by assisting in the selection of colours for the experiments. A detailed description of the methods used in this thesis is provided in Chapters 2, 3, 4, and 5. This section provides an overview of the methods used to collect data for the quantitative and qualitative components of this thesis.

1.4.1 Qualitative Data Collection

This thesis incorporates four different methods: literature survey, interviews, focus group, and questionnaire.

1.4.1.1 Literature Review

The literature review was generated from texts, publications, journals, and research reports written in the English language through the following databases: ProQuest, JSTOR, Wiley Online Library, Science Direct, Emerald, PsycInfo, Google Scholar, Inform, and subject relevant websites. These publications were taken from diverse theoretical fields including interior design, the library studies, learning, colour theory and environmental psychology. The findings lead to a theoretical framework which bridges the gaps between the core research fields: learning spaces in libraries, colour, and the psychological and physiological impact of these factors on learners.

This literature review laid the foundation for the fieldwork and assisted in designing criteria to select colours, to examine them and to identify the type of learning and learning space to be used in this study. In addition, the literature review helped the researcher to identify and select appropriate strategies and methods to collect data. Furthermore, the literature review has contributed significantly to the general context for exploration of the potential role of colour inside university libraries and its impact on the students' learning performance within these learning spaces. The literature review is outlined in Chapter 2 (Cycle 1).

1.4.1.2 Interview Method

Unstructured interviews were used in Cycle 2 (Study A) and Cycle 4 (Study C). This method helped the researcher to obtain in-depth qualitative data, and a detailed understanding of how colours impact on participants' psychology and learning in the individual study room. The unstructured interviews are described in detail in Chapter 3.

1.4.1.3 Focus groups

The focus group was used in Cycle 3 (Study B) as a qualitative technique in addition to the questionnaire. Together, these methods enriched the research with valuable data that enabled the researcher to select suitable colours for the individual study rooms from the participants’ suggestions in the focus group sessions. They also gathered information about how colour can encourage students to study in these spaces. The selected colours were then used in Cycle 4 (Study C) to test their impact on reading comprehension, emotional response and heart rate. These methods are described in detail in Chapter 4.

1.4.2 Quantitative Data Collection

This thesis uses quantitative methods to assess reading comprehension, emotional response and heart rate. The methods are: learning channel preference questionnaire scale, reading comprehension task, colour emotion scale, and physiological recordings.

1.4.2.1 Learning Channel Preference Questionnaire Scale

This questionnaire was used to identify participants’ learning styles. The results identified that they were visual learners. The questionnaire used is detailed in Cycle 2 (Study A— Chapter 3) and Cycle 4 (Study C— Chapter 5).

1.4.2.2 Reading Comprehension

A reading comprehension test was used to assess the learning performance of participants. It was used in Cycle 2 (Study A) and Cycle 4 (Study C). More details are provided in Chapter 3.

1.4.2.3 Colour Emotion Scale

The Semantic Differential Rating method was used in Cycle 2 (Study A) and Cycle 4 (Study C) of this thesis to measure emotional responses to colour, not basic human emotions. This method is appropriate as it has been used extensively to measure certain affective features of meaning related to the dimensions of emotion or feeling (Stamps 2007). Furthermore, it is easy to apply with different age groups or cultures. This method is described in detail in Chapter 2 (Section 2.4.3) and in Chapter 3 (Section 3.2.3.3).

1.4.2.4 Physiological Recordings

The Fingertip Pulse Oximeter was used to record heart rate. This method or test was used in Cycle 2 (Study A) and Cycle 4 (Study C). It is described in more detail in Chapter 3.

1.4.3 The Use of a Full-scale Room

The three main methods used for examining the impact of colour in the indoor environments are outlined in Chapter 2 (Section 2.5.8): 1) full scale room, evaluations from participants who are personally in the real space or in the laboratory, 2) viewing cabinet, and 3) simulations method that imitate actual conditions (photos, videos and software). It was decided that this study would not use participants in the real space (visiting space in the library) because with this method it is difficult to find empty individual study rooms, and difficult to change wall colours and control conditions of this space while it is a functioning facility.

It was also decided not to use a viewing cabinet because the colour experience differs depending on whether it is applied to a small surface or to a large surface. In addition, it is difficult to measure the influence of colour on performance by using colour chips in the viewing cabinet. Further, it was decided not to use simulation methods to create a simulated space by using software programs such as 3D Max or AutoCad, because the output of these simulation programs does not yet approach acceptable reality for research purposes due to the limited capability of the programs to produce a dynamic moving image; and logistically it would require a considerable amount of time and resources to produce the required simulations.

Measuring the influence of colour on students’ performance needs the participants to be in the indoor spaces, where the effects of colour would be more reliable and valid. Therefore, it was decided to use a full-scale room in the laboratory as an alternative to an individual study room in the university library, because it is easy to control and manage the conditions, and it allows flexibility for collecting data from participants. This method was used in Cycle 2 (Study A) and Cycle 4 (Study C).

1.5 Data Analysis

In this study, the qualitative data analysis from following procedures, strategies and outcomes through focus group discussions and interviews with students in the three studies was used to authenticate the information and detail obtained. The analysis of qualitative data in this study was performed based on three steps as proposed by Creswell (2008): data preparation for analysis, identification of key points from the data, and the process of coding and finding themes.

Data preparation for analysis: the researcher arranged all the data that had been collected during the study so that it could be accessed easily and quickly for analysis. The audio/video tapes of focus group discussions, interviews and verbatim notes from questionnaires were transcribed to provide an accurate record of what was said and done. The researcher typed the transcription in a Microsoft Word document, and saved it in specific folders. This technique enabled speedy and convenient access to data.

Identification of key points from the data: after organising all the data, the researcher read the data and listened to the audio/video recordings several times to identify an initial set of themes, notes, and key points. This step enabled the researcher to think about the arrangement of the data, focus on specific issues, and consider whether or not more data was required (Creswell 2008).

Coding and representing themes: coding is an analytical process in which text is labelled and categorised to facilitate analysis and make the data more manageable (Creswell 2008). The researcher labelled, coded and categorised the data. Focus group discussions, interviews, and questionnaire responses were saved in word processing files (.doc format); images were saved in Adobe Photoshop software (jpg format); and audio and videos of focus group discussions were saved in mp3 formats. Through the process of coding, the data could be grouped into several relevant categories or themes so that it became clustered and refined. The data that had been coded were reread to look for consistencies and to clarify themes.

The quantitative data analysis was used to measure the effects of colour on reading comprehension tests, emotional responses, and heart rate by using SPSS software program (Version 20). Generalised Linear Mixed Models (GLMMs) implemented through SPSS's Version 20 were used to analyse the main study data. The GLMM is 'generalised' in the sense that it can handle outcome variables with markedly non-normal distributions; the GLMM is 'mixed' in the sense that it includes both random and fixed effects (Jiang 2007).

In order to identify the suitable colours for individual study rooms, these measures were collected with the qualitative data in relation to the themes that emerged during the data analysis, namely: motivation, emotion, colour preferences, bodily response, motivation, associative properties, intellectual activity, personal connections and spatial perception. These findings are detailed in Chapters 3, 4, and 5. Primary data of the three studies were presented in the form of tables and figures. Additionally, graphs were used to present statistical information or to contextualise the collected data through questionnaires and interviews.

1.6 Research Design of Four Cycles

This study includes four action research cycles: Cycle 1 (literature review); Cycle 2 (Study A); Cycle 3 (Study B); and Cycle 4 (Study C).

Cycle 1 (literature review) aims to demonstrate how libraries became a place for learning and how learning itself changed; and how these changes have affected contemporary library design such as colour schemes. Cycle 1 also helped to identify what colours to test in this project, and what methods should be used to measure the impact of colour on learning performance, heart rate and emotional responses to colour. The aim was not to assess basic human emotions such as anger, fear, happiness or surprise but colour emotion (colour emotion is described in more detail in Chapter 2, Section 2.4.1).

Cycles 2, 3 and 4 include three studies (A, B, and C). Studies A (Cycle 2) and C (Cycle 4) were conducted with 24 university students to test the impact of six colour conditions on the participants' reading comprehension task in each study. Cycle 2 (Study A) examined colours (light red, light blue, light yellow, vivid red, vivid blue and vivid yellow); that were selected from Cycle 1 (the literature survey). Cycle 4 (Study C) examined colours (light yellow, light orange, pale yellow, deep yellow, pale green-yellow and pale purple), based on the findings of Cycle 3 (Study B).

In order to examine the participants' reactions to colour in the indoor environment, it was decided that these studies would use a full-scale room simulation of the real environment by asking the participants to be personally in the space, where heart rates and reading comprehension were measured and colour emotion evaluated. These variables were measured in the presence of each colour condition in the simulated individual study room by letting participants read a paper, with the wall colour changed between sessions. Chapters 3 and 5 describe the methods, test room design and experimental procedures, and results and findings are discussed in detail for Studies A and C.

Several evaluation models have been established by researchers in the field of environmental psychology to measure the influence of colour on users in the built environment (Mehrabian and Russel 1974; Osgood, Suci and Tannenbaum 1957; Russell, Weiss and Mendelsohn 1989; Watson, Clark and Telleggen 1988). Most of these models were based on the self-report method, and were used to measure human emotional state, mood and colour emotion or colour connotation (colour emotion is described in more detail in Chapter 2, Section 2.4.1). The Semantic Differential Rating method (SDR) was established by Osgood, Suci and Tannenbaum (1957) and it has been widely used by researchers to scale colour emotion responses in the indoor environment (Gao and Xin 2006; Kasmar 1992; Odabaşioğlu and Olguntürk 2015). In this thesis, the SDR method asks the observers to describe their emotional response to colours used in Studies A and C rather than how they evaluate the space.

In order to measure the impact of colour on learning performance, student participants, who were tested to be visual learners, were involved. These are learners who prefer viewing and reading to learn. Therefore, a reading comprehension test was used in Cycle 2 (Studies A) and Cycle 4 (Study C).

The researcher used the NCS colour system in this thesis to choose colours and has adopted its terminology. It is a way of describing colours exactly as we see them independent of language, material and culture. In addition, any surface colours that we see can be defined within NCS and given a precise notation regardless of material.

Cycle 3 (Study B) aims to select suitable colours for the individual study room by conducting focus groups to obtain qualitative data from the perspectives of university students who use library spaces for study, as well as to investigate how colours can encourage students to study in that space. The outcome of Cycle 3 (Study B) was tested in Cycle 4 (Study C). Cycle 3 (Study B) comprised two parts. Part 1 was conducted with 17 university students by using three focus groups, using questionnaires and group discussions to ask them to select suitable colours for the individual study room, and to discuss how these specific colours helped and encouraged them to study. Part 2 involved 20 participants who were asked to fill in a survey to determine if they agreed or disagreed with the results of Part 1 regarding the suitable colours selected. All details regarding Cycle 3 (Study B) are described in Chapter 4. Figure 1-4 depicts the map of the four cycles.

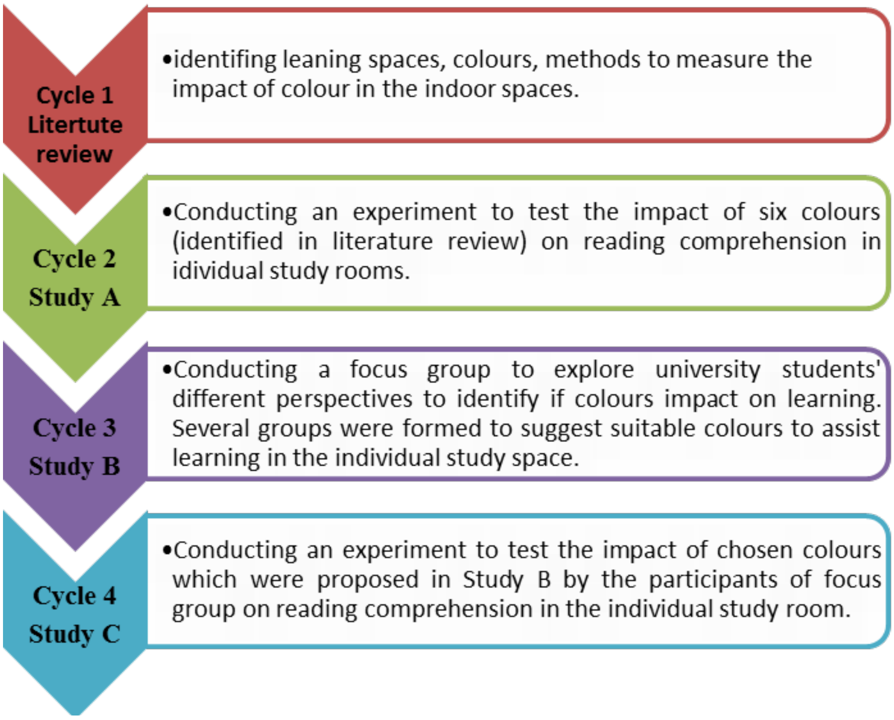


Figure 1-4: Mapping of the three studies

1.7 Significance of Research

It is clear that the role of the university library as a learning centre is gaining greater importance in the educational sector (Sufar, Talib and Hambali 2012). Today the library is a place for learning and exchange of knowledge, as well as where the students spend most of their time. The colours of a library’s learning spaces can have a significant impact on the students’ learning performance by affecting their emotion, and behaviour. Because of the lack of data about the effect of colour in the learning environment, particularly in the individual study room, this research examined the impact of some colours on adult students’ performance.

This study is significant for several reasons. First, it provides a better understanding of the potential role of the use of colour in the university library. Second, this study contributes to new multi-disciplinary knowledge about the development of the technologically advanced libraries of the future. Third, this thesis contributes new knowledge, as it focuses on the impact of colour on reading comprehension in the individual study rooms within university libraries.

Fourth, the use of action research as a methodology in this thesis made the research unique in its approach to collecting and analysing data, and has proven to be a valuable research strategy for the topic. Using a qualitative method acknowledges the complexities of individuals' relationship with and responsiveness to colour. It adds richness to the data collection by demonstrating participants' perspectives and perceptions as learners in regard to colour in learning spaces.

Finally, the findings of the study can be helpful for architects, interior designers and colour designers who seek methods to improve students' performance in the individual study area, while considering the psychological and physiological effects of colour.

1.8 Ethical Considerations

Ethics approval Form C (Application for Approval of Research with Low Risk) for this study was obtained from the Human Research Ethics Committee of Curtin University on 03 July 2012 (approval number BE-82-2012). All participants were provided with information about the nature and purpose of the research and the methods. It was made clear to all participants that their involvement in this study was voluntary and they were informed about their right to withdraw from the research (experiments and focus groups) at any time without prejudice, and assured that no harm would come to them as a result of the information they shared, and that all data from students who had resigned from the study would not be used for the research. All participants were provided with an information sheet and consent form containing this information for the three studies.

Participants' names and details are kept confidential and were not disclosed throughout the course of the study. Every participant was assigned a code in place of names. Access to the data gathered was limited to the researcher and her thesis supervisors. Further, all participants who were involved in the study are acknowledged confidentially for their contribution and cooperation in the acknowledgement section of this thesis.

1.9 Overview of the Thesis

This thesis is organised into seven chapters, and it comprises four action research cycles. The findings of each cycle lead to planning for another cycle. Chapter 1 provides the background, aims and objectives. This chapter also outlines the research question, and discusses briefly the methodology and methods used to collect data for this study. It defines the action research methodology and its process. It also discusses the data collection process and summarises the methods used for the literature review and the three studies. The chapter explains the significance of the research and ethical considerations; and introduced an overview of the organisation of the thesis.

Chapter 2 (Cycle 1) focuses on the theoretical framework and the background study of the research. This chapter clarifies the specific aspects of library, learning and learning environments, emotional response, and colour in order to identify the gaps in knowledge. It starts with a description of the evolution of library building through the ages, and then reviews how and why the library recently became a learning centre in most university life. A learning centre can be defined as “a dynamic environment which integrates provision to support a range of independent and group learning activities” (Saur 2004, 67). An overview of the fundamental knowledge of learning and learning spaces develops an understanding of how learning methods have changed, and how each person has a different favoured manner of learning.

In addition, an overview of emotion and its impact on learning activity is given. Further sections in Chapter 2 (Cycle 1) develop an understanding of contemporary colour research. Colour perception and colour systems are defined; presentation of the NCS and arguments for choosing it to work with it is introduced. Moreover, the impact of colour on psychology, physiological state and performance are described.

Based on the insights from this systematic review, a series of empirical studies were designed to add to the evidence base by demonstrating that colour in the interior environment is capable of affecting positively or negatively human psychology, physiology and performance. In addition, precedent samples of libraries are described and the colours used in these libraries presented. Thus the purpose was to investigate the relationships between colour and learning performance in the learning spaces in university libraries by exploring the impact of colour on emotional response, heart rate and performance. It also summarises existing knowledge about colour presented in previous research into the learning process in learning spaces. Colours for learning spaces were identified and used in the practical application.

Chapter 3 (Cycle 2) presents Study A, reporting the methods followed to conduct the experiment and the procedures and implementation of the experimental design, and discusses the results. Cycle 2 is generated by the reflection on data collected presented in Cycle 1 to test the impact of six colours on emotional response, heart rate and reading comprehension in individual study spaces by using experimental methods and interviews.

Chapter 4 (Cycle 3) presents Study B. Focus groups were used in this study. It is generated by the outcome and reflection on Cycle 2. The aim of Cycle 3 (Study B) was to choose suitable colours for individual study spaces in university libraries based on the users' perspective, and then to be tested in the next study Cycle 4 (Study C). Participants joined focus groups to discuss which colours can motivate students to study in these spaces. As well as the design of the focus group method, the results are presented and discussed in chapter 4.

Chapter 5 (Cycle 4) presents Study C. This study is generated by the outcome and reflection on Cycle 3 (Study B); it aims to test the impact of colours chosen arising from discussion between the focus group participants of the effect of hues and nuances in Study B (Cycle 3) on students' emotional response, heart rate and reading comprehension in the individual study spaces. This chapter also describes the experimental design and data analyses, and discusses the results.

Chapter 6 gives an overview and a summary of the main research findings, and the limitations of the study and directions for future research. This chapter provides the conclusion for the whole thesis. Figure 1-5 below summarises the six chapters as a flow chart.

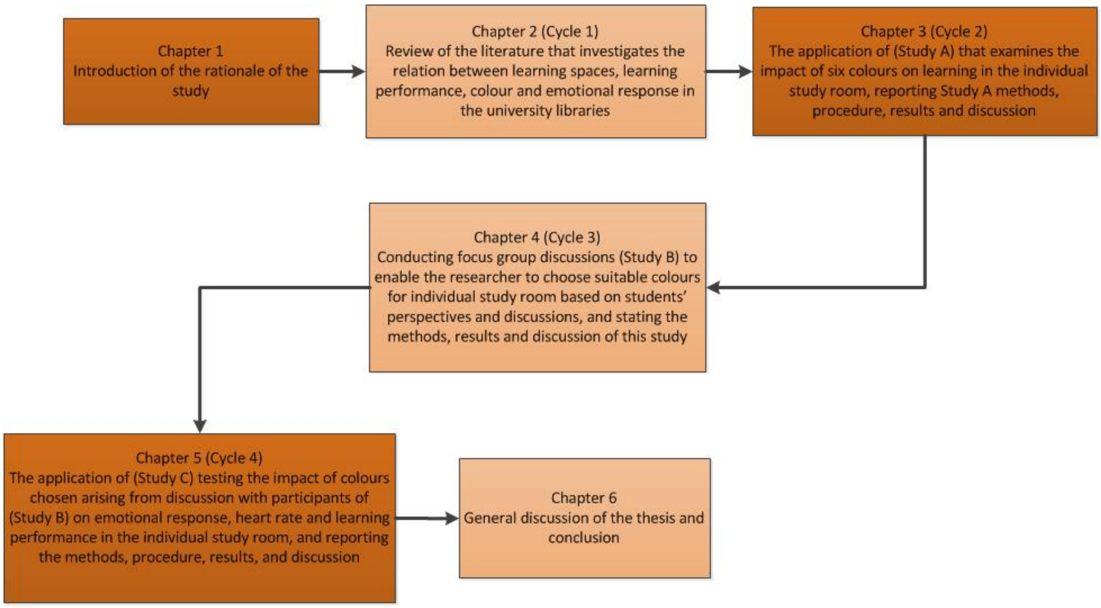


Figure 1-5: The flowchart of the current study

2 CHAPTER 2: CYCLE 1 (LITERATURE REVIEW)

> Great libraries of the world have the ability to inspire, uplift, engage, stimulate thought and provoke emotions; libraries which were once designed for administrative simplicity are now designed for the user experience.
>
> (Parkes and Walton 2010, 24)

2.1 Cycle 1 (Plan 1): The Aim

The aim of Cycle 1 is to gain knowledge about the nature of a library building and how it becomes a place for learning, and also to identify available knowledge on how colours impact on human learning performance, psychology and physiology. Therefore, this chapter will review the literature in relation to libraries, learning, and learning spaces, in order to understanding the relationships between them. Moreover, it will demonstrate that learners learn differently, and explore how these changes have affected the spatial configurations and decoration of libraries. Further, a review of previous studies in the field of colour and learning establishes a base for the researcher to identify which colours should be tested in this project. Previous research surveyed has assisted the researcher to identify what type of learning activity and what aspects of psychology and physiology should be examined to address the research aim. Figure 2-1 shows a framework for the literature review.

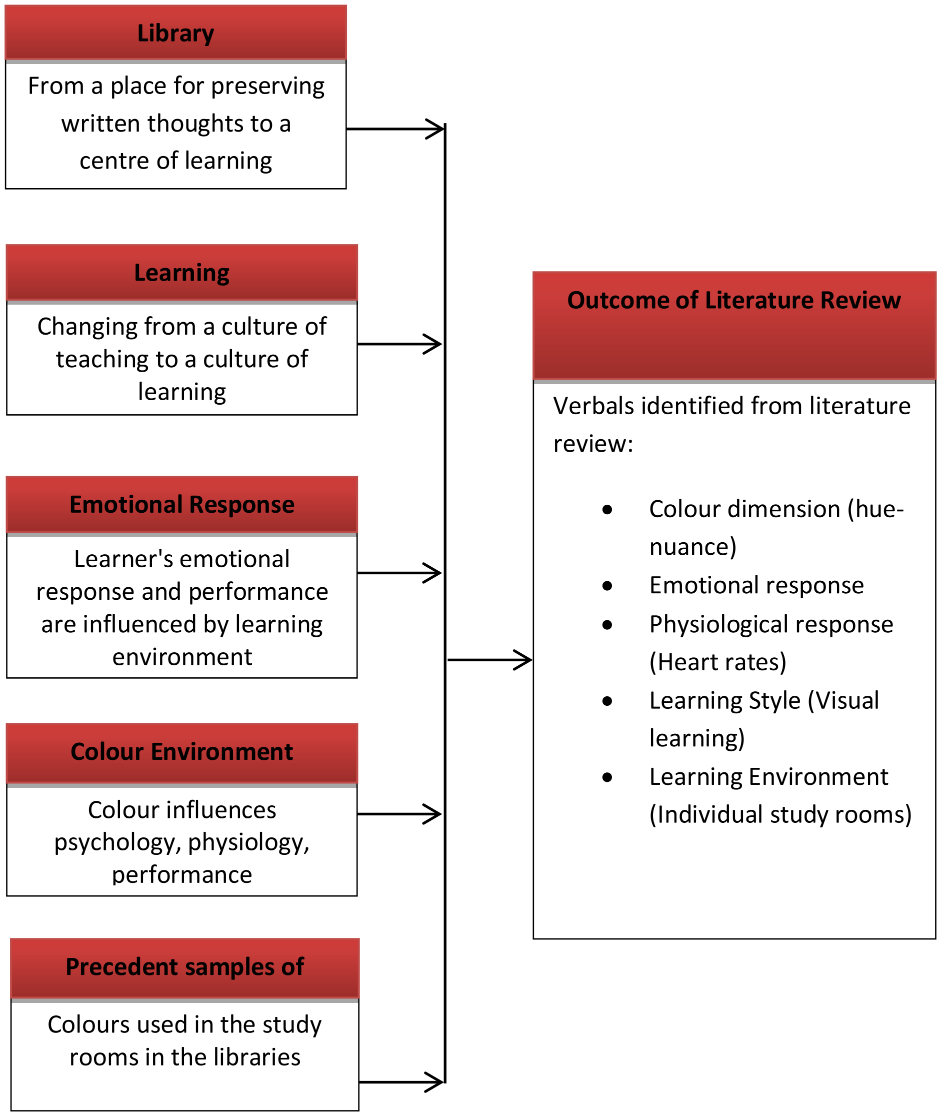


Figure 2-1: Literature review overview

(Al-Ayash 2013)

2.2 Cycle 1 (Act 1): Library as a Learning Space

It is important to understand that libraries have transitioned from a place to preserve written thoughts to a place for active learning and acquiring knowledge. The established learning spaces in university libraries have developed in association with the changes in learning modes and the learners themselves.

2.2.1 Brief History of the Emergence of the University Library

University libraries did not suddenly appear; they have evolved through the ages. The word 'library' comes from the Latin word 'liber which means 'book' in Greek and Romance languages (Reitz 2004). Language was developed by ancient civilisations to convey their thoughts, and in order to record these thoughts, they invented writing. As a consequence, our ancestors built places to preserve these written thoughts, and therefore, such places were the beginning of libraries (Lerner 1999).

There are six stages in the development of libraries through the ages. Table 2-1 summarises the evolution of these stages. Firstly, rooms in temples and palaces were the first form of library in ancient civilisations after the invention of cuneiform writing by the Sumerians and hieroglyphics by the Egyptians in 3000 BC, on clay tablets and papyrus. These libraries were private, not for public (Harris 1995; Lerner 2009) (see Fig. 2-2).

Table 2-1: The evolutionary stages of libraries through the ages

(Al-Ayash 2012)

Date	Type of writing	Materials for writing	Type of storage	Type of library
3000 BC	Cuneiform, hieroglyphic	Clay tablet or papyrus	Rooms in temples, or in palaces	Private
500-1200 AD	Alphabet	Papyrus rolls or animal parchment	Rooms in monasteries and mosques	Private or state
1200-1500	Handwriting	Paper (books)	Rooms in libraries	Public
1500-1800	Printing press	Paper (books)	Library building	Public library, academic library
1800-1900	Mass production printing	Paper (books, journals, newspapers)	Library building	Civic and local public library
1990-Onwards	Electronic digital	Printed information, plus CD ROMs and electronic materials	Physical library and computer disk (virtual library)	All types (national library, public library, academic library and personal library)

Figure 2-2: The shelves of tablets of ancient library in Mesopotamia.
Available from:
https://i0.wp.com/25.media.tumblr.com/tumblr_lxwzmuG4Ho1ql5d2uo1_400.jpg

Historical literature indicates that the first systematically collected library is the Royal Library, established by King Ashurbanipal, dating back to the seventh century BC in northern Iraq (Lerner 2009). He established the library for his personal use, and a few centuries later, the library was opened to scholars. Ashurbanipal's library occupied a number of rooms within his palace. These were well organised, and the materials were arranged in series. Rooms were filled with tablets relating to history and government, literary works, mathematical, astrological or magical collections (Harris 1995). The library continued as a private place for a long time in ancient civilisations. For example, private libraries were common among the wealthy families in Rome by 50 BC (Lerner 1999).

During the second stage, between 500-1200 AD, the form of libraries became more systematic (Harris 1995). After Christianity and Islam spread in Europe and the East, writing was alphabetical and papyrus rolls or animal parchment were used. In Europe, libraries were an essential part of the monastery, where gospels and books of theology were kept. The monastery was not just a place for prayer, it was also for learning activities. For instance, the library served the monastery's teachers and students, and the students learned the principles of grammar, arithmetic, geometry, natural history, astronomy and music (Harris 1995; Lerner 2009).

The third stage was between 1200 and 1500 AD. The form of library changed from private to public. Therefore, this move was an important historical point in libraries' usage (Lerner 1999).

In the fourth stage of library development, their number increased rapidly in Europe between 1500 and 1800 AD as a result of the development of printing technologies, which increased the production of books and decreased their cost (Edwards 2009). These numerous books needed places to keep them; therefore, libraries became very common in this period (Harris 1995; Lerner 1999). During this time, some important libraries were built, such as the Bodleian Library at Oxford, the French National Library in Paris and the Library of the British Museum (Harris 1995).

In the fifth stage, between 1800 and 1900 AD, the demands of education were increased, which led to the creation of a new generation of organised libraries (Edwards 2009). Edwards (2009, 4) states that “education certainly was behind the development of the library as an essential aid to higher learning.” The number of universities expanded in the nineteenth century; they changed their traditional curricula, and the library prospered as a recognisable building type during this time (Brophy 2005). University libraries are dedicated for educational purposes, and are the hub of campus life (Edwards 2009). According to Freeman (2005), an academic library can be considered the heart of an educational institution, and it is a place where new information technologies can be integrated with traditional knowledge references. It provides an environment that supports social and educational modes of learning and research. Libraries are collections of resources gathered for the purposes of reading, study, and reference; thus they are considered as centres of information and research (Aina 2004; Onwubiko and Uzoigwe 2004).

In the sixth stage, in the twentieth century, the libraries became more open and introduced spacious areas and a variety of functions. They changed from an exclusive building type to include wider community access. The plan of libraries provided more than one room for reading (Edwards 2009). The library now serves the academic community in a variety ways to increase its effectiveness. It provides spaces for collaborative study, individual study, workshops and seminars (Bryant, Matthews and Walton 2009). In the past, libraries were created for vast collections of books and other reading materials and they did not provide any of the additional services and opportunities for learning.

The evolution of libraries continued during the twentieth century, and with the application of new technology, the form and storage of information changed. As well as books, journals and newspapers were stored, and information began to be preserved in digital form and became available through worldwide computer networks (Lerner 2009). In recent decades there have been significant changes to university libraries. The main difference between the old libraries and those of today is that the spaces have become more complex and multifunctional. The earlier design was very formal with limited reading rooms, and remained largely unaltered from the eighteenth century until the early twentieth century. Edwards (2009) describes the conventional shape of a library as a cube with a domed ceiling (Fig. 2-3 and 2-4). He describes the library spaces in the eighteenth century thus:

> "In the eighteenth century, the reading room was a domed space surrounded by books on a wall system (bookcases first, open shelves around the perimeter later). After about a century, the space in the reading room was colonised by bookcases arranged as spokes in a huge wheel of learning." (Edwards 2009, 7)

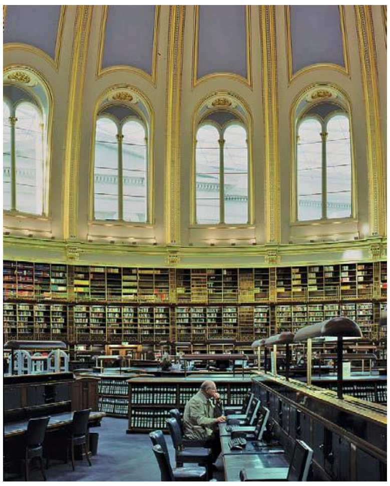


Figure 2-3: The interior of the reading room at the British Library

(Edwards 2009, 11)

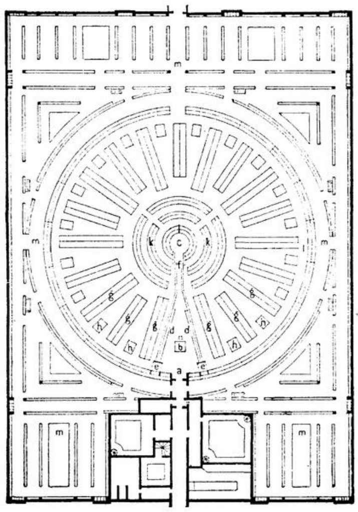


Figure 2-4: The plan of the reading room at the British Library

(Edwards 2009, 11)

As new forms of knowledge are generated, new ways of thinking about education and learning are emerging, and innovative technologies are creating new methods of sorting, cataloguing and delivering information, whether through virtual or physical libraries (Lushington 2002). The challenge of computer based learning and the entry of IT into the education fields have revolutionised the university libraries. The university libraries are becoming more interactive, and as a result, collaborative learning spaces provide appropriate environments for students' needs (Boone 2002). Thus, the library has become a gateway for information, serving a wide spectrum of information seekers as well as having a critical role to play in the facilitation of knowledge generation.

In summary, the emergence of the library was a consequence of the development and growth in rational thought; and its original role was to preserve culture, knowledge and civilisation from generation to generation. The concept of a library has transformed from a place for preserving knowledge to a place for exchanging knowledge. Consequently, university libraries have become not just places for study, they have become places for formal and informal learning and they are now considered as learning centres. These aspects of university library usage are discussed in the following sections.

2.2.2 The University Library as a Learning Centre

Academic libraries are considered essential buildings in universities, a place to learn and explore, and they have become learning centres. Libraries in the twenty-first century have become active places of community and knowledge. Saur (2004) describes today's library as a learning centre providing opportunities for students to engage in different learning activities, with access to learning programs which can be delivered via print, video, computer or television. He defines a learning centre as "a dynamic environment which integrates provision to support a range of independent and group learning activities" (Saur 2004, 67). Learning centres also give the students a chance to link with other learners and benefit from valuable peer group support.

Bennett (2005) points out that higher education has shifted from a culture of teaching toward a culture of learning. In a learning culture, the focus is on helping students become independent learners rather than on the passive transfer of information from teachers to students (Powell 2002). In a learner-centred environment, attention is paid to the experience, knowledge, skills, attitudes and beliefs that learners bring to the university.

A university library is considered a centre of learning because it supports all kinds of learning by providing various types of learning spaces (Edwards 2009). Demas and Scherer (2002) also propose that the library is a place that embodies learning and teaching as well as cultural and educational values. The students can learn independently in the library by studying individually or in group, and also by attending workshops (Frade and Washburn 2006). Waseem (2008) states that, the interactions between individuals and groups contribute to constructing the store of knowledge. Thus academic libraries are a link between students and information or knowledge and are an appropriate environment for students and researchers to study and do research.

Nowadays, the modern university library has expanded to become a computer centre, because library services have advanced with the developments in technology. Libraries make convenient individual connections between people seeking knowledge and people who know how to help them find that knowledge (Lushington 2002). Moreover, the library provides computer access to the internet and wireless technology. The workstations incorporate a variety of utility programs like Microsoft Office, Macromedia and Adobe, as well as multimedia stations, including recorders and videos (Boone 2002). All these facilities help patrons to obtain information and resources easily.

In summary, the library has become a significant place in universities for students who are looking for an appropriate place to acquire knowledge, to learn in different ways (see Figure 2-5).

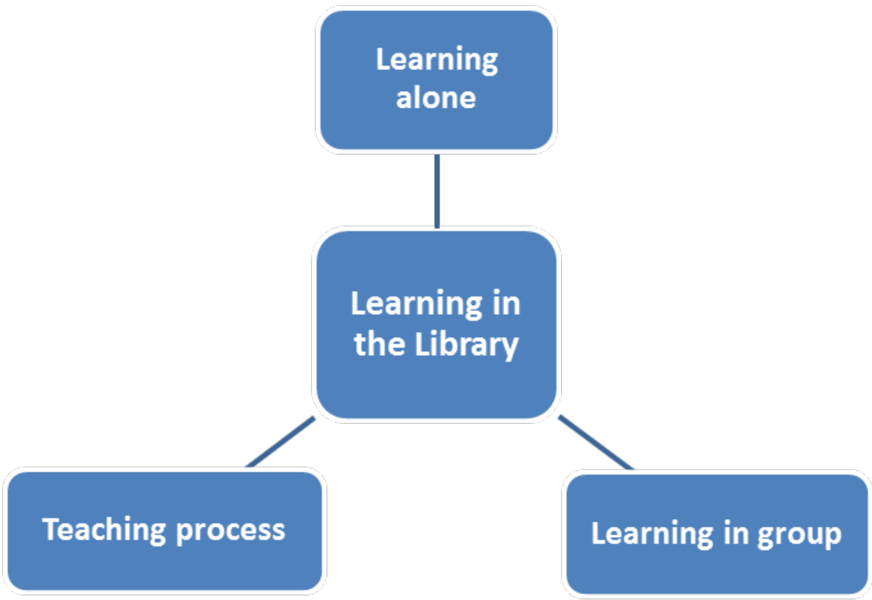


Figure 2-5: The Interaction activities in the university library
(Al-Ayash 2011)

2.2.3 Digital Library and Physical Library

Over recent decades, information technology has changed rapidly, and as it has developed, its impact on most aspects of daily life has increased. The technology has been a major force in libraries since the late 1960s. Increasingly, information is created and offered in a digital format; this transition has required significant changes in the tools and roles of libraries, and this new environment demands workplace flexibility and team-based competencies (Beard and Dale 2010).

The daily tasks for library staff have transformed from manual to technological systems; for example, the finding and borrowing process for books and other library collections takes place through automated catalogue systems instead of card systems (Edwards 2009). Roknuzzaman, Kanai and Umemoto (2009) describe the virtual library as the phenomenon of the international system of electronic networks which enable a user at a computer terminal to search bibliographic citations, databases, electronic publications and other types of information in digital format.

Moreover, contemporary academic libraries provide digital material or electronic sources in addition to traditional sources via the Internet; thus libraries have become more virtual than real, as the students can search, choose, read and download books and journal material through a personal computer or library computer (Beard and Dale 2010). In the digital age information can be accessed anywhere, and that will lead to a decline in the use of physical libraries (Neuman 2003). In brief, access to the knowledge traditionally stored in libraries may become more virtual than physical in the future. Therefore, the physical library, if it is to exist in the future, will need to create attractive and inspirational areas that attract students to come and benefit from a range of library activities that support learning, as well as encourage the exchange of knowledge.

As mentioned above, the digital library helps students to work virtually anywhere and anytime. Although the availability of a library’s collection online has increased greatly, students are still using the physical library for their academic work. Most ethnographic and observational studies confirm that although most students are not using the print material, they are engaged in academic work while they are in the library building (Bryant, Matthews and Walton 2009; Demas 2005; Foster and Gibbons 2007). Bennett (2006) suggests that the factors that make the digital library more valuable are convenience and productivity, saving time and the ability to interact with a virtual environment. However, humans are considered a social species and like places to meet people for conversation, discussion and learning from each other. Therefore, activities have an important value for humans; this value can be found in the physical library which provides various learning spaces that support students’ learning. On the other hand, using the virtual library has tended to isolate people and this may impact negatively on intellectual life (Freeman 2005).

Physical libraries enable social values such as communication, sharing, and connection, which may not be as real or satisfying in the virtual world; thus students are attracted to study in the physical library spaces. Freeman (2005) confirms that the traditional reading room is still considered a favourite area of the library by a significant number of students. Gayton (2008) considers that the value of physical libraries lies in their variety of spaces which support and enhance serious study. Furthermore, Antell and Engell (2007) found that younger scholars support the physical library more than older scholars; perhaps it is because younger scholars came of age in the Internet era, and they appreciate the physical surroundings of the library because they have not had to use the library materials as intensively as previous generations of scholars.

For decades academic libraries have been seen as portals to information, printed resources, and more recently digital resources, but, as Demas states, “we have reawakened to the fact that libraries are fundamentally about people, how they learn, how they use information, and how they participate in the life of a learning community” (Demas 2005, 25). As a result, libraries today are in transition both as institutions and as a building type.

2.3 Learning and Learners

How people learn and know has long been considered a significant question by theorists, who have investigated how people perceive, know and learn. This section reviews the learning process and how learners’ differences impact on their ability to learn and to select a learning strategy, and then discusses the impact of colour on these processes.

2.3.1 Learning and Learning Spaces in University Libraries

New ways of thinking about education and learning are emerging as a result of technological, economic, social and demographic change. The ability to learn is one of the most outstanding human characteristics. Siemens (2004) defines learning as an active process of acquiring knowledge or information that occurs within different environments; learning is focused on connecting specialised information sets.

Learning brings together cognitive, emotional, and environmental influences and experiences for acquiring, enhancing, or making changes in one's knowledge, skills, values, and world views (Illeris 2003).

Furthermore, contemporary forms of learning include different ways of learning, and each person has a different favoured manner of learning or learning preferences, which are often called learning styles. Schunk (2000) points out that learning styles are affected by emotional, biological, psychological and cultural factors as well as past life experiences and the demands of the present environment. The term learning style refers to how people perceive and process information and the most comfortable way to learn and to remember (Spencer-Waterman 2013; Schunk 2000). Learning styles can be divided into three basic styles:

1- *Visual learning*: learners depend on their eyes to learn easily by viewing, watching and observing and by reading about a new concept in books or articles. In addition, pictures, slides, drawings and photos help visual learners.

2- *Auditory learning*: learners recall much of what is discussed or heard in the lectures by concentrating on lessons or listening to audiotapes.

3- *Tactile-kinaesthetic learning*: learning by touching (tactile) and moving (kinaesthetic). The information is taken in through hands and movement. Tactile-kinaesthetic learners like to handle things and to move around themselves. They remember more easily when they write, doodle or draw. Participation in laboratory experiments is a powerful medium for these learners (Spencer-Waterman 2013).

Cassidy (2004) points out that learning styles has a positive impact on academic performance by enhancing intelligence and motivation. Some researchers have studied the effect of learning style on academic achievements; the results show that the preferred learning style can help or hinder success in academic performance (Castro and Peck 2004; Drysdale, Ross and Schulz 2001).

Nowadays, learning is the central activity of university libraries. However, learning takes place everywhere on a college campus, including in classes, libraries and laboratories. Therefore, study spaces in university libraries have changed into learning spaces to meet the evolving needs of the students (McNamara 2012). Today, learning takes different forms. Newton and Fisher (2009) and Oblinger (2006) classify learning into two types: formal learning that is systematic and guided by instruction, and informal learning that results from interactions among individuals or study alone through reading without the direct involvement of the teacher. Informal learning may occur in a variety of places, such as at libraries, and through daily interactions and shared relationships in society. Informal learning is one of the learning forms that facilitate group and individual academic activities, and by its nature is generally more flexible (Hunley and Schaller 2006).

Modern university libraries have included both formal and informal learning; formal learning through workshops and lectures that are held in the libraries, and informal learning through group and individual study where the learners become more independent (Edwards 2009). Students use different ways to learn based on their learning styles. They can learn and understand the study material by reading printed material such as books and journals (visual learning), or listening to lectures in the class or via computer in the library (auditory learning). Reading comprehension can be considered one of the types of visual learning; the students read the text and find the main idea of the text in order to understand the ideas of the certain topic (McNamara 2012). Reading comprehension is defined as the level of understanding of a text's meaning through the interaction between the words that are written (Rayner et al. 2001).

Obviously, university libraries have become places to learn and have been changing their study space into learning spaces based on student's developing needs and their ways of learning (McNamara 2012). According to Thomas (2010), a learning space is a place wherein a learning process occurs, such as classrooms, lecture halls, libraries, laboratories and so on. Furthermore, to promote connectivity, intellectual exploration and deep thought, university libraries have provided a range of study environments to suit a diversity of learning types, like formal learning spaces such as training rooms for seminars or lectures (see Fig. 2-6) and informal learning spaces where learners can share with each other or learn individually, such as reading spaces which include individual (see Fig. 2-7), and group study spaces (see Fig. 2-8), and computer spaces (see Fig. 2-9) (Jamieson 2003; Bennett 2003) (see Fig. 2-10).

In addition, Demas and Scherer (2002) confirm that providing a range of learning spaces in the library will make libraries more effective and appealing spaces, as well as putting students in the mood for study. Providing these different spaces for different activities allows students to easily move from group to individual to computer lab spaces while conducting their research, writing, studying and socialising (Gfeller, Butterfield-Nagy and Grignon 2011; Twait 2009).

Figure 2-6: Training room at Curtin library
(Al-Ayash 2011)

Figure 2-7: Individual study room at Curtin Library
(Al-Ayash 2011)

Figure 2-8: Group study room at ECU Library
(Al-Ayash 2011)

Figure 2-9: Computer area at ECU Library
(Al-Ayash 2011)

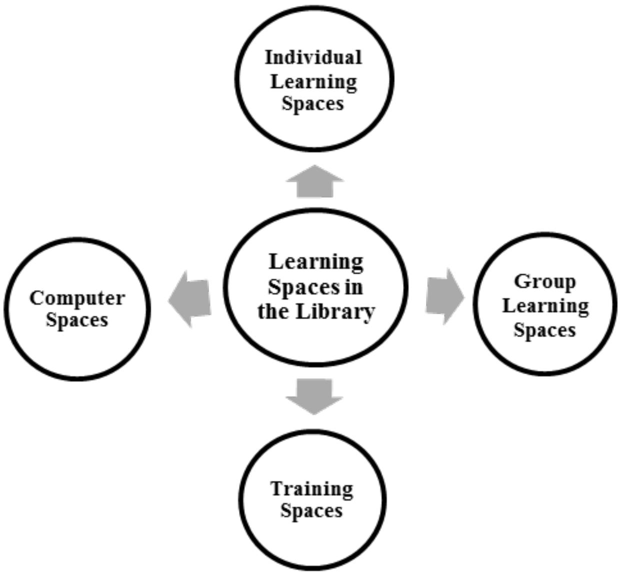


Figure 2-10: The forms of learning spaces in the libraries
(Al-Ayash 2011)

Despite university students commonly using library spaces for collaborative study in group study rooms, they also tend to undertake solo study in individual study areas. Individual study in the library could be in private rooms or in semi-enclosed individual study carrels, which create an environment similar to a partitioned room (Demas and Scherer 2002). In fact, people who work on complex tasks which need a high level of concentration may prefer to work in a private office space because of high noise levels in open-plan environments (Sundstrom et al. 1994). In contrast, people who work on simple tasks which need a low level of concentration prefer to work in open-plan environments (Kaarlela-T et al. 2009).

The library has been more than a store for recorded knowledge. It provides a place for meditation, integration, and creation of new ideas or knowledge. Therefore, students in the library environment use a variety of study spaces according to their task; for example, private study rooms for high concentration and study carrels for low concentration. Individual study rooms or private rooms in university libraries are the focus of the present study. The present study focuses on the effects of colours on informal learning, particularly in the individual study areas in university libraries, and it also focuses on the effects of colours on visual learners (people who prefer learning by reading books or articles via computer) by using a reading comprehension test to measure learning performance.

2.3.2 The Relationship between Space, Learning and Human Psychology

The library space is designed to support a continuum of learning activities. The relationship between space and person is very strong and interdependent, and this will impact on learning activity (Temple 2008). In this connection, the physical learning spaces such as classrooms and lecture halls become an integral part of the learning process and are linked to specific teaching, learning and management strategies which, taken together, embody a specific approach to teaching and learning. Acker and Miller (2005, 3) illustrate the value of learning spaces for today's students as: "… how effectively and efficiently the space provides access to learning resources. These resources include other students, access to information technologies and Web content and flexible student and faculty space configurations that support efficient learning."

In addition, JISC (2006) argues that learning spaces should be able to motivate learners and promote learning as an activity, because physical environments have a significant impact on effective learning and students' performance. They can bring people together and can encourage and motivate exploration, collaboration and discussion (Ball, Beard and Newland 2007). Much current design of learning spaces has moved away from formal lecture halls towards informal learning spaces, because they are social, independent and merge physical and virtual environments (Boys 2011).

Several factors contribute to make learning spaces successful in university libraries. According to Temple (2008), space design plays a significant role in supporting students' learning. As learning is a social activity, the design of learning spaces in libraries should provide welcoming informal and formal spaces; to promote learning, spatial design also needs to include standards of psychological safety, serious purpose and respect (Temple 2008). In addition, creating and maintaining a learning space requires an appropriately supportive climate, where the learning spaces are imbued with a spirit of hospitality where students can enter into fearless communication and allow their respective life experiences to be their primary and most valuable source of growth and maturation as learners (Jamieson 2003).

Oblinger (2006) points out that integrated technology and the provision of various study spaces which focus on collaborative working is one of the important factors to meet users' needs in the library. Likewise, the comfortable and attractive ambience of the learning spaces will lead to socialising and group work (Boys 2011).

Using design, including colour and lighting, can create stimulating and inspirational areas in the library. Jamieson (2008) states that there is a considerable relationship between the built environment and learning activity, where the layout of space substantially influences student comfort, psychology and motivation through attributes such as acoustic quality, lighting levels, and also aesthetic aspects such as colour and textures. Increasing attention has been paid to the effect of the physical environment on human psychology in different fields such as architecture, interior design and environmental psychology (Barrett and Barrett 2010; Gillen, Wright and Spink 2011; Ryu and Jang 2007; Vergeront 2002). Ryu and Jang (2007) state that built environment can affect human's behaviour, emotion, and productivity in some profound ways. People may feel excitement and stimulation when in a neat place or annoyance in a crowded place.

The term physical environment refers to buildings and their interiors. This includes the appearance and layouts of buildings, the arrangement of rooms and ambient conditions (acoustics, air quality, furniture, lighting, colour and room size) (Barrett and Barrett 2010). Ulrich (1983) points out that humans react instantly, unconsciously, emotionally and physiologically in the physical environment, and that emotional responses can be considered an innate phenomenon, and feelings are basically sensations that happen before perception and cognition. Thus exposure to everyday environments may stimulate different responses from the human psychological system (Leather et al. 2003; Vischer 2007). The physical environment is believed to be one of the most influential factors affecting a student's psychological state in learning spaces (Woolner et al. 2007).

There is a need to understand how students' psychology changes according to their perception of environmental elements. Many studies have investigated the influence of the physical environment on human mood and emotion. Karmel (1965) studied the impact of classrooms with or without windows on high school students' emotions. He found that students were unhappy in a classroom without windows, and they had negative feelings about their school. There is some evidence that differences in the indoor lighting environment (levels, spectral distribution and so on) can affect mood (Knez and Kers 2000; Küller et al. 2006). Knez and Kers (2000) found that different kinds of mood were produced when the subjects were exposed to the different colour temperature of lighting.

Research in environmental psychology has demonstrated that various environmental stimuli can affect mood and emotions (Knez 2001). Thus the physical environment has a significant impact on how people feel and perform in a learning space.

Colour is considered an important aspect of the physical environment. It can impact on emotional responses and level of arousal, which may indirectly affect students' academic performance (Holahan 1982). According to Gao, and Xin (2006) and Helvacıoğlu (2011), different colours may sometimes stimulate different emotions and moods. For example, some colours can increase feelings of calmness while others can increase feelings of excitement.

Consequently, library design should focus on user experiences in the library through the creation of flexible spaces for current and future use and provide a range of welcoming, inviting and exciting study environments to suit a diversity of learning styles and student preferences, as well as to fit all learning activities. In summary, all these characteristics contribute to impact on the users' well-being and efficiency.

The setting of interior spaces has a significant impact on learners' comfort, motivation and engagement in learning spaces, and in general on their emotions and behaviour. Emotion is the focus of many studies which have demonstrated that emotions have a significant impact on human psychological and physiological responses to the environment, and that the physical environments can directly influence or change emotional response. In the next section, the literature investigating the relationship between colours, psychology, and physiology will be reviewed.

2.4 Emotional Response

Human emotions play a significant role throughout life because they enrich and colour our lives (Brave and Nass 2002). It is difficult to imagine not feeling happy at our success at achieving important things or not being sad if we lose loved ones. Human emotional responses can be affected by the physical environment (such as colour and lighting). Therefore, in relation to this research a number of questions arise. What is an emotional response? How emotions be measured? And how do emotions influence learning? All these aspects will be discussed in this section.

2.4.1 Definition of Emotional Response

The role of emotions in human cognition and behaviour has received more attention in the last decades. Emotion is a highly complex phenomenon that requires a careful and systematic analysis of its characteristics and components. The complexity of emotion is due to its great sensitivity to personal and contextual circumstances (Ben-Ze'ev 2001). Most psychologists believe that an emotion can be considered a complicated process of responses to a relevant stimulus (Berkowitz 2000). There are many definitions of emotion in the relevant literature. Nevertheless, there are two generally agreed on apsects of what shapes human emotion. First, emotion can be defined as a relatively brief episode of coordinated brain, autonomic, and behavioural changes that facilitate a response to an external or internal event (Davidson, Scherer and Goldsmith 2003). Second, emotion is a psychological reaction to events relevant to the needs, goals, or concerns of an individual (Brave and Nass 2002).

According to Desmet (2003), emotional experience has four components. These are behavioural reactions (e.g. approaching), physiological reactions (e.g. heart rate), expressive reactions (e.g. smiling), and subjective feelings (e.g. feeling amused). Different emotions can be distinguished from one another by the characteristics of the components (Desmet 2003).

The first component is behavioural reactions. This category includes the impulse to act in certain ways that are associated with the particular emotion. For example, when people experience a threat they escape or avoid it (Cardinal et al. 2002). The second component is physiological reactions; these are changes in autonomic nervous system activity, brain activity, heart rate, and blood pressure that accompany emotions (Ben-Ze'ev 2001). A study by Ekman, Levenson and Friesen (1983) identified physiological measures of emotional experience. They found a relationship between physiological states (such as heart rate and body temperature) and emotional states. Their study tested six emotions (surprise, disgust, sadness, anger, fear and happiness) and found an increase in the heart rate in anger and fear compared to happiness; finger temperature increases in anger compared to happiness; and skin resistance decreases in sadness compared to other emotions (see Fig. 2-12).

Philippot, Chapelle, and Blairy (2002) have also studied the impact of physiological states on emotional responses by investigating the effect of manipulating respiration on emotional states. The researchers found that the type of breathing pattern produced different emotional states. Thus, human emotions can be produced by changes in physiological states.

The third component is expressive reactions; it is one of the most obvious indicators of emotional experience (Soussignan 2002). These are the facial, vocal and postural expressions that accompany emotions. For example, anger comes with a fixed stare, contracted eyebrows, compressed lips and brisk movement, and then a raised voice (Ekman and Davidson 1994). Finally, the subjective feelings or evaluation of a situation, such as feeling happy or inspired, are the conscious awareness of the emotional state (Desmet 2003).

In this thesis, the researcher focuses on emotional response to colours. There is a growing interest in the understanding of human feelings in response to seeing colours, and this is called "colour emotion". Studies that often are classified under colour emotion have investigated different issues. A study by Fridell Anter and Billger (2010) has provided a clarification of colour emotion studies. Some studies focus on the relationship between colours and basic human emotions like fear, anger, and happiness (Hårleman 2004; Oberascher and Gallmetzer 2003). Another colour emotion study area deals with colour associations such as warm-cold or hard-soft (Ou et al. 2004; Xin et al. 2004). A third field of colour emotion studies focuses on colour preference, harmony or colour evaluation; for example, a study by Ou et al. (2012) used variables such as "like-dislike".

The colour emotion in this thesis does not refer to basic human emotions such as happiness, surprise, or fear. Rather, colour emotion captures observers' responses on an associated affective dimension specified by investigators, such as warm-cool and hard-soft (Ou et al. 2004). The term colour emotion has been used to indicate the aroused feelings and emotions of people during colour perception (Xin et al. 2004). Ou (2004, 37) defines it thus "colour emotion is the emotion evoked by colours and it can be expressed through words".

This section has reviewed how emotions are produced and how they can be measured as part of the wider enquiry into the psychological and physiological measures and subjective experience of emotions.

2.4.2 Measuring Emotional Responses

To understand the influence of colour on emotional response in the indoor environment, researchers need measuring methods. Researchers offer various methods for measuring emotional responses, and a number of the measuring tools which have been used by researchers to measure emotional response to stimuli in the built environment are reviewed in this section.

As mentioned previously, emotions have four components: behavioural reactions, facial expressions, physiological reactions and subjective feelings. Each emotion component is measured by a different method. Desmet (2003) classified emotion measurement tools as non-verbal and verbal methods. Non-verbal methods measure the facial expression (e.g. smiling), vocal and postural expression of emotion, and physiological component of emotion (e.g. heart rate, blood pressure). Verbal methods comprise self-report methods that measure the subjective feeling component of emotion. This section will discuss the self-report methods and physiological methods, as they are used in this thesis to measure emotions.

2.4.2.1 Verbal methods

The self-report method has been used by researchers to evaluate the influence of environment on people (Desmet 2003). One of the earlier self-report methods is the Semantic Differential Rating method (SDR). It is widely applied for measuring emotional response (Osgood, Suci and Tannenbaum 1957). A semantic scale is composed of polar opposite adjectives separated by a seven point rating scale (Fig. 2-11). The position marked 4 is labelled ‘neutral; neither X nor Y’; the 3 and 5 positions are labelled ‘slightly X and slightly Y’ respectively; the 2 and 6 positions ‘quite X and quite Y’, and the 1 and 7 positions ‘extremely X and extremely Y’ (Osgood, Suci, & Tannenbaum, 1957).

The scores can be assessed by factor analysis procedures to determine possible common factors that underlie the semantic scales. The majority of the semantic scales tend to fall into three principle factors. The first factor is evaluation, concerned with appraisal of whether things are good or bad, fresh-stale, pleasant-unpleasant, friendly-unfriendly. The second factor is potency, associated with power, size, weight and toughness such as heavy-light and strong-weak. The third factor is activity, concerned with quickness, excitement and stimulation, such as warm-cool, calm-exciting and active-passive (Osgood, Suci and Tannenbaum 1957).

(Concept)

Happy _____:_____:____:_____:_____:____:____ Sad

Hard _____:_____:_____:_____:_____:____:_____ Soft

(1) (2) (3) (4) (5) (6) (7)

(Polar term X) (Polar term Y)

Figure 2-11: An illustration of Semantic Differential (SD)

(Osgood, Suci and Tannenbaum 1957)

Another dimensional approach is the Pleasure-Arousal-Dominance dimensional approach (PAD) developed by Mehrabian and Russell (1974). The PAD method consists of a set of 18 bipolar adjective pairs that are each rated on a 9-point scale. Factor analyses of the resulting 18 ratings generate scores on the dimensions of pleasure-displeasure, arousal-non arousal and dominance-submissiveness, to provide a general description of emotions. The pleasure dimension includes the polar opposite terms: unhappy-happy; annoyed-pleased; dissatisfied-satisfied; melancholic-contented; despairing-hopeful; and bored-relaxed. Arousal is the ability to respond within that dimension ranging from sleep to frantic excitement. This dimension includes the bipolar pairs of terms: relaxed-stimulated; calm-excited; sluggish-frenzied; dull-jittery; sleepy wide-awake; unaroused-aroused. Dominance signifies that the individual has freedom to act; in other words, he/she has the ability to control the surrounding environment. This dimension includes the bipolar term pairs: controlled-controlling; influenced-influential; cared for-in control; awed-important; submissive-dominant; guided-autonomous.

The PAD model is based on Osgood et al.'s semantic differential scales; the pleasure factor corresponds to evaluation, the arousal factor corresponds to activity, and the dominance factor corresponds to potency (Mehrabian and Russell 1974). Bradley and Lang (1994) found that this method is widely used as an instrument to assess events, situations and objects. However, this method has a number of difficulties. First, measuring 18 different ratings for each stimulus presented in an experimental session is very complicated, because it requires a great deal of time and effort. Secondly, statistical expertise is needed for the data analysis. SD and PAD methods have been adopted by a large number of researchers in the field of environmental psychology, particularly in colour emotion studies. Both methods cover an important part of human emotional interaction with the interior environment, such as emotional response to colour.

The Positive Affect-Negative Affect Scale model (PANAS) is a method developed by Watson, Clark and Telleggen (1988). This model contains ten Positive Affect expressions, namely: attentive, interested, alert, excited, enthusiastic, inspired, proud, determined, strong and active. The ten Negative Affect expressions are: distressed, hostile, irritable, angry, scared, afraid, ashamed, guilty, nervous and jittery. The model was based on using two opposite dimensions (Mueller and Curhan 2006). The model may not describe the environment semantically in the same way as the Mehrabian and Russel (1974) and Osgood et al. (1957) models do.

There are other various constructed instruments that are used in self-report measurements. One of them is a questionnaire measure called the Affect Grid, which is designed to assess two dimensions of affect: pleasure-displeasure and arousal-sleepiness (Russell, Weiss and Mendelson, 1989). It is composed of a nine-by-nine matrix, and the emotion adjectives are placed at the midpoints of each side of the grid (Larsen et al. 2009) (see Figure 2-12). The research participant first reads the general instructions and then is given specific instructions, such as "Please rate how you are feeling right now" and then places one checkmark somewhere in the grid (Russell, Weiss and Mendelson, 1989).

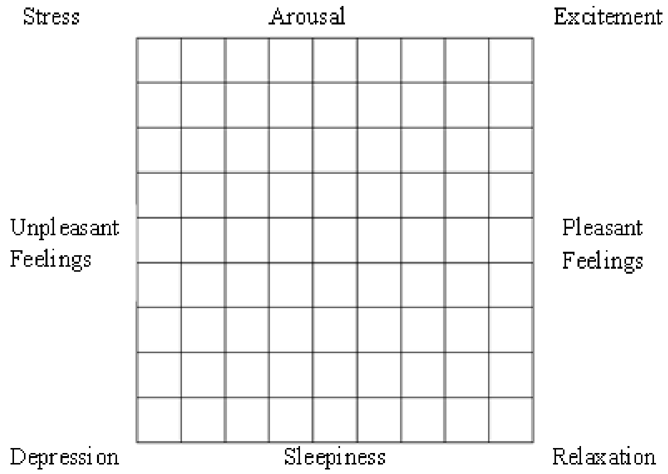


Figure 2-12: The Affect Grid- Scale of Pleasure and Arousal

(Russell, Weiss, and Mendelsohn, 1989, 494)

The advantages of previous self-report methods are that rating scales can be used to assign any set of emotions, and can be used to measure not only individual emotions but also mixed emotions (Desmet 2003). In addition, they are simple, explicit and generally quite reliable (Scherer 2005). On the other hand, the main disadvantage of these methods is their difficult application in translation across cultures (Desmet 2003). It is difficult to translate emotion words as straight translation is not available. Usage of colour emotion words and their characteristics change with languages (Nakamura et al. 2004).

To overcome the problem of between-culture comparisons, a group of non-verbal self-report instruments have recently been developed in which pictograms are used instead of words to designate emotional responses. The Self-Assessment Manikin (SAM) by Bradley and Lang (1994) is an example for this kind of instruments. The SAM is a non-verbal pictorial scale instrument that directly measures the arousal, valence and dominance associated with a participants' affective reaction to various types of stimuli (Bradley and Lang, 1994; Oliveira et al. 2005). This model (SAM), allows the participants to evaluate a situation through the use of selected images (see Fig. 2-13). It includes a five-character scale for each of the dimensions. The evaluator can mark between the characters to produce a nine-point scale. The pleasure dimension is represented by five graphic characters, starting with a smiling figure representing happiness, and ending with a sad figure representing unhappiness. The arousal dimension is also represented by five graphic characters, starting with an excited figure with open eyes and ending with a sleepy figure with closed eyes. The dominance dimension is represented by the same number of graphic characters, starting with a very small figure representing submissiveness and ending with a very large figure representing control or dominance (Koelstra et al. 2012; Oliveira et al. 2005).

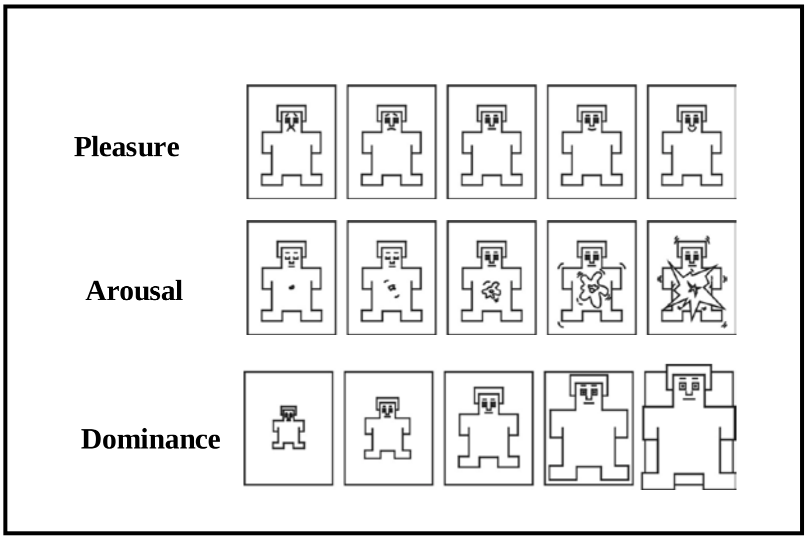


Figure 2-13: The Self -Assessment Manikin Model

(Morris 1995, 2)

In previous research, there is wide agreement on the advantages of the SAM model, as it is easy to use by different age groups (children and adults) and it only takes a short time for the participants to respond; further, it can be used in different countries as it is language free (Grimm and Kroschel 2005; Oliveira et al. 2005). However, there is an important limitation for its application in between-culture studies: this model does not measure distinct emotions but only general emotions (Desmet 2003).

After reviewing the types of verbal methods used to measure emotional response, the researcher selected the Semantic Differential (SD) method. Semantic Differential was used in this thesis because a lot of colour research has been conducted using this method to describe character of rooms in the various colours, and to measure colour emotion. Further, it is easy to be applied with different age groups or cultures. In addition, investigations have shown this method is reliable (Hogg et al. 1979; Sato et al. 2000); by using statistical analysis methods the meaning variables of the scale can be grouped and condensed in many factors.

2.4.2.2 Non-verbal methods

These methods can measure either the expressive or the physiological component of emotion. Expressive reactions (e.g. smiling), both vocal and postural, can be measured by capturing them on short video sequences and analysing them. Physiological reactions refer to activation or arousal such as increase in the heart rate. They indicate changes in activity in the Autonomic Nervous System that is associated with emotions. There are various instruments that measure physiological components of emotion such as blood pressure responses, skin responses, brain waves, and heart rate (Desmet 2003).

It was decided to use a physiological method to measure emotional response to colour in the indoor spaces by measuring heart rate in this thesis. Measurement heart rate is chosen as it is easy to apply in the experiment and it is unobtrusive, so it does not disturb participants during measurement.

2.4.3 Semantic Differential Method to Measure Emotional Response to Colour in the Indoor Environment

Colour should provide occupants of the learning spaces with a suitable atmosphere that supports students to study and concentrate (Chism 2006). Semantic differential words are used to describe the human’s emotional responses to colour, which are usually termed colour emotions (Sato et al. 2000; Xin et al. 2004).

A lot of colour emotion and colour meaning studies have been conducted using semantic differential scales to measure emotional responses to colour, and they have used various types of colour stimuli to test people's evaluative response. Most studies used colour chips, colour in the computer, or colour patches as the colour stimuli (Gao and Xin 2006; Gao et al. 2007; Hogg 1969; Odabaşioğlu and Olguntürk 2015; Ou et al. 2012; Ou, et al. 2004; Xin et al. 2004;). For example, Hogg (1969) used the principal component analysis to classify twelve colour-emotion scales and identified four factors: impact, usualness, evaluation, and warmth. Hog's results showed that the evaluation factor was closely associated with only one scale, pleasant–unpleasant.

Another study conducted by Gao and Xin (2006) used semantic differential scales to evaluate emotional responses to colour samples sized 1.0 cm × 1.5 cm with 70 participants in a psychophysical experiment. They used 12 emotion variables (light-dark, soft-hard, warm-cool, transparent-turbid, pale-deep, distinct-vague, light-heavy, vivid-sombre, weak-strong, dynamic-passive, gaudy-plain and striking-subdued). These emotional variables were divided into three factors (activity index, potency index, definition index).

A study by Xin et al. (2004) has used the same twelve pairs of colour emotions that were used in Gao and Xin's (2006) study. These word pairs represent the fundamental emotional responses of human beings to colour. This study was conducted with 210 participants from Hong Kong, Japan and Thailand using a set of colour samples each 1.0 cm × 1.5 cm to measure colour emotional responses. In addition, a number of studies by Ou et al. (2004) were conducted and used the semantic differential method to evaluate colour emotion. They used 10 colour emotion scales categorised into three factors: Evaluative factor (clean-dirty, fresh-stale, like-dislike); Potency factor (heavy-light, hard-soft, masculine-feminine); and Activity factor (modern-classical, active-passive, tense-relaxed, warm-cool) in a psychophysical experiment. Each observer assessed twenty 3 × 3 inch colour patches that were presented one by one in a viewing cabinet.

A few studies have used the SD method to describe colour in a real room (Hårleman 2001; Odabaşioğlu and Olguntürk 2015). In a study by Hårleman (2001), the SD method was used to describe the characteristics of a painted room, in terms of emotional tone (light-heavy), dynamism (advancing-receding), spatial quality (closed-open, distinct-diffused) and character (warm-cool). A semantic differential scale was used also to evaluate the effects of coloured light on the perception of an empty interior space in a study by Odabaşioğlu and Olguntürk (2015). Three colours of lighting (red, green and white) were assessed by 97 participants, and they evaluated the experiment room in a questionnaire assessing eight factors: pleasantness, arousal, aesthetics, usefulness, comfort, spaciousness, colour and lighting quality (see Table 2-2).

Table 2-2: Eight scales and adjective pairs used in Odabaşioğlu and Olguntürk's (2015) study

Pleasantness	Arousal	Aesthetics	Usefulness
attractive / unattractive	static / dynamic	beautiful / ugly	private / public
satisfying / unsatis-fying	interesting / boring	clean / dirty	efficient / inefficient
like / dislike	cheerful / gloomy	distinctive / ordinary	convenient / inconve-nient
pleasant / unpleasant	calming / exciting	tasteful / tasteless	useful / useless
impressive / unimpres-sive	relaxing / tense	usual / unusual	functional / non-func-tional
		stylish / unstylish	
Comfort	**Spaciousness**	**Light**	**Colour**
comfortable / uncom-fortable	high / low	bright / dim	light / dark
glaring / non-glaring	large / small	clear / hazy	vibrant / dull
	spacious / cramped	light / dark	warm / cool
great eye discomfort / no eye discomfort	wide / narrow	good lighting / poor lighting	strong / weak

All these studies use the three primary factors introduced by Osgood et al.(1957), that is, evaluation, potency, and activity, to select colour emotion scales for factor extraction. Semantic differential scales developed by Osgood (1957) were used in this thesis to assess the emotional responses to colour during the experimental sessions. This method is useful in situations with different age groups or cultures, because it is easy for the researcher to construct and easy for the respondents to use, and provides reliable quantitative data (Franz 2006). The semantic differential technique measures certain affective features of meaning related to the dimensions of emotion or feeling which seem to be universal in the human species; therefore, it has been used extensively to measure feelings (Stamp 2007). The studies cited above were based on experimental data from various countries.

This thesis used the SD method to evaluate emotional response to one coloured wall in the individual study room, and does not claim to evaluate the impact of the whole room. The wall acts as a large colour patch by hanging coloured panels on one wall (see Chapter 3, Section 3.2.4.1 for more details). The scale of the colour relative to the participant's position and visual field while undertaking the task is important.

2.4.4 The Influence of Emotion on Learning

The literature on educational psychology provides evidence about how student learning is influenced by emotions. Recent research on the relationship between emotions and learning performance confirms the integral relationship between emotions and learning (Ruthig et al. 2008). Emotions can impact on what is learned from the surrounding conditions, as feelings can drive attention. According to Efklides and Volet (2005), emotions are triggered by learning processes such as learning tasks or by a person's history in learning situations; these can influence the willingness of individuals to be involved in the learning process.

Researchers deduced that the information we derive from the surrounding environment can be influenced by our affective states. For instance, people who feel happy most of the time are able to pay considerable attention to things and events that have a happy meaning for them (Berkowitz 2000). Forgas and Bower (1987, cited in Berkowitz 2000, 79) conducted a study which confirms the impact of feelings on people's concentration and attention:

> In this experiment, the male and female subjects were put in either a good or a bad mood by being misled about how well they had done on a preliminary test; then, seated before a computer screen, they were asked to read a series of statements describing a stranger. In line with the notion of effective-attentional congruence, the happy subjects spent more time looking at the positive information about the stranger than about the negative information, whereas the unhappy subjects took more time to read the stranger's negative qualities.

In the above study, people who have bad feelings tend to focus on negative things or events while people who have good feelings tend always to focus and interact with positive things or events. Meyer and Turner (2006) point out that human thinking can be influenced by emotional states. When students feel secure, happy and excited about the subject matter they are studying, they will learn and achieve more effectively. Emotions can profoundly impact on academic motivation, awareness of learning and performance (Pekrun 2006).

During recent years, several researchers in the field of memory studies have found that positive and negative moods have the ability to stimulate learning states and memory retrieval. Pekrun et al. (2002) showed that learning and memory can be affected by mood; their results indicated that learned events and memories of the emotion experienced in the learning state were retained in the mind. Thus, the person can remember better if the same emotion exists during the time the material is remembered. In addition, recovery of material is improved when the mood is positive at retrieval time. Bower (2014) states that happy people retrieved happy memories more rapidly than sad ones, while sad subjects retrieved sad memories more rapidly than happy ones.

Pekrun et al. (2002) state that learning performance can be enhanced by positive emotions which help to improve motivation. Therefore, emotions may stimulate or reduce students’ motivation to achieve a learning goal. Pekrun (2006) classified specific emotions into two dimensions. Firstly, emotions are activated; for example, enjoyment and anger increase physiological arousal and tend to help students take positive action, in the case of enjoyment, or negative action, in the case of anger. Secondly, deactivating emotions such as satisfaction or monotony may lead to a decrease in arousal and action. So, negative deactivating emotions may impede learning performance, while positive activating emotions facilitate students’ learning activity. For example, enjoyment can enhance motivation and task concentration, whereas boredom has been shown to do the opposite (Pekrun et al. 2002; Ruthig et al. 2008).

Kuschel, Förster and Denzler (2010) showed that a positive mood can enhance performance on a creative task. Therefore, feeling happy tends to create free associations, increasing the ability to solve problems through insight, while a positive mood can impair cognitive tasks involving assessing, memory and planning because positive emotion can distract people and reduce their concentration on the task.

In general, positive material or events can be remembered better if the mood and emotion are positive. Thus, emotions can play a role in the students' learning activities; this means that students who are distracted, depressed or made anxious by negative events or stimuli cannot focus to process information. On the other hand, positive emotions such as feelings of confidence and happiness help students to think, master a learning task and process new knowledge.

2.5 Colour in Learning Environments of Libraries

It is obvious that colour plays an important role in our environment. It is difficult to imagine life without colours. They can add definition and beauty to any space, and convey meanings and information about our surroundings through our vision. Therefore, the correct use of colour can reinforce users' ability to interact with their environment properly. The question of the nature of colour has confused humans since ancient times and has produced many answers. This section will discuss perception of colour, colour attributes, colour vision and colour systems. It also discusses the influence of colour on psychology, physiology and performance. This section also reviews methods for examining the impact of colour in the indoor environment.

2.5.1 Colour Perception

Colour is one of the environmental variables which influence the ambience of a space, as well as stimulating people on visual, physical and emotional levels. It appears to be one of the most powerful elements in our environment, and it is typically one of the first features that individuals notice when entering a room (Holtzschue 2002). People know what colours surround them, such as red, blue or green, but the question of what is colour is still ambiguous. Philosophers still debate about the nature of colour; some of them regard colour as an objective property, while others consider it is a subjective experience (Bleicher 2012). Is colour something physical like radiant energy that comes directly into the eye? Or is it reflected from a surface? Or is it the experience you might have when you look at an object?

Depending on the branch of science, colour is perceived from different points of view:

> The physician thinks of radiation and wavelength, the chemist of pigments and mixtures of materials, the physiologist of the anatomy of the eye and working receptors, nerve cells and brain centres. The psychologist thinks of colour as sensory perception and human conditioning, the artist of a palette or the expressive quality of colour. The architect and designer think of colour as a property and experience of objects and their function in the environment. (Bergström 2008, 6)

Two distinct fields of research, physics and psychology, explain colour differently. Colour in physics is wavelength; in psychology, it is the personal perception of the object.

Physics is interested in the light that enters the eye which enables people to see their environment, and it is considered as radiant light. The properties of this light can be measured and interpreted without taking the eye into consideration. Physics deals with the quality and quantity of light without any reference to any observer (Pile 1997). Colour may be defined as an attribute of light or of objects or surfaces which provoke the sensor cells of the eye and is described by various colour names such as red or green (Pile 1997; Hardin 1993).

In the psychological field, colour can be perceived in the mind and it is associated with conscious, subconscious and unconscious levels that are related to human behaviour. It focuses on the relationship between the colours as calculated for the observer and the colour actually perceived by the mind (Hardin 1993). Mahnke (1996) states that the human reaction to colour can result in a psychological reaction. “Colour is not the property of objects, spaces, or surfaces; it is the sensation caused by certain qualities of light that the eye recognizes and the brain interprets” (Mahnke 1996, 2).

The term colour is often referred to as the colour of light and the colour of an object, with different meanings. According to Camgöz (2000, 8), the colour of light "is radiant power at various wavelength of the visually effective spectrum which is considered to extend approximately from 380 to 780 nm (visible spectrum)"; whereas the colour of an object, or object colour, as Kaufman (1984; cited in Camgöz 2000, 8) stated, "is the colour of light reflected from or transmitted through an object when it is illuminated by a standard light source."

Green-Armytage (2009, 2006) argues that there is a difference between colour as an objective property and colour as a subjective experience, and he proposes that there are seven different kinds of colour; the kind of colour in a given situation is determined by the means used to identify the colour. Colours can be identified in various ways: by name in general language to indicate both a physical property and a visual experience (conventional colour); by chemical analysis (substance colour); by referring to a formula guide (formula colour); by using a spectrophotometer as a measurement instrument (spectral profile colour, psychophysical colour); by direct contiguity with samples in a colour atlas (inherent colour); or by comparing colours with the samples in an atlas when direct contiguity is not possible (perceived colour) (Green-Armytage 2009).

In an architectural context, colours are categorised as perceived colour and inherent colour. The perceived colour refers to what we see in a certain viewing situation, changing with light, viewing distance and surrounding colours. The inherent colour is the perceived colour that the surface would have if viewed under standardised conditions, and it can be measured through visual comparison with standardised colour samples (Fridell Anter 2000).

Colour is always influenced by light conditions. According to Klarén (2015), the colour of an object can change slightly in different light conditions, which reveals the character of the light. For example, a white wall illuminated by a warm light can be viewed as slightly yellowish. In addition, natural daylight has an important impact on colour appearance. Hurvich (1981) asserts that the ability to see colour is dependent on the presence and the nature of light sources; for example, a green leaf will appear bluish green in daylight but yellowish green in incandescent light.

Hårleman (2009) indicates that there are considerable differences in the colour appearance of indoor spaces from different compass directions. For example, the windows of interior environments that face north or south can be differently illuminated:

> Daylight reaching south-facing interiors can be said to lack some blueness since bluish-making wavelengths are spread out in the atmosphere and this effect creates differences not only in light colour but also in colour appearance and colour emotion in relation to rooms in different directions. (Hårleman 2009, 69)

Klarén 2015 points out that in addition to light coming from the light source, surfaces can reflect light; such as in the case of illuminated white surfaces.

Surface quality also influences the appearance of a colour. It is clearly documented that different material properties like surface roughness and gloss can affect colour perception (Giesel and Gegenfurtner 2010; Granzier, Vergne and Gegenfurtner 2014; Martinson and Bukoski 2005). For example, a glossy surface will appear very different from a matte surface with the same colour, and it reflects more light than a matte surface (Martinson and Bukoski 2005). Giesel and Gegenfurtner (2010) investigated the effects of different materials of real objects on colour perception; they used materials varying in roughness, gloss, matte and corrugated surfaces while the lighting was constant. They found that hue was perceived as quite stable across their manipulations, but that saturation and lightness judgments were affected.

Colour experience in the interior environment is perceptual and cognitive. That is, the level of perception depends on people's experience of the world and the cultural aspect. Therefore, this thesis focuses on the relationship between the observer and colour perceived in the mind, according to their reaction when they see and experience colour and how they explain its effects in the indoor spaces. For reasons mentioned above, light as a variable has been excluded in this thesis, and the light source is constant in experiments when colours are changed, to avoid the complications of changes in colour appearance caused by lighting. Further, a matte surface is used in this thesis to prevent the reflection of light from the wall's surface and to keep the colour appearance constant.

2.5.2 Colour Vision

The perception of colour is essential to our visual experience and it is our most powerful information channel (Garber and Hyatt 2003). In order to understand a colour, it is essential to know how humans see colour. Object, light, eye, and brain are the basic elements of sensation and perception of colour. The response to the visual stimulus of light is considered the first step in colour perception; this reaction to the visual stimulus is called sensation. However, a sensation alone is not enough to understand the event (Bleicher 2012).

The process of perceiving colour starts from the human eyes, when the light wavelengths enter the eye and stimulate the receptor cones located in the back of the eye. This stimulation causes an electrical disturbance that is transferred to the optical nerves behind the eyeball and is in turn fed to the optical area at the base of the brain. Then, the brain interprets this information into colour (Portillo 2009). Therefore, the visual sense is an important factor enabling people to see colour. Ladau, Smith and Place (1989, 46) explains this situation as follows (see Fig. 2-14):

> When light hits an object some of the light waves absorbed by the molecules of the objects surface, while others are completely or partially reflected off the surface. These reflected light waves are picked up by our eyes and transmitted to the brain as colour information. To appear red, for example, an object will absorb almost all of the spectral wavelength expect the reds which will reflect.

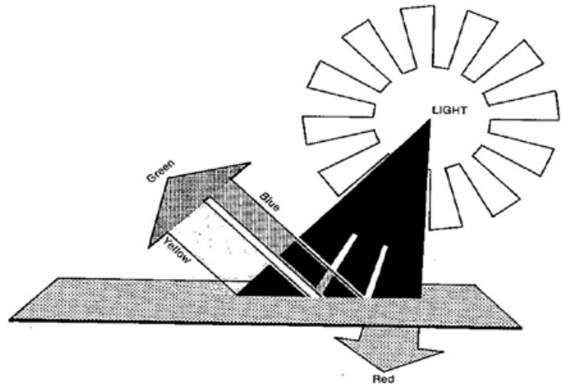


Figure 2-14: The perceived colour reflected from the surface

(Ladau, Smith and Place 1989)

Therefore, the experience of colour depends on the intensity of light, the spectral characteristics of light falling on a surface, the reflectance characteristic of the surface and the colour of surrounding objects. All light sources, whether natural or artificial (incandescent, fluorescent, sodium, LED etc.) can create differences in the vision of colour. It is important to take into account when using coloured light in the interior spaces that it will confuse the vision of all the colours in the space. For example, red light converts pale and warm colours into a uniform red and makes dark colours look black (Ferhman and Ferhman 2000).

2.5.3 Colour Attributes

In order to use colour effectively in the indoor environment, designers need to understand the basic terminology of colour. There are differences in colour terminologies according to colour systems used. For example, some authors use the terms hue, lightness and saturation. American authors use the terms introduced by Munsell, where colours are identified by hue, value and chroma, while Swedish authors use the terms of the NCS colour system, where colours are identified by hue and nuance (Fairchild 2005; Hård and Enberg 2009).

In general, colour has three attributes which are used to distinguish one colour from all other perceived colours; these are hue, saturation, and lightness. Hue is the quality or characteristic of colour that is usually associated with names such as red, green, blue, which are determined by wavelength. Saturation is the other attribute of colour and refers to the intensity or vividness or chroma of a given colour that distinguishes it from a weaker colour. Lightness of colour is a measure of how much light is reflected from its surface, and is essentially the white to black property of the colour (Fairchild 2005; Ferhman and Ferhman 2000). Each of these colour attributes may have an influence on human psychology and physiology states (Camgöz et al. 2004).

Colour is also classified according to temperature. Half of the colour wheel is classified as warm and the other half as cool. Colours associated with red and yellow are considered warm, while cool colours are associated with blue (Nielson and Taylor 2007). There are many theories of colour that they examine the relationships between different colours, how colours work together and the visual phenomena. In addition, understanding the colour contrast is important to determine how colour is perceived, how colour scheme is developed and how objects are highlighted. Contrast in everyday experiences emphasises differences, seeing details around us are mediated in the visual world by contrast (Camöz 2000). According to Mahnke (1996), colour contrast can be used to create different impression such as emphasising indoor spaces with hue, lightness, and saturation contrasts; these terms referred to Munsell colour system. These are the terms used by Mahnke and not the terms the researcher will be using later in this thesis.

Colours are used to create harmonious colour schemes of indoor environments. Colour harmony represents a satisfying balance or unity of colours. Combinations of colours that exist in harmony are pleasing to the eye (Holtzschue 2002). Physical and psychological effects of colour should be considered by designers in the interior environment taking into account both the functional and aesthetical aspects of the colour. It is difficult to understand what it makes some combinations of colour pleasing and the other ones unpleasing. Therefore, awareness of traditional harmonious colour schemes can be helpful in understanding why certain colours work together and why some of them do not (Helvacıoğlu 2011).

2.5.4 Colour Systems

Many colour systems have been established to understand inherent relationship between colours these theoretically based colour classification system to solve practical colour planning problems. These colour order systems have been developed to bring organisation into the confusion of the colour range, to present the colours in sequence, and according to their relationship to each other (Mahnke 1996). As mentioned previously, colour can be described by three separate dimensions or attributes, and colour systems use different terms of the three dimensions to describe colour's appearance. According to Holtzschue (2002), these dimensions characterise aspects of something whether it is a tangible or intangible thing, for example a car, a wavelength of light or a dress. That means each dimension describes a quality of something and gives more information about colours. Different colour ordering systems have been developed, such as the CIE Lab System, HSB Colour System, the Ostwald System, the Munsell System, and the Natural Colour System (NCS).

Two colour order systems that are widely used by designers are the Munsell System and the Natural Colour System (NCS). The structure of the Munsell system is shaped like a tree with branches at right angles to the central axis. The Munsell System uses ten major hues which are arranged clockwise on the colour wheel (see Fig. 2-15). The five principal hues are red (5R), yellow (5Y), green (5G), blue (5B), and purple (5P). The five intermediate hues are yellow-red (5YR), green-yellow (5GY), blue-green (5BG), purple-blue (5PB), and red-purple (5RP), halfway between the principal hues (Fairchild 2005).

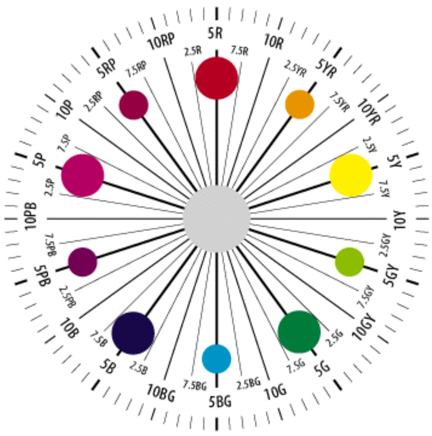


Figure 2-15: A view showing the Munsell hue circle

http://dba.med.sc.edu/price/irf/Adobe_tg/models/images/munsell_sphere.gif

This system identifies surface colours in terms of three attributes, hue, value and chroma (Fehrman and Fehrman 2000). The value dimension refers to the lightness or darkness of a colour, which varies vertically along the colour value from solid black (value 0) at the bottom to white (value 10) at the top, and between these are a number of divisions of grey (see Figure 2-16). The visual difference between neighbouring hues is judged to be uniform all around the circle (Fairchild 2005). Chroma dimension means that the higher the chroma the more vivid the colour; the chroma scale is open-ended (Kuehni 2000) (see Fig. 2-17). In the Munsell Book of Color there are 40 hue pages, and each hue is identified as, for example, 2.5R, 5R, 7.5R, 10R, 2.5YR and so on. In the Munsell System, the notation of a colour 5R 5/14 represents a vivid primary red with a value of 5 and a chroma of 14. A colour with a value of 5 has practically the same light reflectance as a mid-grey (Harkness 2006).

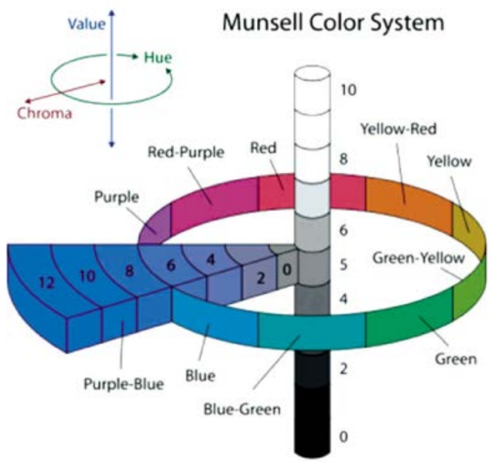


Figure 2-16: A view showing hue, value and chroma scales
arranged in colour space
https://upload.wikimedia.org/wikipedia/commons/thumb/d/d5/Munsell-system.svg/290px-Munsell-system.svg.png

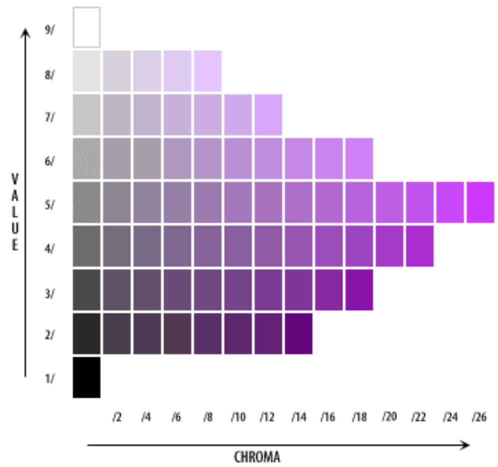


Figure 2-17: Munsell's value (vertical) and chroma (horizontal)

http://dba.med.sc.edu/price/irf/Adobe_tg/models/images/5RP.gif

The Natural Colour System (NCS) is based on defining six elementary colours, which are red, yellow, green, blue, white and black (Kuehni 2000).

> By elementary color we mean those six color sensations which have no resemblance to each other. In the achromatic elementary *color* White, for example, one cannot see any resemblance to Black, nor to any of the four *chromatic elementary colors*. Similarly, the elementary color Red has no resemblance to either Black or White, nor to any of the other three chromatic elementary colors. (Hård and Sivik 1981, 132)

NCS describes the formal basic elements of the colour language, and it provides the ability to identify characteristics and relations between colours (Hard and Sivik 2001). It is used directly to determine the perceived colour of surfaces. A colour is determined in this way as an absolute measure based on colour perception, thus the NCS is a method of describing colour perception. The structure of the NCS is a double cone. This is described by Paul Green-Armytage:

> The four chromatic elementary colours Yellow, Red, Blue and Green are spaced at equal intervals on the circumference of a circle which forms the base that is common to both cones. One cone, pointing up, has the elementary colour White at its apex. The other cone, pointing down, has the elementary colour Black at its apex. Colours on the circumference of the circle have maximum chromaticness – they are as vivid as can be imagined. From the circumference the colours are increasingly whitish as they approach the White apex and increasingly blackish as they approach the Black apex. The four chromatic Elementary colours divide the circle into four quadrants. The visual difference between neighbouring hues is judged to be uniform within a quadrant but the visual difference between neighbouring colours in one quadrant may not be the same as that in another quadrant. (Green-Armytage 2015)

In the NCS, all colour perceptions are related to the six Elementary Colours by the extent to which they resemble them. The colours on a page of the atlas all have the same hue but have different nuances. A colour's nuance is the sum of its whiteness, blackness and chromaticness. Whiteness is the degree of resemblance to White, blackness is the degree of resemblance to Black, and chromaticness is the degree of resemblance to a colour of maximum chromaticness for that hue (Hård and Enberg 2009). So, the nuance refers to the whiteness, blackness and chromaticness of the colour which gives the colour its own distinctive place within a colour triangle. The colour system used for this project is the NCS. The hue circle of the NCS is shown with a part cross section (colour triangle) in Figures 2-18 and 2-19.

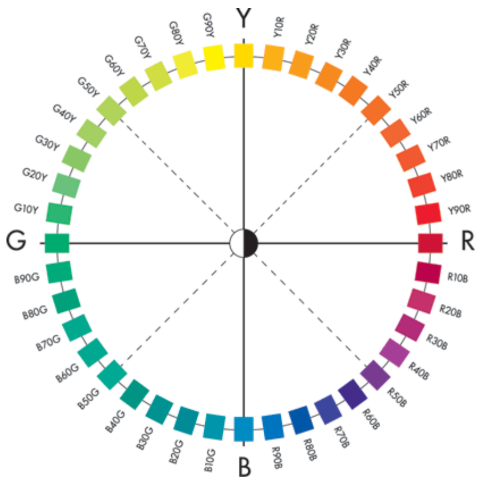


Figure 2-18: NCS Colour Circle

http://www.ncscolour.com/PageFiles/615/NCS_Colour_Circle.png

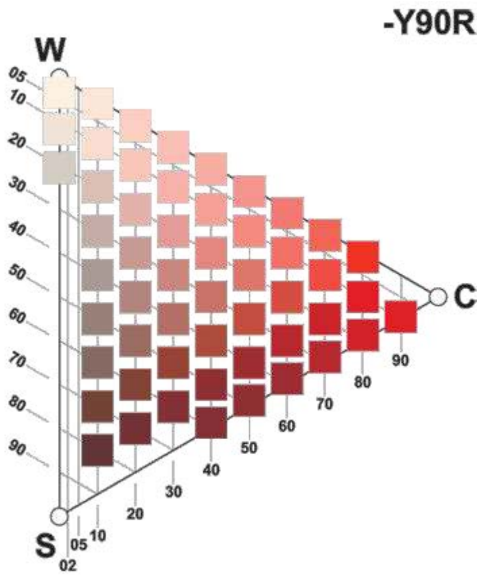


Figure 2-19: NCS Colour Triangle

http://4.bp.blogspot.com/_uXhISda1dSw/Sh0fxcJ_HVI/AAAAAAAAAJY/xKRTuU0_6NA/s200/NCS-Colour-Triangle.gif

This system would certainly be helpful in research and for colour design to identify and describe different colour groups in the same way; it also provides an intellectual image of a colour’s appearance (Hård and Sivik 1981). Smedal (1983) states that the NCS system depends on the eye itself (visual experience) to discover the location of certain colours in the NCS atlas. The colours in the NCS system are easily characterised by graphic illustrations and by letter-digit notations (Derefeldt, Hedin and Sahlin 1990). Spillmann (1983) explained the difference in structure between the Munsell colour system and NCS colour system and the preference for the NCS structure for use in environmental design:

> While Munsell's parameters 'value' and 'chroma' are very useful for visual analysis of single colours by interpolation, the NCS parameters 'blackness' and 'chromaticness' supplied by whiteness seem to the author more suitable for solving problems of colour juxtaposition in environmental design…the same NCS nuance gives to colours of different hues an optimum of inner relationship keeping on the other hand the natural contrast in value analogous to the spectrum. Equal Munsell value and chroma makes colours of different hues just superficially similar, while the inner relations of whiteness and blackness remain different. (Spillmann 1983, 5)

Moreover, the NCS system provides accurate colour, because the numeric colour codes called NCS Notations describe the colour's attributes in detail, thus enabling accurate description of the colour. For example, in the NCS notation (1060-Y25R) 10 refers to blackness 'S', 60 refers to chromaticness 'C', Y-R represents the yellow-red quadrant, and 25 represents the proportion of 'R' in 'C' (Hård and Enberg 2009). In addition, NCS can be used by people with no particular knowledge about colour and with no previous experience in colour specification or colour measurement (Agoston 1987).

In summary, the NCS system is found to be useful for verbal descriptions of the basic colour percept in the study. The NCS notation represents a specific colour percept, describes the colour visually, and does not depend on limitations caused by pigments or light rays. The notation of the NCS is easily understood when compared with the other systems and verbal description of the appearance of a colour is possible. It is a way of describing colours exactly as we see them independent of language, material and culture. In addition, any surface colours that we see can be defined within NCS and given a precise notation regardless of material. For all the advantages of the Natural Colour System summarised above, therefore, the NCS system is selected for this study to match the colours used in the experiments, and its terminology adopted.

2.5.5 Psychological Impact of Colour in the Indoor Spaces

Indoor environment has been shown to be strongly correlated with human psychological well-being (Holtzschue 2002). There is a wide range of literature on colour psychology research, based on the association or connotation, meaning, and emotion of colour. For example, Ou, Luo, Woodcock and Wright (2004) confirm that various emotional states such as excitement, activity or calmness can be triggered by specific colours. For instance, vivid red is considered to be an arousing, exciting, and stimulating colour; orange is lively and energetic; vivid yellow is cheerful and enjoyable; purple is dignified, and blue is associated with comfort and security (Ballast 2002, Elliot et al. 2007).

Furthermore, some colours have both positive and negative effects (Elliot and Niesta 2008). For instance, red is associated with excitement, activity, happiness and love, but on the other hand it is associated with aggression, blood and anger. Kaya and Epps (2004) found that vivid green stimulates positive emotions such as relaxation and comfort. This effect is due to the association of the colour green with nature and trees, producing feelings of comfort, freshness and calmness. On the other hand, vivid green-yellow stimulates negative emotions such as feelings of sickness and disgust because it is associated with vomit. In addition, Kay and Epps' study found that neutral colours such as grey and black usually evoke passive emotions, including the feelings of sadness, depression and boredom, because they are associated with bad weather and rainy and cloudy days. Thus the meaning and impacts of colour depend on the context. A colour can have different associations in different contexts. For example, in an academic setting, red is related to danger and mistakes, whereas in a social context, red can be related to romance and has a more positive association (Elliot and Niesta 2008).

The relationship between colour and emotion has been widely studied in different contexts. Colour has an essential role in the interior spaces, as it adds life to the interior spaces we inhabit and can make a space more alive and active (Hård and Sivik 2001). Therefore, colours should be used properly to give the right message to individuals through the built environment (Kaya and Crosby 2006).

A large number of research studies have evaluated the emotional response to colour in the indoor spaces, and they found a significant impact of colour on human psychological states (Kwallek, Lewis, and Robbins 1988; Küller, Ballal, Laike, Mikellides and Tonello 2006; Stone 2001). However, some studies did not find any impact of colour on emotions; for instance, Anisworth, Simpson and Cassell (1993) did not find significant differences in mood states in a red, blue-green or white office when the subjects performed office tasks. Similarly, Beach, Wise and Wise (1988) found in their literature review that there was no relationship between environmental colours and mood.

Abbas et al. (2006) state that colours can evoke positive or negative emotional responses. This means that the emotion is related to the subjective experience of the person and their reaction to colour. A study by Küller, Ballal, Laike, Mikellides and Tonello (2006) investigated the impact of indoor lighting and colour on individuals' moods. The study was conducted in real work environments at different seasons and in countries with different latitudes, with a total of 988 subjects participating in the study. The findings showed that the mood of the individuals was better in the colourful environment throughout the year. According to the results, the use of good colour enhances a positive mood.

As mentioned previously, colour can be described in terms of temperature, such as warm or cool; a number of studies have compared the impact of cool and warm colours such as blue and red on the emotions (Kwallek, Lewis, and Robbins 1988; Stone 2001). For example, Kwallek, Lewis, and Robbins (1988) have studied the effect of office interior colours (red and blue) on workers' mood and productivity. The results showed that people exposed to warm red reported higher levels of anxiety than did people exposed to a cool blue colour. These results agree with Stone's findings that students had a high positive mood in a carrel painted light blue, whereas there was a lower positive mood in a vivid red carrel in the open-plan setting (Stone 2001).

Moreover, colour attributes such as hue and nuance may play an important role in determining the effect of colour on emotions. Several studies report that the emotional effects of colours are due more to their perceived blackness, whiteness and chromaticness than to their hue (Xin et al. 2004). For instance, a study by Kwallek et al. (1996) comparing nine monochromatic office colours found that chromaticness was a strong predictor of differences in mood between males and females. The results of that study revealed that females were more prone to depression, confusion and anger in office colours with low chromaticness (white, grey, beige), whereas males experienced more depression, confusion and anger in office colours with high chromaticness (green, blue, purple, red, yellow and orange). Another study by Valdez and Mehrabian (1994) showed that more chromaticness in colours regardless of hue increases feelings of arousal, and the pleasure experienced from colours was due more to their nuance and chromaticness than their hue.

Colour can impact on the perception and dimension of interior spaces. Holtzschue (2002) confirms that colour can influence the size, weight and distance of indoor space. For example, light and pale colours can make the indoor spaces appear larger, further away and lighter, while dark or more chromatic colours tend to create small and narrowing spaces and they make things seem heavier (Fehrman and Fehrman 2000).

Moreover, colour has an aesthetic aspect that influences the aesthetic of a space. Menke (2008, 55) defines aesthetic as “a capability of sensory perception and … a judgment about the relation that the presentation of the object has to the feeling of pleasure and displeasure.” Colour can increase the aesthetic aspect of interior spaces and it can emphasise the beauty of the materials being used. The beauty of colours creates enjoyable spaces and thus improves the quality of people’s lives and their moods, and helps them to feel happy and relaxed (Brown 2004). The use of multiple colours or arousing colours contribute to create an active space, and can create more attractive spaces than the more commonly used colours which have a passive effect on mood (Shen et al. 2000).

Overall, previous colour studies have shown that colours have a strong impact on human mood, emotion and perception of space. This study focuses on the emotional response to colour as one of the variables influencing learning performance in university libraries.

2.5.6 Physiological Impact of Colour in the Indoor Spaces

Colour has a profound influence on physiological attributes of humans such as heart rate, blood pressure, body temperature, visual systems and brain waves (Martinson and Bukoski 2005). Desmet (2003) defines physiological responses as the change in the physical properties of the person. According to Kaya and Epps (2004), colours can influence body temperature. For instance, warm colours such as red, yellow and orange are generally considered to be arousing, stimulating people to feel warm, whereas cool colours such as green, blue and purple increase feelings of coldness (Ballast 2002). Most previous studies have examined the effect of colours on the physiological state of people by using colour chips or colours presented via computer, but studies examining the effect of colours on human physiology in the indoor environment (colours placed on interior walls) are very few.

Scientific studies have examined the effect of colour on galvanic skin responses (GSR) such as sweating, brain waves, heart rate, oxygen levels in the blood, eye blink frequency and blood pressure (Abbas, Kumar and Mclahlan 2006; Küller, Mikellides and Janssens 2009; Kaiser 1984). In previous research there is a large agreement that physiological state can be affected by colour. For example, a study by Küller, Mikellides, and Janssens (2009) examined the physiological impact of colours in the indoor environment by creating two rooms of totally different character. In the room with many colours and patterns, the alpha component of the EEG was considerably lower than in the colourless (grey) room. In a study by Kaiser (1984) tested the impact of colours on the brain in the interior environment by using red and blue. The red room creates more anxiety than blue room, because red stimulates the brain to produce lower alpha waves. It was also found that participants were sleepier and drowsier in the blue room. This indicates that the colour blue creates a physical relaxation response in people.

Abbas, Kumar and Mclahlan (2006) examined the impact of colour and light on physiological states by measuring heart rate. Their results showed significant changes in heart rate due to participants' exposure to different coloured lights with various intensities for eight minutes. They also found that there was an increase in the number of heart beats of participants when they were more exposed to red, indicating that red is arousing. In response to blue, the participants' heart rates decreased slightly; therefore, blue is deemed calming. This indicates that red creates more arousal and therefore more anxiety in people than blue does. It can be concluded from previous studies that physiological state (heart rate, brain waves, blood pressure) can be affected by colours.

On the other hand, some studies did not find any differences in physiological state such as heart rate and galvanic skin response when the participants were exposed to different colour conditions. For example, in a study by Caldwell and Jones (1985), red, white and blue lights, equated with brightness, were projected on a wall covered with white paper for less than one minute, and measurements were taken of eye blinks, skin conductance, finger pulse volume and heart rate. There were no colour effects for any of the cortical and autonomic measures. In another study by Jacobs and Hustmyer (1974), red, yellow, green, and blue colours of the same luminance were projected on a screen for one minute each. There was a colour effect on the GSR, but no differences in heart rate and respiration. The results also revealed that red was the most arousing colour, followed by green, yellow, and blue. These contradictory results were probably due to the reduced exposure time to the colours of one minute or less (Jacobs and Hustmyer 1974). Therefore, the time exposure should be long enough to allow the participants of the study to adapt to colour conditions prior to measurement of the physiological and emotional responses and changes.

Meerwin, Rodeck and Mahnke (2007) argue that colours can affect visual performance, for instance causing in eye fatigue, because colour can stress the eyes, which leads to muscle contraction. Moreover, Portillo (2009) showed that using a dominant bright white in interior surroundings led to visual fatigue and psychological discomfort. Therefore, an increase in eyestrain can reduce students' ability to focus clearly on their task. Verghese (2001) discusses signal detection theory and the process of visual search. This theory claims that the human mind constantly struggles to order visual information. Therefore, using too much distraction such as colours or patterns in the interior environment can make visual searching more difficult.

In summary, the differences in the arousal effects of colour cause physiological changes (heart rate, blood pressure or eye fatigue) in humans which may influence learning performance in the university libraries. To sum up, this knowledge of colour can contribute to knowledge about learning and challenge the spaces and colours used to date in university libraries. In term of physiological assessment, the selected method will be determined according to the availability of equipment. In the present study, heart rate (HR) is expected to be a good physiological measure of the effect of environmental colour conditions on people, as it is easy and fast to apply in the experiments for this study.

2.5.7 The Impact of Colour on Performance

In general, findings in studies on the relationship between colour and learning performance are unclear, and the impact of colour on human performance is inconsistent. Some studies failed to detect the effects of colour on human performance (Ainsworth, Simpson and Cassell 1993; Stone and English 1998). However, other studies have found that human performance can be affected by colours in indoor spaces (Kwallek and Lewis 1990; Kwallek, Soon and Lewis 2007; Stone 2001; Stone 2003). For instance, Kwallek and Lewis (1990) compared the impacts of a vivid red, a vivid green and a white office environment on worker productivity and mood. The results showed that although participants perceived the white office to be more appropriate and less distracting than the vivid red or green offices, fewer errors were made in a clerical task in the red office. This may be because vivid red is more arousing, while white is more calming. Therefore, the participants were able to focus more on the task in the red and green conditions and made fewer errors than in the white conditions. Further, if the task is boring, a vivid red condition may stimulate individuals and enhance their performance (Kwallek and Lewis 1990).

Another study by Kwallek, Soon and Lewis (2007) has studied the impact of three interior colours (red, blue-green or white) on worker productivity. The workers' perofrmance was measured through their tasks and task accuracy, taking into account the individual differences in environmental sensitivity. The findings were that the participants performed better in a red office and worse in a blue-green office. In that context, it was suggested that the influences of interior colours on workers' performance depended upon their time of exposure to indoor colours.

These results indicate that stimulating colours can enhance human performance more than less stimulating colours. Birren (1997) found that monotoned environments may induce feelings of anxiety, fear and distress resulting from under stimulation. This absence of stimulation may cause a sense of restlessness, excessive emotional response, difficulty in concentration and irritation. Kennedy (2005) confirmed that attention and motor process can be improved by colour stimulation in the learning environment, resulting in better academic performance.

Colour dimensions play an important role in determining the effect of colour on performance. Some studies have investigated the effect of colour nuance on worker productivity. For example, a study by Kwallek et al. (1996) focused on the effects of nine different colours on short-term worker productivity, The study found that participants performed worse in a white office interior than in any of eight other interior colours (red, green, orange, yellow, blue, beige, grey and purple). Further analysis showed that the performance of participants was worse in light coloured offices than in dark coloured offices. This indicates that the nuance of colour plays a significant role in determining a colour's effect on worker productivity.

Other studies investigated the impact of the hue and nuance dimensions on cognitive task performance. For instance, Stone (2003) studied the effect of carrel colours (dark red, or light blue) on performance. The results showed that the performance of participants was affected by colours. When working on a stimulating or high demand task, performance was better in light blue conditions compared to dark red conditions. When working on a boring or low demand task, performance was better in dark red conditions compared to light blue conditions. This study (Stone 2003) concluded that dark red is stimulating and light blue is calming; the calming environment is helpful if the task is stimulating, and a stimulating environment is beneficial if the task is boring.

Another study by Stone (2001) researched the effect of the study setting (private or open-plan), environmental colour (light blue, dark red, or white) and study material (reading or math comprehension) on adult students' mood, satisfaction, motivation and performance. The results indicated that reading task performance was affected by environmental colour, and participants' reading performance significantly decreased in a red setting. This result was probably due to the difficulty of the reading task, one which may have needed more concentration, so if the colour red is over stimulating, then focus could be drawn away from the task, leading to decreased performance levels (Stone 2001). These findings are consistent with previous studies that indicated the colour blue can enhance tasks requiring judgment and accuracy, while red can impair psychomotor activity (Nakshian 1964; Soldat, Sinclair and Mark 1997).

Several studies focus on the relationship between arousal and performance. Mehrabian (1995) considered arousability to be a trait associated with individual differences in processing environmental stimuli. In psychology, the Yerkes-Dodson Law (1908) proposes that there is a curvilinear relationship between arousal and performance. Up to a certain point, increased arousal can actually help individuals perform better. After reaching an optimal level of arousal, any further increase in arousal will lead to decreased performance.

Some studies focus on the impact of colours on people's performance on computers. For example, Mehta and Zhu (2009) provide important insights into the effects of the colours vivid red and vivid blue on people's performance by taking into account different activated motivations. This study was conducted on computers, and colour was manipulated through the background screen colour, using vivid red and vivid blue. They concluded that the colour red enhances performance on detail-oriented tasks (tasks that require focus and careful attention) via an avoidance motivation. In contrast, the colour blue enhances creative performance via an approach motivation, because blue is associated with openness, peace and calmness. However, a study by Soldat and Sinclair (2001) posits the opposite; they contend that blue connotes a negative meaning such as sadness, which induces careful and aversive processing.

Other studies have investigated the impact of colour on creative performance. In a recent study, Lichtenfeld et al. (2012) examine the impact of green on creative performance in four experiments with contrasting colours, both achromatic (white, grey) and chromatic (red, blue). The results showe that participants were more creative when they viewed the colour green before doing a creative task than those who viewed blue, white, red or grey.

Some research has studied the impact of colour on accuracy performance. A study by Öztürk, Yılmazer and Ural (2012) investigated the effects of chromatic (light yellow-red) and achromatic colour schemes (light grey) of a private office on people's performance. The findings show that accuracy performance was better in the room with the chromatic scheme (light yellow-red) than in the room with the achromatic scheme (light grey). This is due to the positive emotional response to the chromatic scheme, which was found to be more pleasant, attractive, satisfying and dynamic than the one with the achromatic scheme (Öztürk, Yılmazer and Ural 2012).

In summary, the effects of colours can change people's attention levels and concentration, thus influencing human performance in learning spaces. A lack of colour stimulation can create a sense of restlessness, excessive emotional response and difficulty in concentration. From these studies of colour and its possible effects on people performance, it can be concluded that type of stimuli, duration of exposure and individual differences such as their reactions to the exposure of colour stimuli, age and gender are all factors affecting the relation between colour and people performance.

Most studies reviewed in sections (2.5.5, 2.5.6 and 2.5.7) examine the effect of colours (red, blue and yellow) on human psychology, physiology and performance in office work with different tasks; there is a lack research on the impact of colour on learning performance in learning spaces. This thesis focuses on the influence of colour on learning performance (reading comprehension task) in different colour conditions, measuring responses by conducting experiments in a full-scale room.

2.5.8 A Review of Methods for Examining the Impact of Colour in the Indoor Environment

The researchers used different methods to understand the effect of colours on human performance, psychology and physiology. According to previous studies which have investigated the impact of interior colour, three methods have been used: participants present in the space, such as in the studies of Küller, Mikellides, and Janssens (2009), Kwallek et al. (1996), Kwallek, Soon and Lewis (2007), and Stone (2001); or looking at a viewing cabinet such as in the studies of Akbay (2013), Ou et al. (2004), and Gao and Xin (2006); or viewing simulations that imitate actual conditions, as in the studies of Helvacıoğlu (2011), Camgöz, Yener and Güvenç (2004) and Cubukcu, and Kahraman (2008). All these three methods are summarised below to decide which methods could be used in this thesis.

2.5.8.1 Full-Scale Rooms

Participants' evaluation of the stimuli in the physical environment can be evaluated either by having them visit the space or by replicating the space in a laboratory. After being in the space, the participants express their impression by answering a questionnaire. Various studies have been conducted to examine the influence of colour in the indoor environment, carried out in full-scale rooms painted in various colours; for example, Küller, Mikellides and Janssens (2009), Kwallek et al. (1996) and Kwallek, Soon and Lewis (2007). Küller, Mikellides and Janssens (2009) conducted three experiments on the psychological and physiological impacts of coloured rooms on people's mood and performance in the experimental space. Experiment 1 compared a colourful room and a grey room, whereas in experiment 2 and 3 red and blue rooms were compared. This study evaluated the perceived quality of the room, mood and performance.

Another study by Kwallek et al. (1996) examined the influence of the nine monochromatic office interior colours on clerical task performance, mood and colour preference. Each individual office including all four walls was painted one of the following nine colours: red, white, green, orange yellow, blue, beige, grey and purple (see Fig. 2-20). A study by Kwallek, Soon and Lewis (2007) investigated the effects of three office colour interiors (white, red, and blue-green) on worker productivity. All these studies tested the effect of four wall colours in the indoor environment.

Figure 2-20: The nine colours used in the Kwallek et al study

(Kwallek et al. 1996, 451)

Other studies have tested the impact of one wall colour on human reactions in the indoor environment. For instance, Stone's (2001) study examined the effect of colours on adult students' mood and performance in private and open-plan environments. In a private study room, colour was manipulated by hanging a 121.3 cm ×242.7 cm sheet on the wall, which was painted dark red, light blue, or white. The desk was facing the panel (see Fig. 2-21). For the open plan condition, the researcher used three study carrels; these desks were built by attaching hardboard panels to the sides and front of the desks. The partitions were also painted dark red, light blue or white (see Fig. 2-22).

It can be concluded from the studies above that an effective method to evaluate the influence of colour in the indoor environment is when the participants are in the space, because the participants will be in the real environment and the results will be more valid. Kwallek et al. (1997) stated that simply viewing pictures or slides of interior environments cannot measure human performance; people need to be exposed to real interior environments. Therefore, in this thesis, the researcher has used a full-scale room in Cycle 2 (Study A) and Cycle 4 (Study C).

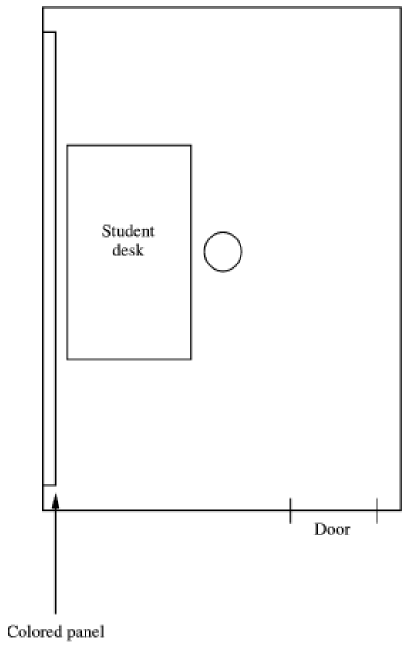


Figure 2-21: Space design of the private study area

(Stone 2001, 183)

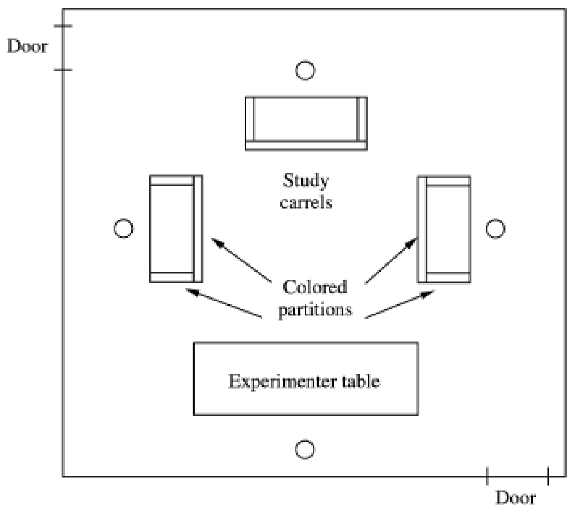


Figure 2-22: Space design of the open-plan study area

(Stone 2001, 184)

2.5.8.2 Viewing Cabinet

A number of colour studies have used a viewing cabinet to examine the participants' reactions to colours (Akbay 2013; Gao and Xin 2006; Ou et al. 2004). Using booths in colour research is an effective way to compare two or more colour conditions. Akaby (2013) investigated the attitudinal approaches of individuals towards perceived colours. The viewing cabinet was used in this study and situated within the experiment room. The viewing cabinet was a rectangular shape (width 71 cm, Height 54 cm, depth 42 cm), and it consisted of five surfaces: top, bottom, back and two sides. The inside surfaces were painted with medium grey (see Fig. 2-23). The eleven basic colours were tested; the colour samples were presented in the cabinet during the experiment in size A6 (148mm × 105 mm) (see Fig. 2-24). The purpose for using a viewing cabinet was to create a reliable viewing condition for colours to be perceived under consistent light.

Figure 2-23: The viewing cabinet used in the experiment
(Akaby 2013, 42)

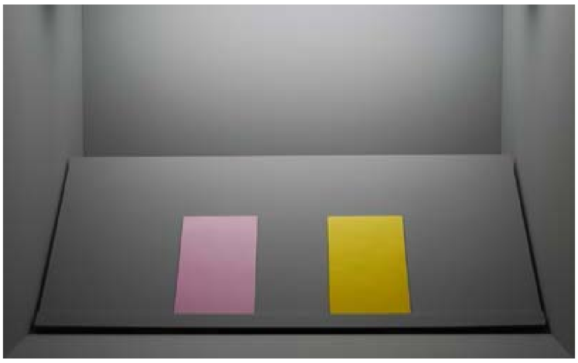


Figure 2-24: Colour samples presented inside the viewing cabinet
(Akaby 2013, 67)

Another study by Ou et al. (2004) examined the relationship between colour emotions and colour-appearance attributes. The experiment was carried out in a dark room and the participants assessed twenty 3 × 3 inch colour patches that were presented one by one in a viewing cabinet. This cabinet was illuminated by a D65 simulator, and the colour grey was used as the background inside the cabinet. Gao and Xin (2006) evaluated emotional responses to 218 Munsell colour samples sized of 1.0 cm × 1.5 cm and presented in the viewing cabinet, in terms of hue, lightness, and chroma.

It can be seen from the above studies that the use of the viewing cabinet to examine and compare the influence of different colour conditions in the indoor environment is feasible and practical for examining the direct psychological impacts of colours on humans. However, the main disadvantage of using this method is that the participants can only evaluate the colours of the indoor environment from limited angles, and on a small scale. Further, this method does not allow the participants to engage with small colour chips.

In the present study, colours were applied on one wall; the main focus of this study is evaluating single colours on one wall in the individual study room because the dominant wall colours affect the students more than the side walls do.

2.5.8.3 Simulation Methods

Simulation refers to the experimental modelling which represents particular environments or events. Simulation methods include the use of photographs, computer graphic software programs and scale models (Marans and Stokols 2013). According to several researchers (Cubukcu and Kahraman 2008; Dijkstra 2009; Helvacıoğlu 2011) using simulation images such as colour photographs and slides is acceptable in psychological studies. Some studies have used graphic software programs to create simulations of indoor environments, such as 3ds Max, or Second Life to simulate indoor environments. For example, Helvacıoğlu (2011) examined human reactions to individual colours in interior space. The interior spaces were shown to participants from a computer screen by video. The four different coloured living rooms (red, green, blue, grey) were created and designed by using Second Life software (3D modelling) (see Fig. 2-25). Second Life software imitates the real world or simulations of the world (Helmer 2007). Then videos for all those spaces were generated by CamSudio 2.6 Beta program. Each video started from the entrance door of the space and ended again at the same point (Helvacıoğlu 2011).

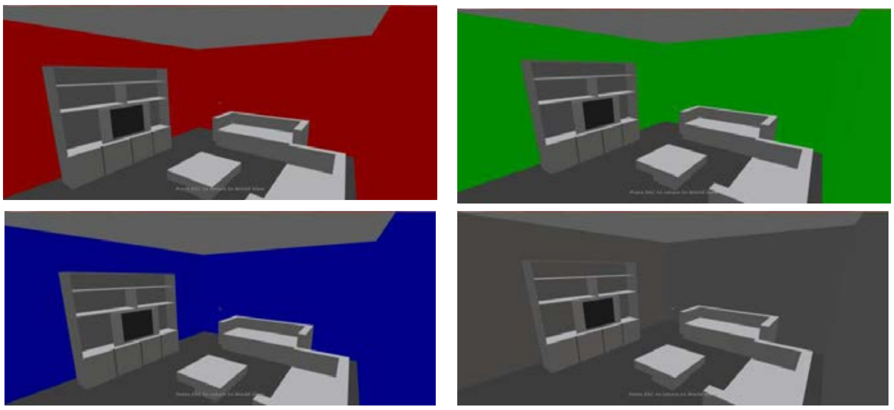


Figure 2-25: A view for all four coloured interior spaces
(Helvacıoğlu 2011, 160)

Several studies have used Adobe Photoshop for photographic simulations of real environment. A study by Dijkstra (2009) investigated the relation between a green wall colour (versus white) and stress in the hospital environment by evaluating the responses to photographic simulations of real environment. In this study, the participants were exposed to two photos of the hospital room on a computer, and the photos were manipulated using Adobe Photoshop software (see Fig. 2-26). The researcher asked the participants to look at the photo for at least 15 seconds, and then they were asked to complete a measure assessing stress. According to Stamps (1990), people’s reactions to photographic simulations of real environments are adequately similar to people’s reactions to the actual environment.

Figure 2-26: Photos of the hospital room white versus green
(Dijkstra 2009, 93)

At a further stage in Dijkstra’s study (2009), she used photos of the counselling environment, which were manipulated using Adobe Photoshop software, to examine the effects of wall colour on participants’ self-disclosure and impressions of the counselling environment. In the first condition, participants were exposed to a photo of the counselling room via computer with white walls; in the other condition the participants were exposed to a photo of the same space with green walls (see Fig. 2-27).

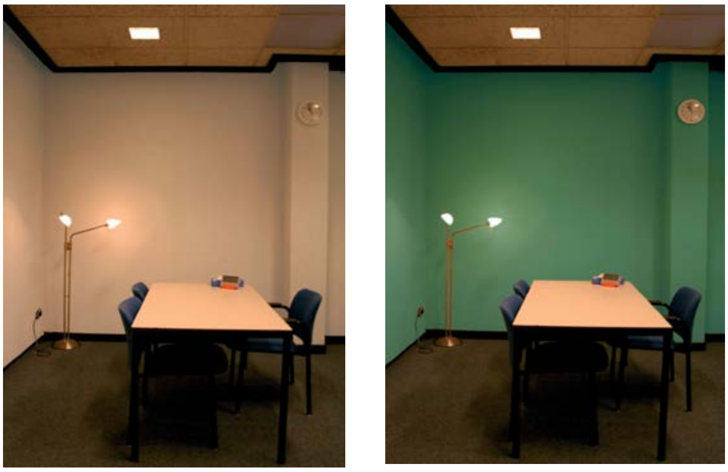


Figure 2-27: Photos of counselling rooms (white versus green)
(Dijkstra 2009, 108)

Another study by Cubukcu and Kahraman (2008) used photographic simulation to investigate the effects of hue, saturation, and lightness on colour preferences for a building exterior. This study used a photograph of the hotel exterior, and it was edited to create a set of eight images with different hues, and a set of 72 images with different lightness and saturation levels. Adobe Photoshop 6.0 was used to edit images; all images were created in JPG format and RGB mode (see Fig. 2-28).

Figure 2-28: Adobe Photoshop used to edit the photograph of the hotel to evaluate colours

(Cubukcu and Kahraman 2008, 399)

A study by Stahre, Billger and Fridell Anter (2009) used 3Ds Max 8.0 to create a virtual environment, and Adobe Photoshop to correct the colour appearance on the rendered textures. The findings of this study indicated that colour appearance can be difficult to translate from reality to virtual models. The angles of view are limited on a computer desktop display compared to real view, and the interior space shown on the computer screen is smaller than the reality.

Scale model is another type of simulation method. The use of scale models is widely adopted as an efficient method for evaluating the design of interior environments (Marans and Stokols 2013). A study by Kunishima and Yanase (1985) examined the relationship between the wall colour of a living room model and viewers' impression of it. In this study, a 1:10 scale model was made of a living room measuring 3.6m × 4.5m and 2.45m high. Seven colours were selected for testing in this experiment to be tested. Three panels were prepared for each colour for insertion into the model. The colour of the ceiling and floor was grey. A colour slide was taken of the model fitted with wall panels for each colour, and the slides were projected onto the screen. According to Kunishima and Yanase (1985), the results showed that using the scale model to represent the actual environment can be reliable and accepted to evaluate the colour in the indoor spaces, because it is very difficult to change the wall colour and other details of the room one after another.

Hogg et al. (1979) conducted a study to make semantic differential ratings of colour samples (chips) and a simulated interior space (scale model). The floor and walls of the scale model were painted grey, the panels of colour were presented in the scale model of a room space, and the coloured panels represented the end wall of the model.

In summary, full-scale models and real settings are not always available, affordable, and efficient; therefore, using simulation methods (photos, computer graphic software programs and scale models) to evaluate colours in the indoor environments is cheaper and easier to use in research and provides the flexibility to collect data from participants. Further, they can accurately simulate indoor environments. Therefore, in the current research, the researcher adopted both Photoshop and Scale models in Study B (focus group) to obtain the participants' opinions regarding colours used in the individual study room.

2.5.9 Colour in Learning Spaces of University Libraries

The impact of colours in different context was discussed in previous sections. It is evident that there are different criteria and design objectives for different environments that require distinct ambiences and serve varied functions. The functions of colour in the learning environment of libraries are varied; one is to define the atmosphere or type of learning activity, such as individual study, group study or studying via computer (Brown 2002). In recent years, attention has turned to psychological effects of colour on the occupants of study spaces in libraries, since students spend an increasing amount of time in library spaces.

As mentioned before, a library is considered a home for many students, as they spend a considerable time in the library studying. Therefore, the users of the library are likely to be affected by the surrounding spaces, and the elements of interior design can have a powerful supportive impact on learning activity in university libraries (Chism 2006). Colour is one of the many considerations in library design that support students' creativity and performance. In general, colour in the learning environment seeks to create a comfortable environment that enhances the visual process and reduces stress, often through the use of greens, blues, browns and earth tones (Daggett, Cobble and Gertel 2008).

Colour has psychological and physiological effects on human comfort, attention and enjoyment; a number of studies have concluded that colour can influence mental activity, in particular, students' motivation and concentration (Wang and Russ 2008). For example, the colour red stimulates motor excitation, and could affect motor activities such as hand tremor. Therefore, it is not appropriate for spaces designed for focused mental tasks (Nakshian 1964).

A library's colours should express its contents and excite its patrons' interest in order to stimulate their intellectual activity. Specifically, when the designer is selecting suitable colours for specific functions, he or she should consider activities inside the library like reading, computer access and discussions among students (Sufar, Talib and Hambali 2012). Colours used inside libraries should support students to feel alert and comfortable but not sleepy. For instance, the colour light green is restful but is unsuitable for library spaces, because it may encourage more relaxation than activation. Sufar, Talib and Hambali (2012) point out that colour design has developed throughout evolution of libraries; old libraries used dark colours such as brown, grey, beige, gold, deep red, and deep green, but modern libraries use bright colours such as orange, blue, yellow, and green.

There are different viewpoints about appropriate colours for libraries. Some studies indicate to the importance of hue more than nuance. For example, Pile (1997) states that the colour blue encourages deep thought and meditation and is the colour of intellectual activity, because of its associations with tranquillity and relaxation. Therefore, blue may be a good choice for creative tasks such as production of ideas or problem solutions in quiet study areas in the library. On the other hand, Mahnke (1996) suggests that pale or light green produces an affect that improve calmness and concentration.

Colours usually selected based on the function of the building. A study by Kaya and Crosby (2006) tested individuals' colour associations for different building types. Their findings suggest that the colours red and yellow are the most appropriate colours for educational buildings, based on the previous knowledge and experience of participants. The participants claimed that red and yellow reminded them of colours used in their schools.

In addition, the choice of colour depends on the type of human activity, such as memory and intellectual activity in case of libraries. For example, the colour red has been linked with increased production of ideas and action, and is considered ideal for learning environments (Psychological Effects of Color 2013). The colour yellow is also related to intellectual activity, and is claimed to enhance memory and to promote the understanding of new thoughts (Adams and Osgood 1973).

Draper and Brooks (1979) state that colours inside the library should be subdued, light, and not too bright. They propose the best colours for study or meeting rooms are earth tones like brown, tan, beige and clay colours, in order to reflect the seriousness of the place. They also point out that the designer should consider the lighting used inside a library when choosing the colour scheme, in order to eliminate reflections. Drabenstott et al. (1993) state that lighting must illuminate users' materials without causing glare and visual disturbances from the display device.

Overall, in my review of previous studies I have found there is a lack of information regarding colour studies in learning environments, especially in the individual study spaces of university libraries in the interactive digital age. In addition, how colours in individual study areas affect students' concentration is unknown. Furthermore, there are few studies regarding the appropriate colours for use inside a library.

2.6 Precedent Samples of Libraries

The aim of this section is to present real life examples of university libraries and demonstrate the colour design used in their learning spaces. Given the lack of information from the literature review regarding colours used in learning environments of university libraries, the researcher has selected six university libraries as case studies for learning spaces. Four university libraries are local in Australia: three in Perth (Robertson Library, Edith Cowan Library, and Reid Library); and one library in Sydney (Fisher Library). Two international university libraries are selected; one in USA (Suzzallo Library) and one in Germany (Philological Library).

The six university libraries featured in this survey were chosen because they have different colour schemes (warm colours, cool colours or neutral colours) in their learning environments. Some of the examples show the logic of the use of colours according to the type of learning activity, while others do not. Moreover, these libraries are selected as precedent studies because they represent local and international university libraries across three continents (Australia, Europe and America).

The Australian university libraries have been visited by the researcher, and personal observation was used to record notes. In addition, photographs were taken to describe the colours used in these libraries. A Google search was used to find the international university libraries. It was difficult to find images of learning environments for some university libraries in Google, therefore, the researcher selected the university libraries web site that published images for their main learning spaces.

The six university libraries are summarised from personal observation of the library's architecture and the colour schemes of learning spaces. Each library is first described and then analyzed.

2.6.1 Robertson Library, Curtin University, Perth, Australia

Robertson library is located at Curtin University in Perth. It was built in 1971 and designed by Vin Davies (White 1996). This building offers six levels (Fig. 2-29) of spaces including a variety of types of study spaces: study carrels (Fig. 2-30), training room (Fig. 2-31), computer area (Fig. 2-32), group study rooms (Fig. 2-33) and individual study rooms (Fig. 2-34). The purpose of these spaces is to facilitate formal and informal learning. In general, the interior design of Robertson Library is intended to foster social groupings by providing spaces to encourage interaction within varying sizes of groups.

As seen in Figures 2-30–2-34, the basic colours used in the study room areas are neutral (off white beige and light grey) for the walls, and most spaces are carpeted in dark grey. These colours are very institutional and pale, which makes the space very serious. They do not reflect modern design, which uses active colours to stimulate and inspire students to engage in learning activities. It is thought that neutral colours can negatively affect students' learning performance, due to the association of neutral colours with passive emotions, producing feelings of sadness and depression, because they are related to bad weather and cloudy days (Kaya and Epps 2004). Another study by Küller, Mikellides and Janssens (2009) confirmed that the performance of workers is poor in grey rooms compared to colourful rooms.

A few warm colours are used in some study areas for walls and chairs, such as light yellow on Level 5 to identify the space of the Teaching Resource Collection, and a small area for study (Fig. 2-35). Brown (the colour of timber) is used in the study carrels (Fig. 2-30), and in the individual study rooms for walls, desk and shelves (Fig. 2-34). A few cool colours can be found in a small area, such as vivid blue in the silent computer zone (Fig. 2-36). In general, colours used in study areas in the Robertson Library are very traditional, which make the study spaces seem very similar. In the study spaces, particularly the individual and group study rooms, there is a lack of colours such as red or yellow that can stimulate the students' intellect. According to a study of the Psychological Effects of Color (2013), the colour red has been linked with an increased production of ideas and action, and is considered ideal for learning environments. The colour yellow is also related to intellectual activity, and is claimed to enhance memory and to promote the understanding of new thoughts (Adams and Osgood 1973).

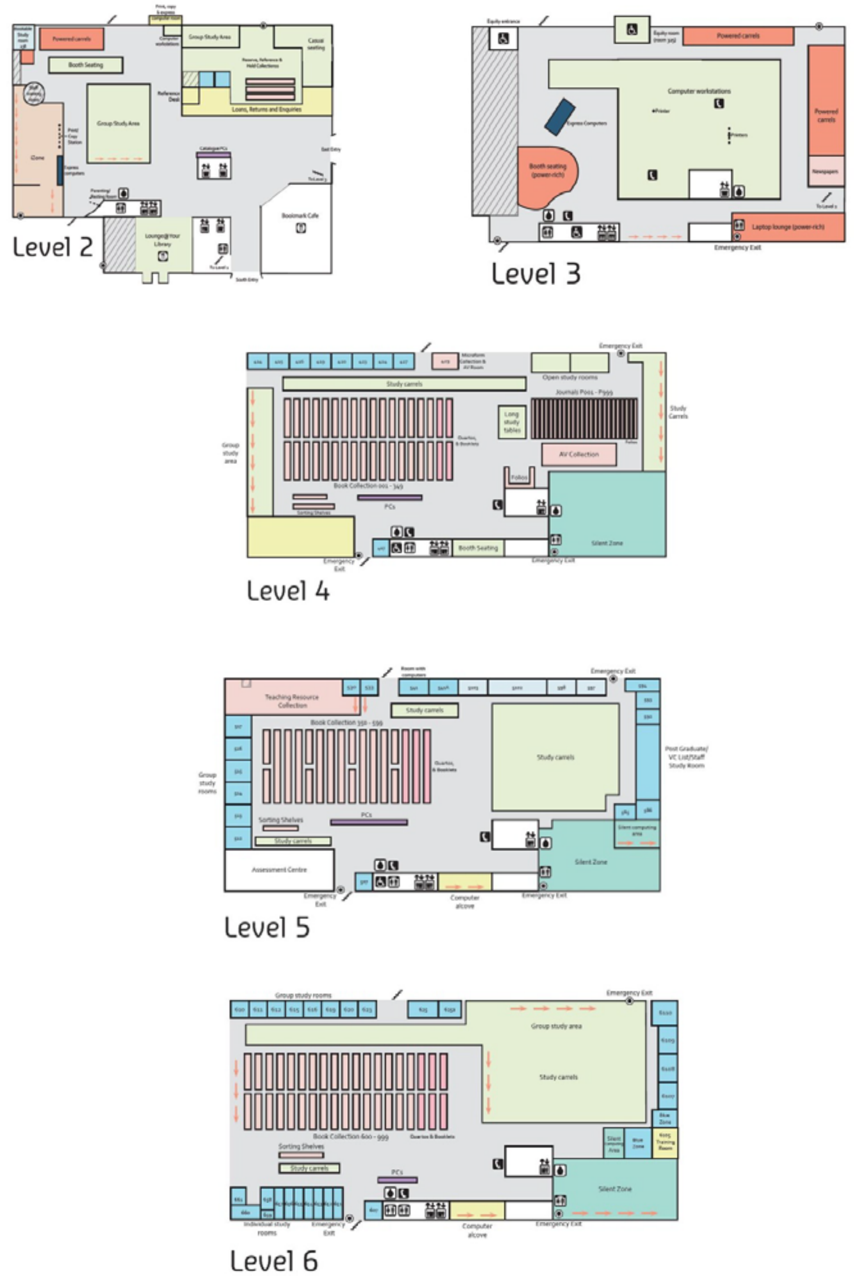


Figure 2-29: Robertson Library Floor Plans
(Robertson Library at Curtin University 2012)
http://library.curtin.edu.au/local/docs/about/robertson-library-floor-plans-web.pdf.

Figure 2-30: Study carrel area at Robertson Library
(Al-Ayash 2012)

Figure 2-31: Training area at Robertson Library
(Al-Ayash 2012)

Figure 2-32: Computer area at Robertson Library
(Al-Ayash 2012)

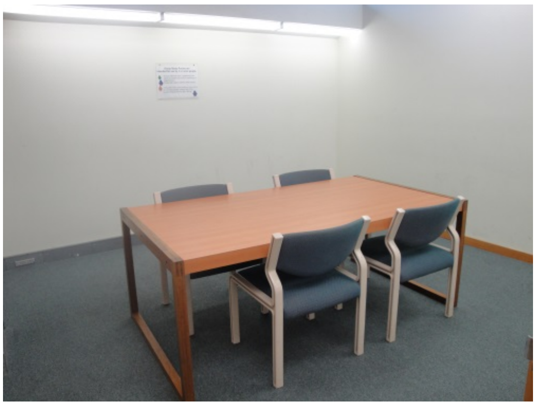


Figure 2-33: Group study area at Robertson Library
(Al-Ayash 2012)

Figure 2-34: Individual study room at Robertson Library
(Al-Ayash 2012)

Figure 2-35: The colour light yellow at Robertson Library
(Al-Ayash 2012)

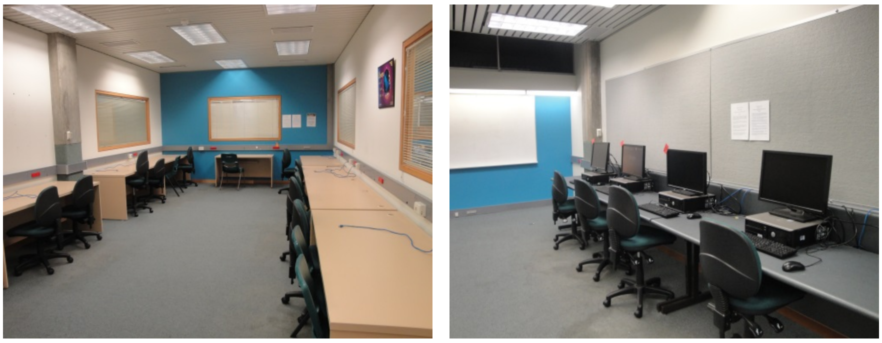


Figure 2-36: Silent computer zone at Robertson Library
(Al-Ayash 2012)

2.6.2 Reid Library, University of Western Australia, Perth, Australia

The Reid Library is the main library building in the University of Western Australia. It was opened in 1964 and named after Sir Alex Reid, former Chancellor of the University. It was designed by a Western Australian architectural firm, Cameron, Chisholm and Nicol. It consists of four levels (Fig. 2-37), and different types of study spaces are provided in a variety of sizes and a variety of types: collaborative study zone (Fig. 2-38); computer area (Fig. 2-39); study carrels area (Fig. 2-40); silent study zone (Fig. 2-41); group study rooms (Fig. 2-42); individual study rooms (Fig. 2-43); and training room (Fig. 2-44). The variety of sizes of spaces allows for individual, small group, and large group activities.

The interior is primarily warm-coloured wood, giving a feeling of warmth. The colours light beige and light yellow are used for walls in all learning environments of library, as well as brown timber in a small area. In the individual study room, the students face a dark colour when sitting and studying at the desk; the side walls are a brown timber colour. Dark grey is used for computer chairs, blue for reading chairs, and red in the collaborative study area. As for study carrels, the colours used are brown (colour of timber) and dark green on the top of the desks. It is held that using dark colours in study spaces increase feelings of warmth, darkness and depression. Colours with a high degree of blackness would increase feelings of sadness, and that would impact negatively on learners in the library. In general, the colours used in all learning spaces of this library make the space unpleasant.

In addition, most spaces are carpeted in dark grey, and some have composite tiles. In fact, the interior colours tend to be very traditional; therefore, the study spaces may not be aesthetically pleasing to students who study at the Reid Library and may be less stimulating to study and learn in. Neutral colours such as grey are considered lacking in emotion and elicit negative feelings such as sadness, depression, tiredness and boredom (Kaya and Epps 2004).

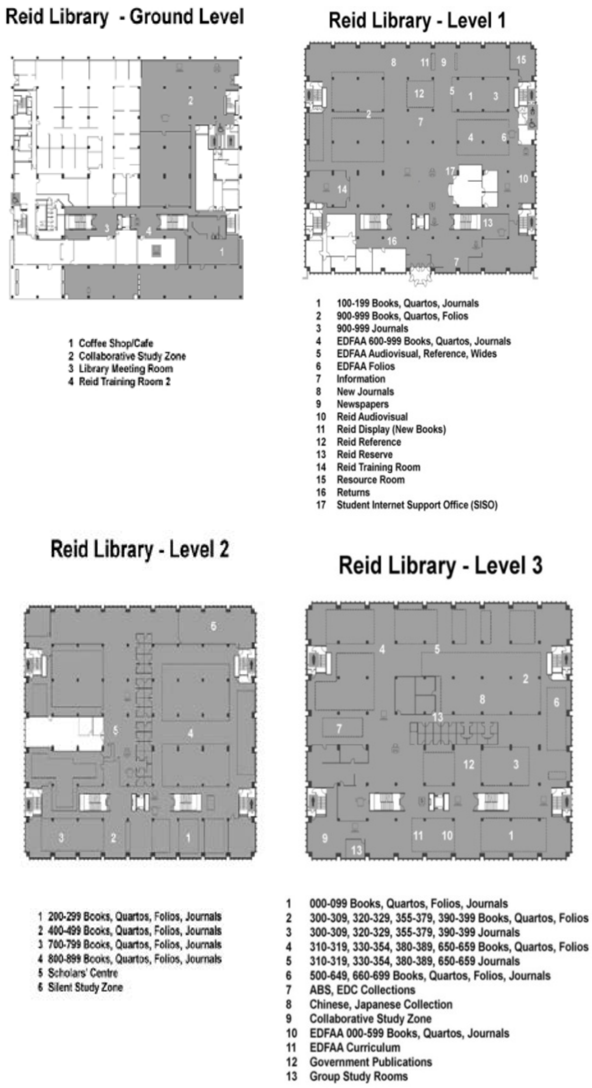


Figure 2-37: Reid Library Floor Plans
(Reid Library at the University of Western Australia 2012)

http://www.library.uwa.edu.au/contact/reid-arts-business/floor-plans

Figure 2-38: Collaborative study zone at Reid Library

(Al-Ayash 2012)

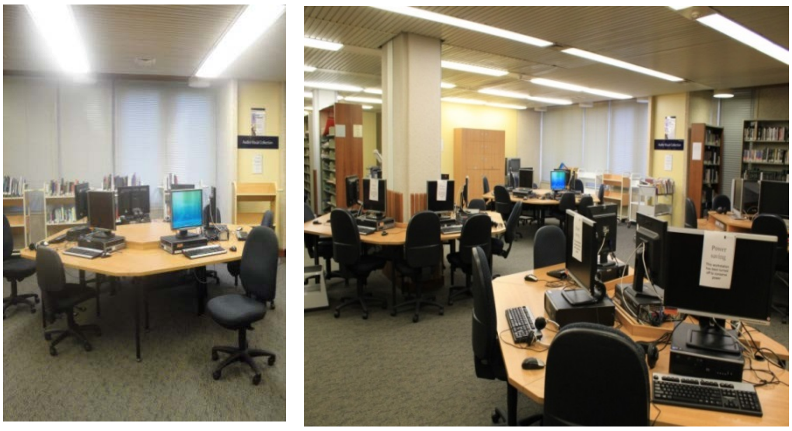


Figure 2-39: Computer area at Reid Library
(Al-Ayash 2012)

Figure 2-40: Study carrels area at Reid Library
(Al-Ayash 2012)

Figure 2-41: Silent study zone at Reid Library
(Al-Ayash 2012)

Figure 2-42: Group study room at Reid Library
(Al-Ayash 2012)

Figure 2-43: Individual study room at Reid Library
(Al-Ayash 2012)

Figure 2-44: Training room at Reid Library
(Al-Ayash 2012)

2.6.3 Edith Cowan Library, Edith Cowan University, Joondalup, Perth, Australia

Edith Cowan Library (ECU) is located at Joondalup in Perth; it was built in 2006. Jones Coulter Young is the architect of this modern library. This building with four floors provides a vibrant and diverse set of learning spaces for all students (Hislop 2008). The provision of flexible and various learning spaces can help to create a stimulating environment that promotes critical thinking and lifelong learning; for example, the carrels study area (Fig. 2-45), quiet study areas (Fig. 2-46), silent study room (Fig. 2-47), group study rooms (Fig. 2-48), indivdual study rooms (Fig. 2-49), meeting room (Fig. 2-50) and computer area (Fig. 2-51).

As these images show, the colourful spaces of the ECU library reflect contemporary design. The colour scheme used for the learning spaces' walls is warm-coloured; for example, vivid red in the quiet study area and group study rooms; vivid yellow in the individual study rooms; light yellow features in the silent study room; and orange in some group study rooms. These colours give warmth to the interiors of the learning spaces in the library, making the study spaces more active and stimulating. White is used in the carrels study area for walls and carrel.

All spaces are carpeted in dark grey, and the same colour is used for the chairs in the individual study rooms and computer area. It was noticed that a vivid colour (vivid yellow) is used on the wall in the front of the desk in the individual study room, so that the students face the coloured wall. While the side walls are a neutral colour (white), the wall in front of the desk has the dominant effect on students.

It was observed that yellow is used in different nuances in the study spaces. For example, in the meeting room, buff (yellow-orange) is used for walls, ceiling and table. In the computer area, pale yellow is used as a basic colour for walls and computer benches, and light beige for the ceiling.

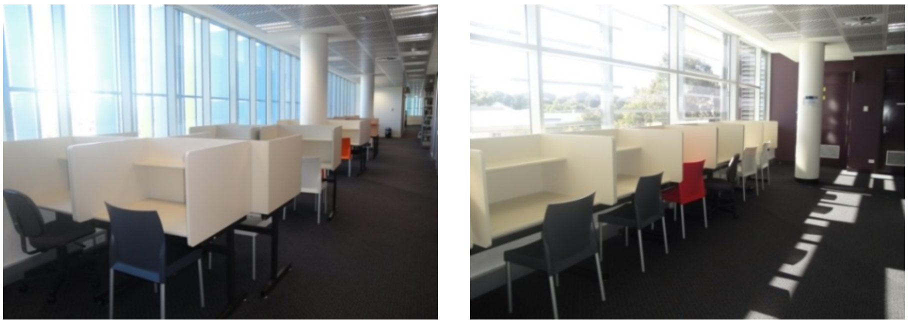


Figure 2-45: Carrel study area at ECU Library
(Al-Ayash 2012)

Figure 2-46: Quiet study area at ECU Library
(Al-Ayash 2012)

Figure 2-47: Silent study room at ECU Library
(Al-Ayash 2012)

Figure 2-48: Group study rooms at ECU Library

(AL-Ayash 2012)

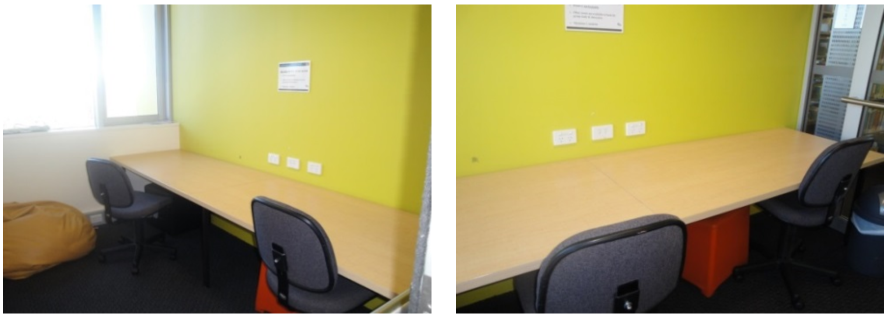


Figure 2-49: Individual study room at ECU Library
(Al-Ayash 2012)

Figure 2-50: Meeting room at ECU Library
(Al-Ayash 2012)

Figure 2-51: Computer area ECU Library
(Al-Ayash 2012)

2.6.4 Fisher Library, University of Sydney

Fisher Library is the main library at the University of Sydney and was built in 1908. The original building was located at the south-western corner of the Main Quadrangle and then moved to its present location in 1962. It was designed by joint architects Edward Herbert Farmer (the NSW Government Architect) and T E O'Mahony. The present library comprises two integrated buildings, which were built separately in the early days of the university. Fisher Undergraduate Library (Building F03) was established in 1962 and is used by undergraduate students of the university. Fisher Research library (Building F04) was built in 1967 and extended its spaces by providing flexible and various learning spaces for studying, working and socialising (Fig. 2-52) (Shipp 2005; Fisher Library University of Sydney 2014).

As in the libraries discussed above, Fisher Library provides different types, sizes and shapes of learning spaces, which can be used for different purposes and activities. The interior design of this library provides stimulation in the learning environment by using a variety of colours, materials and textures. Light beige is the basic colour for all interior walls, while the columns are dark grey and the ceiling light grey. It was noticed that different colour schemes are used in each study area for the furniture. For example, green is used in the quiet study area, with dark green and dark grey in the carpet, and the carrel study desks are dark greeny-yellow and light beige. In addition, dark yellow and dark brown are used for sofas in the quiet study area (Fig. 2-53).

Fisher Library provides sound booth rooms for students; the interior of these booths is primarily warm-coloured wood for the side walls and light beige for the front wall, with dark grey and dark green for the carpet (Fig. 2-54). In the computer area, the colour orange is used in combination with dark grey in the carpet, and also in the sofas. Light beige for the top of the computer bench and dark grey panels behind the computer screen are used to reduce reflection from the screen, and dark grey for all the computer chairs (Fig. 2-55).

The Fisher Library also offers spaces for training, seminars and group study in an innovative and modern way. Light beige and dark grey are the prevailing colours in these spaces as well. However, the designer has used the warm colour, red, in the furniture and carpet to add excitement to the interior spaces, and also in the sofas for social activity (Fig. 2-56). As for group study rooms, walls are white with the neutral colours light and dark grey as decoration. It is noted that neutral colours have negative effects on performance, because they are associated with negative emotions such as sadness and depression and boredom (Fig. 2-57).

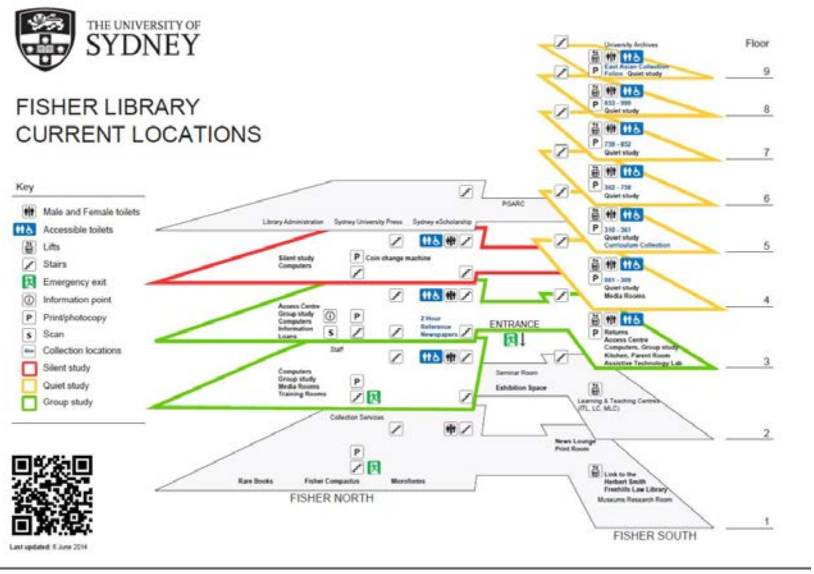


Figure 2-52: Fisher Library Floor plan

(Fisher Library-University of Sydney 2014)
https://library.sydney.edu.au/libraries/fisher/FisherFloorPlan.pdf

Figure 2-53: Quiet study area at Fisher Library

(Al-Ayash 2014)

Figure 2-54: Sound booth at Fisher Library
(Al-Ayash 2014)

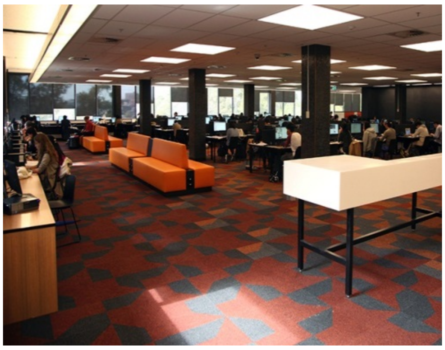



Figure 2-55: Computer area at Fisher Library
(Al-Ayash 2014)


Figure 2-56: Training area and social area at Fisher Library
(Al-Ayash 2014)

Figure 2-57: Group study room at Fisher Library

(Al-Ayash 2014)

2.6.5 Suzzallo Library, University of Washington, USA

Suzzallo library is the central library of the University of Washington, named after Henry Suzzallo, the fifteenth president of the University, and opened in 1926. The library was designed by Carl F. Gould and Charles H. Bebb. It was renovated and added to many times, and the final addition was completed in 1990 (Suzzallo Library Information 2013). It has five floors. It offers a variety of study spaces on all floors to fit students' needs: computer spaces, group study rooms, scholars' study rooms, quiet study areas, main reading room and research commons (see Figure 2-58).

The main wall colour is off-white on all floors, and warm-coloured wood gives feeling of warmth. As can be seen in Figure 2–59, the main reading room is covered by a vaulted ceiling with vibrantly coloured and gilded details. Oak bookcases along the walls are topped with hand-carved friezes representing native plants of Washington State (Suzzallo Library Information 2013). It appears like a cathedral building and it expresses the time of its design in the early twentieth century.

The colours of other study spaces are lighter than in the main reading room; light beige and off-white are used in these spaces. The colours are very neutral and institutional in computer spaces; the walls and floors are covered with light beige carpet, tables are light beige, and chairs are dark green (Fig. 2- 60). The quiet study space (Fig. 2-61), study carrel space (Fig. 2-62) and scholars' study rooms (Fig. 2-63) also have walls and floors of light beige. Furniture such as tables and chairs are light-coloured timber.

The colours used in the group study rooms are very traditional: light grey for the walls, and floors are covered with dark grey carpet. The furniture is light beige for tables and light grey for chairs (Fig. 2-64). In contrast, the research common area is a lively, colourful collaborative space, with bright green and red in some walls combined with light grey (Fig. 2-65), (Fig. 2-66), and (Fig. 2-67).

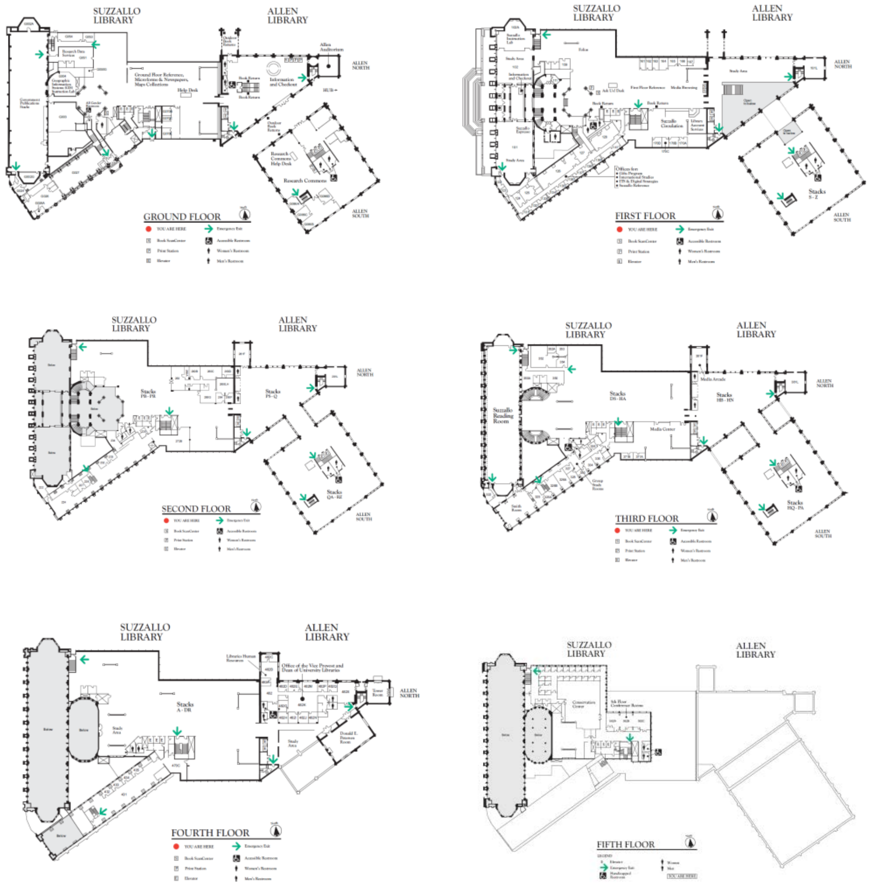


Figure 2-58: Suzzallo Library Floor plan

http://www.lib.washington.edu/images2/graphics/suzzallo-allen-building-maps

Figure 2-59: Suzzallo Reading Room

(http://www.lib.washington.edu/suzzallo/study/study-spaces/reading-room)

Figure 2-60: Computer space at Suzzallo Library
http://www.lib.washington.edu/suzzallo/study/study-spaces/copy_of_computer-spaces

Figure 2-61: Quiet study space at Suzzallo Library

http://www.lib.washington.edu/suzzallo/study/study-spaces/suzzallo-first

Figure 2-62: Carrel study space at Suzzallo Library
http://www.lib.washington.edu/suzzallo/study/study-spaces/assigned-carrels

Figure 2-63: Scholars' study space at Suzzallo Library

http://www.lib.washington.edu/suzzallo/study/study-spaces/scholar-study-rooms

Figure 2-64: Group study rooms at Suzzallo Library

http://www.lib.washington.edu/suzzallo/study/study-spaces/suzzallo-group-study

Figure 2-65: Research common space at Suzzallo Library
(http://www.lib.washington.edu/suzzallo/study/study-spaces/research-commons)

Figure 2-66: Research common space (media space) at Suzzallo Library
http://www.lib.washington.edu/suzzallo/study/study-spaces/research-commons

Figure 2-67: Research common space at Suzzallo Library
http://www.lib.washington.edu/suzzallo/study/study-spaces/research-commons

2.6.6 Philological Library, Free University, Berlin, Germany

The philological library at the Free University in Berlin was designed in 2005 by Norman Foster. The designer has created the library on the model of a human brain with open and transparent structures, and it includes five levels. The book shelves are distributed over the five levels and the reading spaces are situated at a continuous desk around the outer edge on each level. Thus the readers can sit next to each other at the continuous desks without facing one another, and this arrangement of workspaces will help to motivate readers' concentration. The architect states that the building is like a human skull sheltering the brain. The building has a very contemporary style from both outside and inside. There is a little information on the interior finishes of the building. The colours used within this library are muted (grey and white); there are warm colours as well, and they have high chromaticness in some areas, like melon yellow for the entrance and red for the chairs; all spaces are carpeted in dark grey; see Figure 2-68 (Werner and Diecks 2004).

In addition, computer areas are also distributed around the outer edge on each level (see Fig. 2-69). Although there are some warm colours used in this library, such as orange and red, the colours of learning spaces are still very neutral and institutional. These colour schemes make learning spaces less stimulating and less active. In addition, the colour schemes of the Philological Library disagree with the colours proposed in the literature review, where it was argued that yellow and red can stimulate the mind and help students to be more focused. As for the group study room, the colour beige is predominantly used with a little red in the corner of the wall. The desk is off-white and chairs are vivid red. The colour red makes the space more lively and stimulating (see Fig. 2-70).

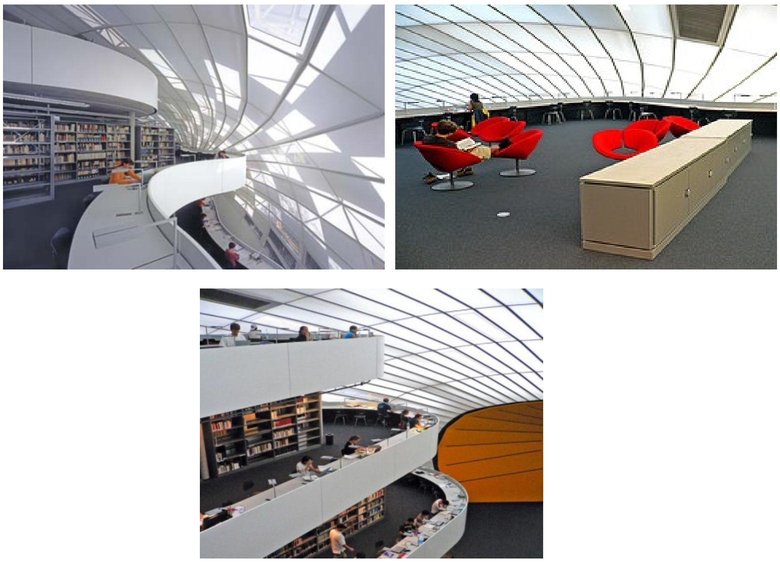


Figure 2-68: The interior colours used in Philological Library
(Werner and Dieckes 2004)

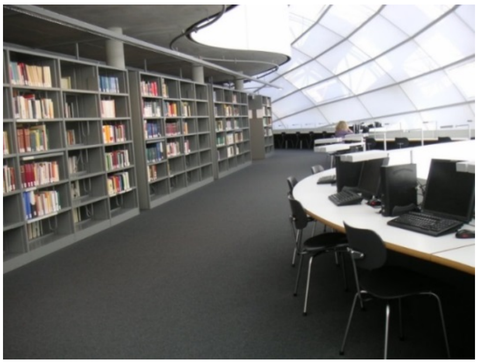


Figure 2-69: The computer area in Philological Library

(Werner and Dieckes 2004)

Figure 2-70: Colours used in group study room in Philological Library

(Werner and Dieckes 2004)

2.7 Cycle 1 (Reflection 1): Chapter Conclusion

This chapter provides an overview of key literature relevant to this research, and discusses how libraries have changed from being places to protect and preserve culture, knowledge and civilisation to places for the acquisition and exchange of knowledge. This chapter identifies the types of learning and learning spaces in the university libraries; it was found that students may prefer at times to study in private rooms, especially when they work on complex tasks that need a high level of concentration. The chapter provides an overview of the relationship between learning, psychology, physiology and colour in the learning spaces. In addition, this chapter overviews the methods used to examine the impact of colour on emotional response, physiological state and performance in the indoor environment. Finally, examples of libraries have been described in this chapter to identify the colours used in their learning environments, including individual study spaces.

It established that colours have a significant influence on human psychology, physiology and performance in different contexts. However, the ways in which wall colour influences students' learning performance in the individual study spaces of university libraries are not investigated in the literature. Some studies have examined the effects of colours (red, yellow, blue, green) on reading tasks, math comprehension or creative performance in different situations such as in carrel study spaces or open plan study areas in an actual environment or via computer (Mehta and Zhu 2009; Stone 2001; Stone 2003). Most previous studies discussed in the literature review show that the level of performance can be low in light colour conditions. This indicates that the nuance of colour plays a significant role in determining a colour's effect on worker productivity.

The literature review found no studies that investigated the effects of colour in isolation from other stimuli in learning environments. In general, studies that manipulated several environmental stimuli clearly support the general notion that the physical learning environment affects students' learning performance. However, a literature search on the effects of colour on learning environments in the university library found that conclusive evidence is lacking. Therefore, the main conclusion of this review is that research on the design of learning environments in university libraries is in need of well conducted and controlled experiments. In addition, the researcher found there were inconsistent findings regarding the suitable colours used in the university library, particularly in the individual study areas. Further, most past studies have examined the effects of the colours red, yellow and blue on performance of office tasks or learning activities in their research. Therefore, the researcher decided to examine the effect of red, yellow and blue on learning performance in a university sitting in this study.

On this basis, the researcher intends to examine the impact of colours that are proposed in Cycle 1 (the literature review) (Mehta and Zhu 2009; Öztürk, Yılmazer and Ural 2012; Stone 2001; Stone 2003) on visual learning (reading comprehension) in the individual study rooms of university libraries. It was decided to examine the effects of two different nuances of red, blue and yellow (vivid red, vivid blue, vivid yellow, light red, light blue and light yellow) in Cycle 2 (Study A). Figure 2-71 shows the main findings of this chapter (Cycle 1). The next chapter describes in detail the research design, methods, results and discussion of Cycle 2 (Study A).

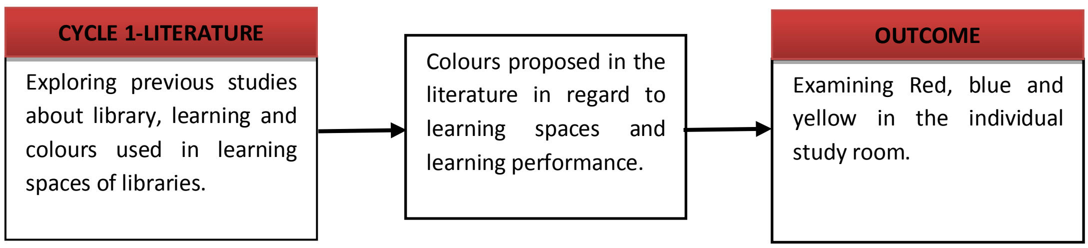


Figure 2-71: Outcome of Cycle 1

3 CHAPTER 3: CYCLE 2 (STUDY A)

3.1 Cycle 2 (Plan 2): The Aim of Study A

It was important for the researcher in Chapter 2 (Cycle 1) to gain knowledge and experience of how people react to colours, in order to understand the influence of colour in the learning environment. The main aim of Cycle 2 (Study A) is to test the effect of colours on a learning activity in an individual study room of the university library. The choice of colours to be tested in this study was based on the information discussed in Cycle 1 (literature review). Although most studies indicated that red, blue and yellow could be appropriate colours for performance, it was not clear which nuance of these colours might be suitable for certain activity like learning performance, especially for reading tasks. Therefore, the researcher decided to test two different nuances of each hue, vivid colours and light colours (vivid red, vivid blue, vivid yellow, light red, light blue, and light yellow). In addition, this first study aims to identify if the current students find these six colours are potentially effective for the design of contemporary learning environments within current university libraries, in the context of contemporary learning methods.

This experimental study was conducted to answer the questions outlined in Chapter 1:

1. To what extent do the hue and nuance dimensions of colour influence reading comprehension in the individual study room?

2. To what extent do the hue and nuance dimensions of colour influence heart rate and emotional response to colour in the individual study room?

3. To what extent do emotional response to colour and heart rate mediate the relationship between colour and reading comprehension in the individual study room?

In order to achieve the objective of this thesis, the experimental method used in this study was to place the participants in a space in a laboratory (see Section 2.5.8.1 in Chapter 2). Three outcomes were assessed across six colour conditions: reading comprehension, emotional response and heart rate. Although three types of learning styles were identified in Chapter 2 (visual learning, auditory learning and tactile-kinaesthetic learning) the study focuses on visual learners (people who prefer learning by viewing and reading hardcopy of books or articles) as discussed on Chapter 2 (Section 2.3.1). Learning performance was assessed by using a reading comprehension test in the library (as discussed in Chapter 2, Section 2.3.1). The Semantic Differential method scale was used to describe emotional response to colour (as discussed in Chapter 2, Section 2.4.3), and heart rate was selected to be measured as one aspect of a person's physiological state.

The individual study room was chosen as one of the learning spaces in the library. As mentioned previously, there are four kinds of learning spaces in the academic library: individual study areas, group study areas, computer areas and training areas (Bennett 2003; Jamieson 2003). This study focuses on the individual study areas, as there is a paucity of rigorous research published in the field of colour studies into the learning spaces of individual study areas, including how wall colours in these spaces affect students' concentration, and how this impacts on learning. Figure 3-1 illustrates the map of Cycle 2 (Study A). The experimental method of this study had participants read articles in a small room where colour was changed between sessions, and their emotional response to colour and heart rates were measured before their reading.

The following sections describe the experimental setting, participant recruitment, colour selection, the instruments used to collect data, and the design of the experimental room.

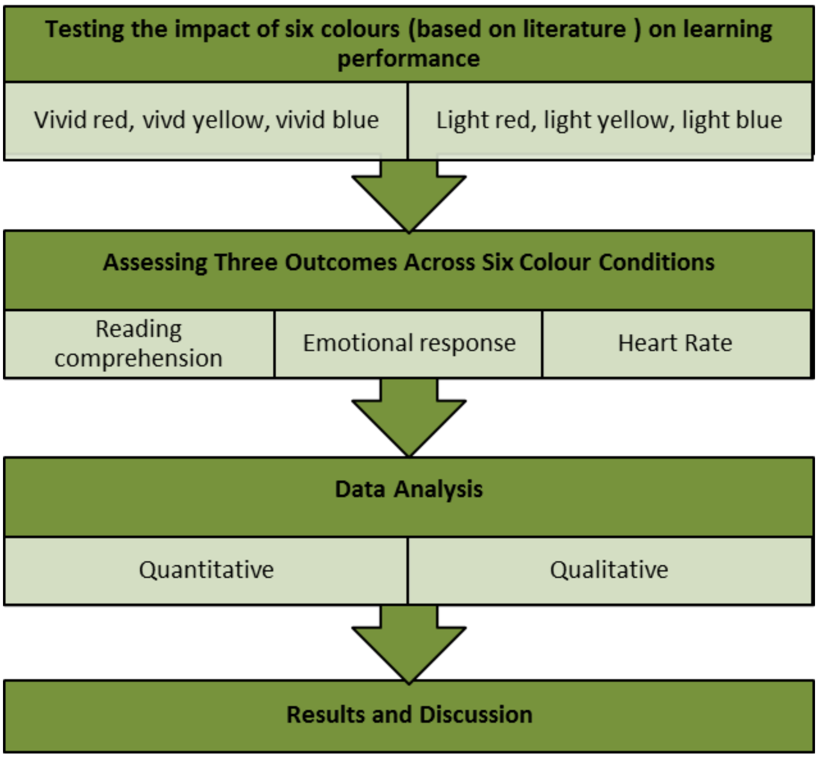


Figure 3-1: The Map of Cycle 2 (Study A)

3.2 Cycle 2 (Act 2): Preparation for Study A

As mentioned in the planning of Cycle 2, this experiment focuses on recording the effect of colours on reading comprehension, heart rate and emotional response in the individual study space. This section will describe in detail the number of participants, the instruments used to collect data, the experimental design and experimental procedure.

3.2.1 Participants

The number of participants for Study A was determined by using the statistical package G*Power Version 3.1.2, a power analysis program for a variety of statistical tests (Faul et al. 2009). According to this program, at least 24 participants are required to capture a ‘moderate’ interaction between hue and whiteness. Accordingly, 11 males (45.8%) and 13 females (54.2%) were recruited from undergraduate and postgraduate students at Curtin University in Western Australia. The participants’ ages ranged between 20 and 38 years. Some participants were international students (with English as their second language), while others were native English speakers. None of the participants had defective vision, as verified with Ishihara Colour Blindness Test (ICBT). Participants were also asked to complete a Learning Channel Preference Questionnaire (O'Brien 1989) which revealed that all participants were visual learners.

3.2.2 Colour Samples

The colours used in this study were chosen from the NCS Colour System, which orders colours according to hue and nuance (NCS 2004). Unlike other ordering systems, the NCS system captures how colours are perceived in relation to these dimensions. The colours used in this experiment were three hues, vivid red (S 1080-R), vivid yellow (S 0580-Y) and vivid blue (S 1565-B) with one colour sample from each hue having a higher level of whiteness — light red (S 0540-R), light yellow (S 0540-Y) and light blue (S 0540-B). The neutral colour white (S 0300-N) was used for the two sides walls (Fig. 3-2).

Note that terms from everyday language are used in this thesis to refer to different nuances (Green-Armytage 2002). The most chromatic colours will be described as 'vivid'; colours that are a bit more whitish as 'light'; those that are even more whitish as 'pale'; the more blackish colours as 'strong'; and those that are even more blackish as 'deep'.

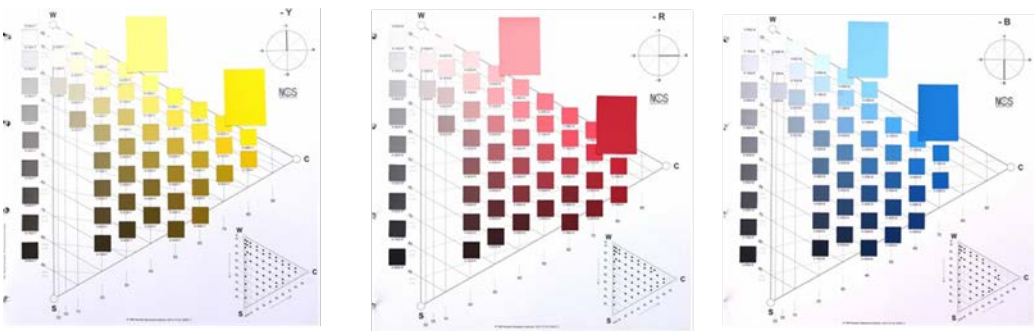


Figure 3-2: The position of the study colours in the NCS triangles

(NCS 2004)

3.2.3 Instruments

Five instruments were used to collect data during the experiment. Each is described below (3.2.3.1 to 3.2.3.6).

3.2.3.1 Colour Blindness Test

The Ishihara Colour Blindness Test (ICBT) has been used for checking colour vision. The test consists of 14 plates, each with a circular image consisting of coloured dots as in pointillist painting. Numerals within the circles of dots are distinguishable if the individual has normal colour vision. Only the first 11 plates were used to detect general colour deficiency. Each participant had to correctly identify 10 or more plates to be deemed to have normal vision and therefore eligible to participate. Each plate was held at a right angle to the participant's line of sight. The experimenter instructed the participant to "please read the numbers" and allowed the participants three seconds to respond (Ishihara 1993).

3.2.3.2 Learning Channel Preference Questionnaire O'Brien (1989)

This questionnaire is designed to identify students' learning style. It is divided into three categories: visual, auditory, and haptic or kinaesthetic learning styles. Each category contains 10 questions, giving a total of 30 questions across the three categories. Participants were asked to rate each statement on a 3-point scale according to how it generally related to them (3 often applies, 2 sometimes applies or 1 never or almost never applies). Scores are totalled in each category; the category with the highest scores represents the participant's preferred learning style, and the lowest score is the least preferred learning style (see Appendix 1).

3.2.3.3 Emotional Response Scales to Colour

The Semantic Differential method was used to assess the emotional response of participants to the wall colours, not assessing basic human emotions (such as anger, fear, happiness or surprise). Nine bipolar colour-emotion scales were used in the experiment: dark/light, pleasant/unpleasant, fresh/stale, heavy/light, calm/exciting, dull/sharp, tense/relaxed, warm/cool, and interesting/boring. These scales were chosen from the adjectives originally proposed by Osgood et al. (1957) in their semantic differential studies in the 1950s. In addition, these adjectives are used in colour emotion research by Gao and Xin (2006), Gao et al. (2007), Ou et al. (2004), Ou et al. (2012), and Xin et al. (2004) to describe human emotional responses to colour samples. In this study these adjectives are used to describe emotional responses to one coloured wall in an interior environment while seated directly in front of it.

Each adjective pair is scored on a 7-point semantic differential rating scale. Participants were asked during the experimental session "what emotional response do you associate with this colour?" (see Appendix 2).

3.2.3.4 Physiological Recordings

The Fingertip Pulse Oximeter (MD300C21/Beijing Choice Electronic Technology) was used to record heart rate. This device consists of a transmitter which is held to the subject's thumb with a portable digital output mechanism. The equipment is unobtrusive.

3.2.3.5 Learning Performance Assessment

Because all participants were identified as visual learners, reading rather than audio reading comprehension tests were used to assess learning performance. The participants were asked to read a passage from a paper and then they answered seven multiple choice questions. These tests were adopted from SAT Comprehension Test website (SAT Reading Comprehension 2012). The reading tests were of comparable difficulty across the six colour conditions. The passages covered different topics and genres such as science (420 words), social life (473 words), novel (500 words), psychology (488 words), literature (525) and politics (520 words).

3.2.3.6 Interviews

An unstructured interview was used as qualitative data in Cycle 2 (Study **A)** after completing the experiment for each colour condition. An unstructured interview is like a guided conversation. It contains open-ended questions, and it is more flexible than a structured interview, as questions can be adapted and changed depending on the respondent's answers; it can be completely informal (Fontana and Prokos 2010). In addition, it increases validity because it gives the interviewer the opportunity to check for a deeper understanding. The participants were asked "does this colour motivate you to study and help you to focus? Why?" This method was used to obtain more in-depth qualitative data. The interviews were recorded by using a digital tape recorder.

3.2.4 Experimental Room Design

This section describes the interior set-up of the experimental room and the colour selection.

3.2.4.1 Room Design

Two rooms were set up in the School of Built Environment within Curtin University for the experimental phase of the study. The first was an adaptation room in neutral colours with light grey walls and ceiling (S 1500-N) and dark grey floor (S 7500-N); the room was 3.60m long × 2.55m wide × 3m high. This functioned as an adaptation room. The purpose of the waiting room was two-fold: (1) to allow the participants to read the information sheet, sign the consent form and take the Colour Blindness Test; (2) to allow participants to adapt to neutral conditions before being exposed to the six colours in the test room, as well as to record their heart rate prior to the experiment. The adaptation was necessary to eradicate the potentially confounding perceptual differences between participants who came from bright daylight via the exterior of the building, and those who came from dim interiors through the internal routes of the building. The interior setup of this room comprised two chairs and a table (Fig. 3-3).

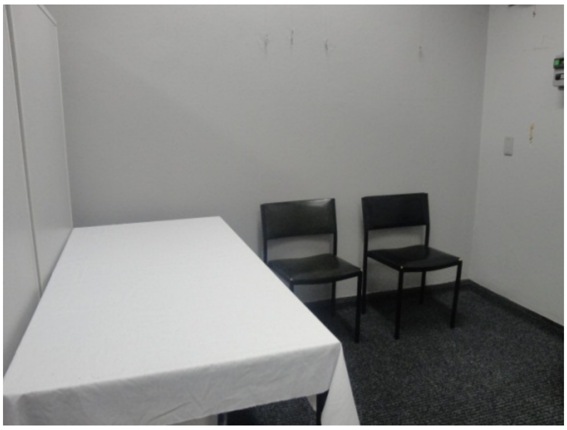


Figure 3-3: Room 1- an adaptation room where participants were informed about the experimental procedure, administered the Ishihara Colour Blindness Test (ICBT), and had their baseline HR measured.

(Al-Ayash 2012)

The second room was the test room (3.68m long × 2.88m wide × 3m high); it had no windows, so that no natural light entered the test room, thereby eliminating any fluctuations of natural daylight from filtering into the room and interfering with participants' reactions to the experimental colours. In this study, it is critical to distinguish the emotional responses and heart rate responses to colour; other stimulations should be minimal. In order to achieve this intent some design ideas were applied:

- The walls, floor, ceiling and furniture colours were neutral colours (lack of hue). The main variable being investigated was one experimental wall. Participants faced this wall when siting at the desk in the test room.

- Space was generic and conventional to eliminate the influence of other design elements.

To achieve these conditions, the walls and ceiling were painted white and the floor was dark grey. Neutral colours such as white and grey were intended to reduce any effects of contrasting hues (Öztürk, Yılmazer, and Ural 2012). The test room was divided by a partition in order to establish an individual study area (1.80m long × 1.30m wide × 3m high) (Fig. 3-4). Colours were manipulated by hanging Corflute panels 180cm × 180cm × 2mm thick on one wall. These panels were painted one of the following colours for each session (vivid red S 1080-R, vivid yellow S 0580-Y, vivid blue S 1565-B, light red S 0540-R, light yellow S 0540-Y or light blue S 0540-B). The wall behind the coloured panel, the side walls and the ceiling were painted white (S 0300-N).

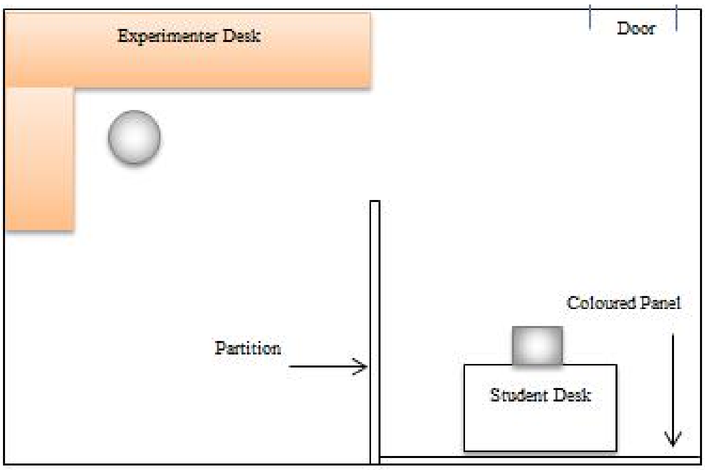


Figure 3-4: Room 2-Plan of the test room showing the relative positions of the experimenter's desk, the participant's desk, the coloured panel, and the partition. (Al-Ayash 2012)

Each coloured panel was hung on the wall so that it extended 1.70m above the top of the desk. The room was furnished with a white student desk (90cm long × 60cm wide × 72 high) and one grey chair (S 7502-N). The student desk was centred along the wall, and faced the coloured panel. In addition, the experimenter's desk was located behind the participant on the left side so that the experimenter could check the time and measure the heart rate (HR) of the participant during the experimental session (see Fig. 3-4 and Fig. 3- 5).

Figure 3-5: The six colour schemes used in the study. Colours were painted onto Corflute panels and hung in front of the desk where the participant was seated

(Al-Ayash 2012)

The experimental room was made as comfortable and simple, and used neutral colours in order to minimise the influence of extraneous factors on the relationship between colour and participant outcomes in terms of emotional response, heart rate, and reading comprehension.

Ambient temperatures of Rooms 1 and 2 were recorded on several occasions on different days; the temperature of both rooms was a constant 25˚C. The rooms were located internally in the basement of a multi-level building; their temperature and humidity vary little throughout the year. The test room was illuminated with four celling Osram florescent tubes (36 W), having a correlated colour temperature (CCT) of 3500 Kelvin and 75-82 colour-rendering index (CRI), and 3350 lumens. The average illuminance was 360 Lux on the desk; illuminance and luminance were measured using a digital light meter, model Lutron LM-81LX.

3.2.5 Experimental Procedure

Participants were not forewarned concerning the colours to which they would be exposed. The researcher told them "this experiment looks at how the colours of a space impact on the learning activity." This eliminates participant expectancy bias concerning the colours tested. The participants in this study were first taken to an adaptation room (Fig. 3-3), which was located outside the door of the test room. In this room, the Ishihara Colour Blindness Test (ICBT) was administered to the participants. After the participants passed this test, they were asked to read the information sheet (Appendix 3) outlining the experimental procedure. The purpose of the study was explained to the participants, and they then indicated their willingness to participate by signing the consent form (Appendix 4). The consent form was kept separate from the main questionnaires to ensure participants' anonymity. Next, they were asked to answer The Learning Channel Preference questionnaire in order to identify their learning styles. This procedure was followed on the first visit only and it lasted for ten minutes.

All participants were then tested individually. Each participant stayed alone in the first room, "an adaptation room," for at least five minutes before entering the test room in order to adapt to room conditions and to have their baseline heart rate measured before the experimental session. Baseline heart rate was measured prior to being exposed to each of the six colours. After the timer rang to signal the end of the five minutes, the researcher re-entered an adoption room to record the participant's baseline heart rate.

The participant was then led into the test room, seated at the desk facing the selected coloured panel, and asked to focus on the coloured panel for five minutes. At the end of the five minutes, the participants rated their emotional responses to the colour (Semantic Differential). Waiting for five minutes before completing the Colour Emotion questionnaire reduces any interference from the initial adaptive response to the coloured panel. Küller and Mikellids (1993) emphasise the importance of controlling the exposure time to the colour stimulus. If the exposure time to colour is too short, such as one minute, it will measure just the initial response to the colour.

After completing the emotional response rating, participants' heart rates were taken again. To assess their learning performance, they were given a reading comprehension task which involved studying the text for five minutes and then they were given ten minutes to answer comprehension questions.

Finally, they were interviewed for five minutes to obtain more in-depth qualitative data. This was recorded by digital tape recorder. This process was conducted six times and each time the participant was exposed to a different colour condition. There was one day free between one session and the next (a wash-out period), to reduce carry-over effects from one colour to the others. The experiment took thirty minutes for each colour. Data on the participant's emotional response, heart rate and reading comprehension test were subsequently analysed with inferential statistics.

The order in which the colours were presented was counterbalanced across participants according to a Balanced Latin Square design. A Balanced Latin Square design was used to control order effects, which ensures that each experimental condition appears an equal number of times in each row and column of the square (Ai 2013). Bradley (1958) described the Latin square that has the feature of counterbalancing immediate sequential effects. As Bradley states, this method is important when:

> It may be suspected that reaction to any given experimental condition will be influenced (a) by the number of experimental conditions preceding it, i.e., by its ordinal position in the sequence of presentation, (b) by the particular experimental condition immediately preceding it. This situation is commonly encountered in psychological experiments when every subject is run under all experimental conditions. Such experimental designs reduce variance at the expense of introducing sequential effects such as learning, fatigue, and interactions between reactions to various experimental conditions, particularly those adjacent in order of presentation. (Bradley 1958, 525)

In this design, each colour appears exactly once in each row and exactly once in each column, as shown in Table (3-1).

Table 3-1: Balanced Latin Square design

Participant Number	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6
8, 13, 17,19	C1	C2	C6	C3	C5	C4
2, 7, 10, 20	C2	C3	C1	C4	C6	C5
4, 5, 14, 22	C3	C4	C2	C5	C1	C6
9, 11, 15, 21	C4	C5	C3	C6	C2	C1
1, 3, 12, 16	C5	C6	C4	C1	C3	C2
6, 18, 23, 24	C6	C1	C5	C2	C4	C3

N=24

3.3 Cycle 2 (Observe 2): Analysing Data and Results of Study A

A series of Generalised Linear Mixed Models (GLMMs) were tested in order to determine whether the participant's emotional response, heart rate and reading comprehension test varied as a function of colour. The GLMM represents a special class of regression model. The GLMM is generalised in the sense that it can accommodate outcome variables with markedly non-normal distributions; the GLMM is mixed in the sense that it includes both random and fixed effects (Jiang 2007). For the present GLMMs, there was one nominal random effect (participant) and two categorical fixed effects (hues: red, yellow, blue; nuances: vivid, light). The GLMMs were implemented through the SPSS (Version 20) GENLINMIXED procedure. In order to optimise the likelihood of convergence, a separate GLMM analysis was run for each outcome measure.

3.3.1 Reading Comprehension

The results obtained from the participants' responses regarding the reading comprehension showed that the main effect of nuance was significant ($F[1,138] = 5.41$, $p = .022$). Reading comprehension scores were significantly higher in the vivid colour conditions compared to the light colour conditions (see Fig. 3-6). However, the main effect of hue was non-significant ($F[2,138] = 0.39$, $p = .676$). These results indicate that reading performance did not differ significantly across the three hues. The Hue x Nuance interaction was non-significant ($F[2,138] = 0.24$, $p = .784$)

indicating that the main effects can be interpreted on one another. Explanations of the *F*-value, dfs, and *p*-values are included in Appendix 5.

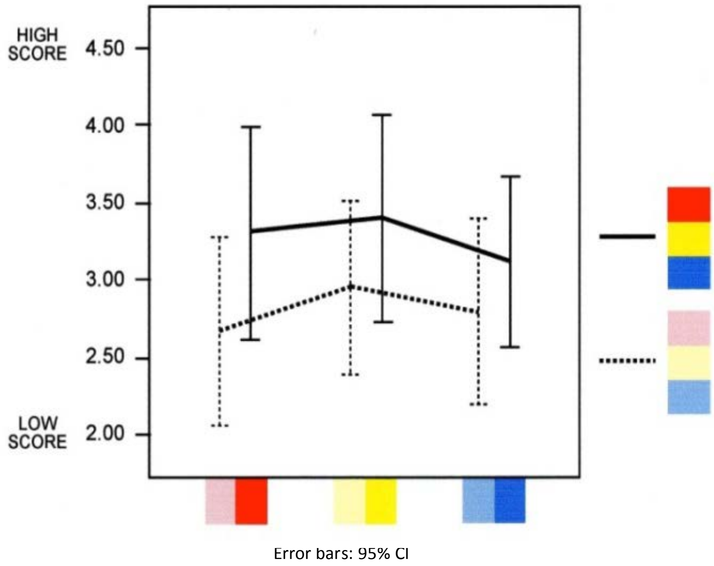


Figure 3-6: The data represent group means for reading scores and their 95% confidence intervals. Nuance had a significant effect on reading scores ($P = 0.022$).

3.3.2 Heart Rate Response

To examine the impact of the experimental conditions on physiological responses, heart rates were recorded on two separate occasions, once before each experimental session and then again during each experimental session. The results found that the main effect for hue was significant ($F[1,138] = 11.93$, $p < .001$). The graph suggests that, regardless of nuance, the red and yellow conditions caused increases in heart rate, whereas the blue condition caused a decrease in the heart rate. LSD (least significant difference) contrasts conducted on the main effect for hue indicated that heart rate increased to the same degree in the red and yellow conditions ($p = .315$), and there was a significant difference between the degree that the heart rate decreased in the blue condition and the degree that the heart rate increased in the red condition ($p < .001$) and in the yellow condition ($p < .001$).

The main effect for nuance was not significant ($F[2,138] = 3.64$, $p = .058$), indicating that changes in heart rate did not differ significantly between the light and vivid conditions (see Fig. 3-7). Likewise, the Hue x Nuance interaction was non-significant (F[2,138] = 0.60, p = .548) indicating that the main effects can be interpreted independently on one another.

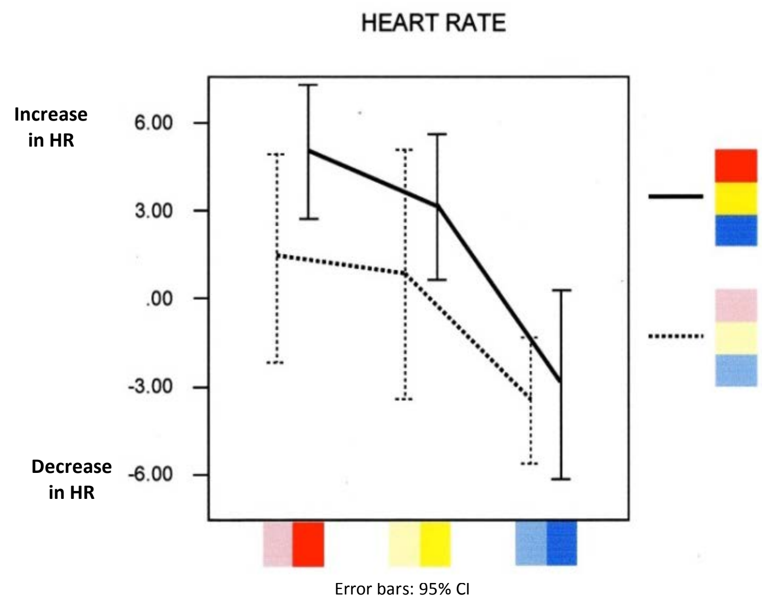


Figure 3-7: The data represent group means for HR fluctuations from baseline and their 95% confidence intervals. Hue had a significant effect on heart rate (P<0.001).

Furthermore, the correlations between heart rate change and reading performance within each of the six Nuance x Hue conditions were computed. The heart rate change was analysed as an ordinal variable (Table 3-2) and as a binary variable (Table 3-3). As can be seen, there are no relationships between heart rate change and reading performance. This means that heart rate change did not mediate the relationship between the colour and reading comprehension.

Table 3-2: Pearson correlations between heart rate change and reading performance within each of the six Nuance x Hue conditions (N = 24)

Nuance	Hue		
	Red	Yellow	Blue
Light	r = .014, p = .947	r = .297, p = .159	r = -.345, p = .099
Vivid	r = .213, p = .318	r = -.300, p = .154	r = .325, p = .122

Table 3-3: Point-biserial correlations between heart rate change (increase versus decrease) and reading performance within each of the six Nuance x Hue conditions (N = 24)

Nuance	Hue		
	Red	Yellow	Blue
Light	r = .014, p = .949	r = .156, p = .478	r = -.117, p = .603
Vivid	r = .000, p = 1.000	r = -.143, p = .504	r = -.143, p = .504

3.3.3 Emotional Responses to Colour

In order to quantify the emotional reaction to each colour, the two-point method was used. Reactions were scored on a seven point semantic differential rating scale. The score -3 was given to the selection of the left-hand word in each pair, such as ‘‘dark’’, ‘‘pleasant’’, “fresh”, “heavy”, “calm”, “dull”, “tense”, “warm” or “interesting”; whereas a score +3 was given to the selection of the right-hand word such as “light”, “unpleasant”, “stale”, “light”, “exciting”, “sharp”, “relaxed”, “cool”, or “boring”.

The results showed that the Hue x Nuance interaction was non-significant for pleasant/unpleasant (F[2,138] = 1.27, p = .285) (Fig.3–8), fresh/stale (F[2,138] = 1.40, p = .250) (Fig. 3-9), heavy/light (F[2,138] = 0.86, p = .425) (Fig. 3-10), calm/exciting (F[2,138] = 0.21, p = .811) (Fig. 3-11), tense/relaxed (F[2,138] = 0.38, p = .687) (Fig. 3-12), warm/cool (F[2,138] = 0.67, p = .515) (Fig. 3-13), dull/sharp

(F[2,138] = 1.05, p = .353) (Fig. 3-14) and interesting/boring (F[2,138] = 0.41, p = .668) (Fig. 3-15). For these scales, therefore, each of the two main effects can be interpreted independently of one another. For the dark/light scale, however, the Hue x Nuance interaction was significant (F[2,138] = 5.37, p = .006) (Fig. 3-16) indicating that, for this scale, each main effect can no longer be interpreted independently.

The main effect of nuance was significant for “pleasant/unpleasant” (F[1,138] = 14.21, p < .001), “fresh/stale” (F[1,138] = 11.88, p = .001), “heavy/light” (F[1,138] = 71.10, p < .001), “calm/exciting” (F[1,138] = 7.52, p = .007), “tense/relaxed” (F[1,138] = 31.91, p < .001), “warm/cool” (F[1,138] = 20.05, p < .001) and “dull/sharp” (F[1,138] = 8.98, p = .003). As can be seen in Figures 3-8 to 3-14, the nuance main effect indicates that the light colour conditions were rated as significantly more pleasant, fresh, calm, dull, relaxed and cool than the vivid conditions. In addition, light colours tended to be rated as light whereas vivid colours tended to be rated as heavy. However, the non-significant main effect of nuance was found on “interesting/boring” (F[1,138] = 0.45, p = .502) indicating that, *regardless of hue*, ratings did not differ significantly between the light and the vivid conditions (see Fig. 3-15).

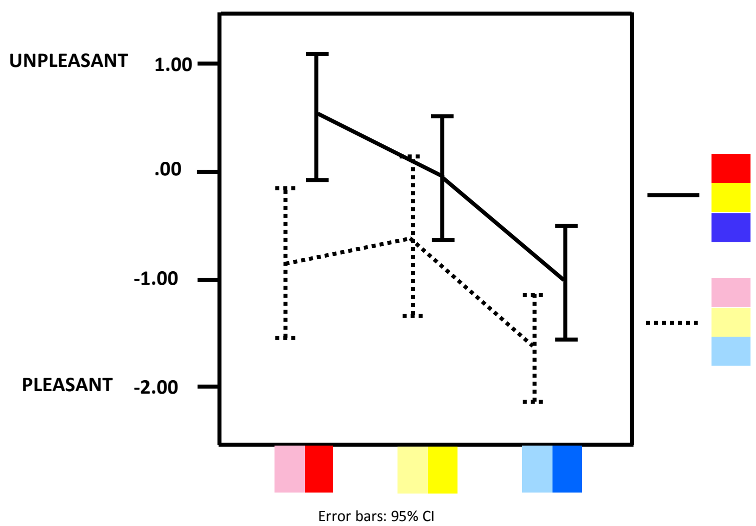


Figure 3-8: Unpleasant-Pleasant

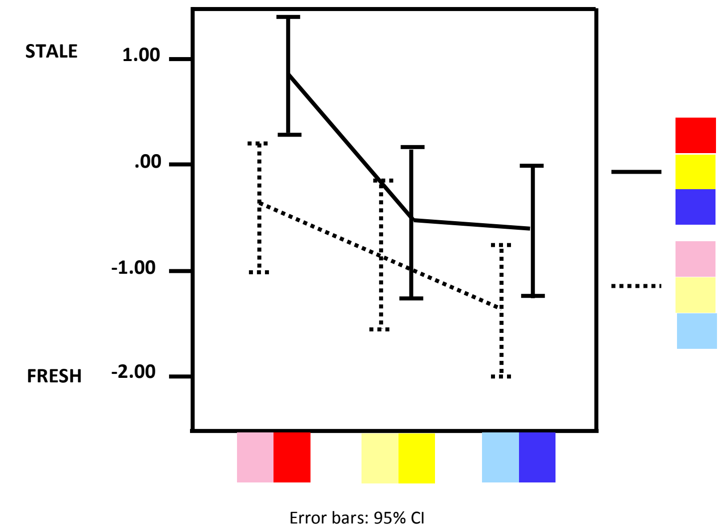


Figure 3-9: Stale-Fresh

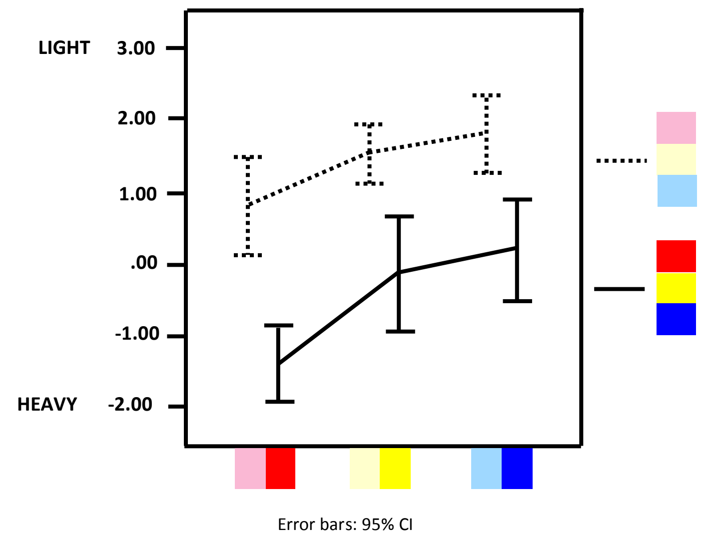


Figure 3-10: Light-Heavy

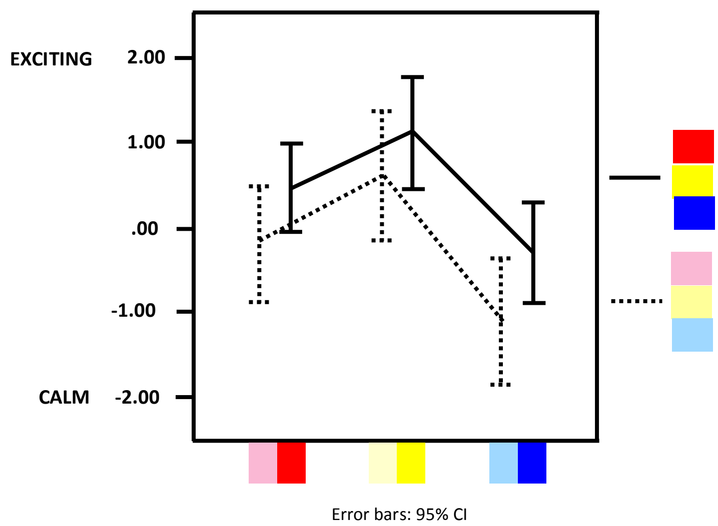


Figure 3-11: Exciting -Calm

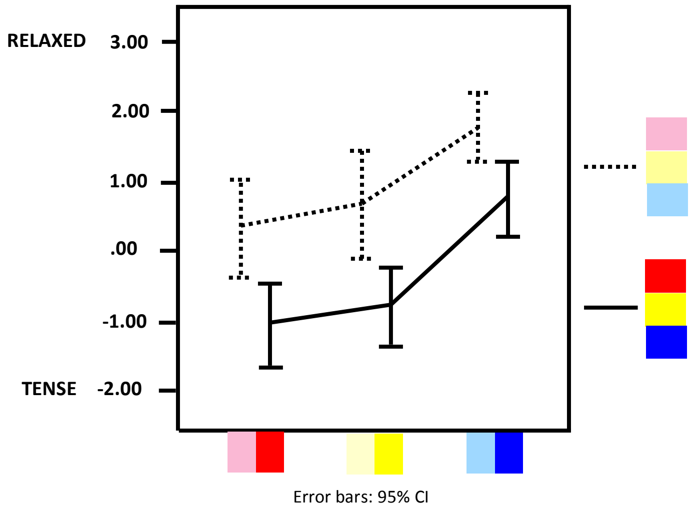


Figure 3-12: Relaxed-Tense

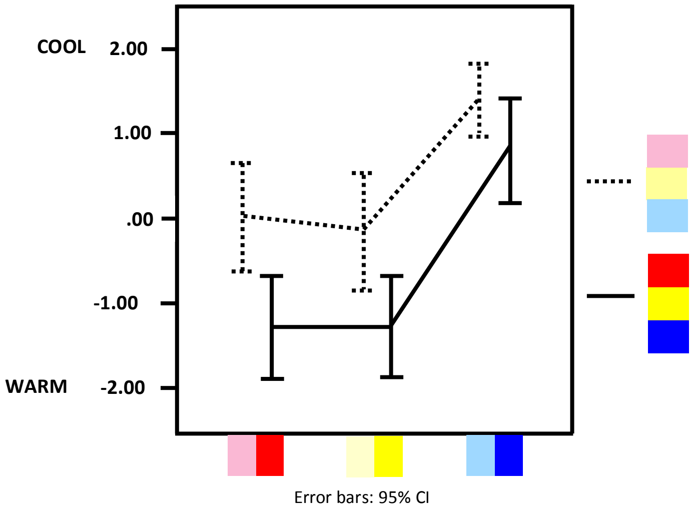


Figure 3-13: Cool-Warm

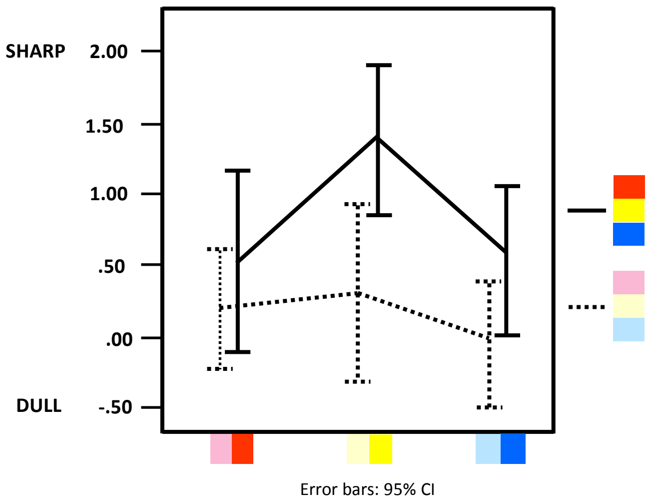


Figure 3-14: Sharp-Dull

The main effect of hue was significant for “pleasant/unpleasant” ($F[2,138] = 11.32$, $p < .001$), “fresh/stale” ($F[2,138] = 10.33$, $p < .001$), “heavy/light” ($F[2,138] = 12.53$, $p < .001$), “calm/exciting” ($F[2,138] = 12.56$, $p < .001$), “tense/relaxed” ($F[2,138] = 20.27$, $p < .001$), “warm/cool” ($F[2,138] = 30.69$, $p < .001$) and “interesting/boring” ($F[2,138] = 3.59$, $p = .030$). These effects are graphed in Figures 3-8–3-13 and 3-15. LSD (least significant difference) contrasts conducted on the main effect for hue indicated that, regardless of nuance, blue was rated significantly more pleasant than either red ($p < .001$) or yellow ($p = .003$); no significant difference was found between red and yellow ($p =.414$). Blue was rated as significantly calmer than either red ($p = .007$) or yellow ($p < .001$); and red was rated significantly calmer than yellow ($p = .025$). Blue was rated significantly less tense than either red ($p < .001$) or yellow ($p < .001$); there was no significant difference between red and yellow ($p =.231$).

In addition, blue was rated significantly cooler than either red ($p < .001$) or yellow ($p < .001$); there was no significant difference between red and yellow ($p =.696$). Moreover, the participants rated blue as significantly more interesting than red ($p = .008$); there was no significant difference between red and yellow ($p =.152$) or between blue and yellow ($p < .219$). As seen in Figure 3-9, red was rated as significantly less fresh than either blue ($p < .001$) or yellow ($p = .001$); there was no significant difference between blue and yellow ($p =.277$). Red was also rated as significantly heavier than either blue ($p < .001$) or yellow ($p < .001$); there was no significant difference between blue and yellow ($p =.346$). A non-significant effect of hue was found for “sharp/dull” ($F[2,138] = 3.06$, $p = .050$) indicating that ratings did not differ significantly across the three hues (see Fig. 3-14).

The Hue x Nuance interaction for dark/light is graphed in Figure 3-16. The graph suggests that individuals tended to rate towards the light (as opposed to dark) end of the scale in the light colour condition and towards the dark end of the scale in the vivid condition. LSD contrasts conducted across the interaction indicated that red was rated significantly darker than yellow ($p < .001$) and blue ($p < .001$), and blue was rated significantly darker than yellow ($p = .009$) but only in the vivid condition. In the light condition, there were no significant differences in ratings across hues.

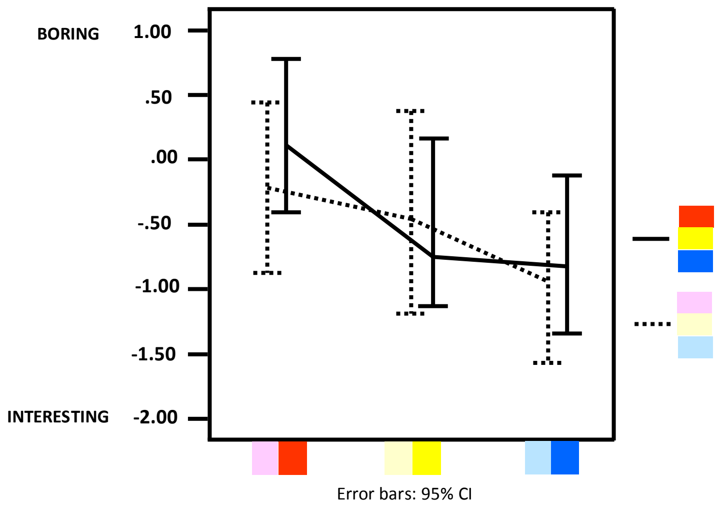


Figure 3-15: Interesting-Boring

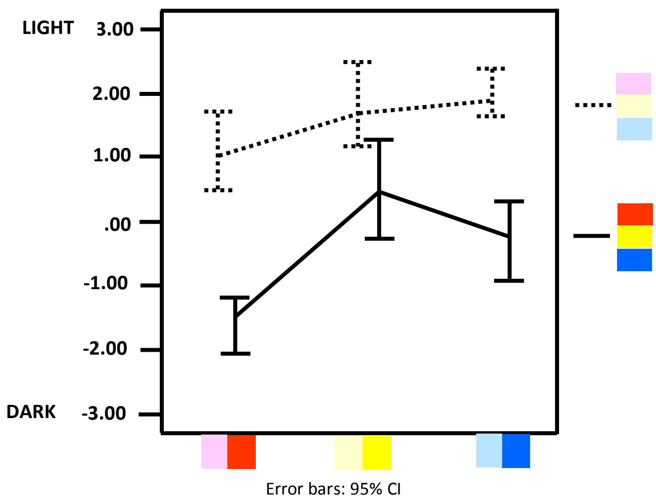


Figure 3-16: Light-Dark

Moreover, the relationships between each of the nine emotions and reading comprehension for each of the six Nuance x Hue conditions were examined; that is, 54 correlations (see Tables 3-4–3-9). A seen in the tables, only two of the correlations were significant at the conventional probability level of .05. At the .05 level, however, we would expect 2-3 of the 54 correlations to be significant just by chance. Therefore, it is concluded that there is no relationship between emotional responses and reading comprehension, which means that emotional response cannot mediate the relationship between the colours and reading performance.

Table 3-4: Pearson correlations between emotions and reading performance in the red/light condition (N = 24)

	Dark	Pleasant	Fresh	Heavy	Calm	Sharp	Tense	Warm	Interesting
R	.272	-.200	-.112	.183	.348	.223	.111	**-.419***	-.344
p-value	.198	.348	.602	.393	.095	.294	.605	**.042**	.100

Table 3-5: Pearson correlations between emotions and reading performance in the yellow/light condition (N = 24)

	Dark	Pleasant	Fresh	Heavy	Calm	Sharp	Tense	Warm	Interesting
R	-.239	.228	.235	-.091	.051	.378	-.044	.101	.131
p-value	.261	.284	.269	.674	.812	.069	.837	.640	.542

Table 3-6: Pearson correlations between emotions and reading performance in the blue/light condition (N = 24)

	Dark	Pleasant	Fresh	Heavy	Calm	Sharp	Tense	Warm	Interesting
R	.368	-.148	-.268	.143	.039	**.457***	.396	.194	-.101
p-value	.077	.490	.205	.505	.858	**.025**	.056	.363	.637

Table 3-7: Pearson correlations between emotions and reading performance in the red/vivid condition (N = 24)

	Dark	Pleasant	Fresh	Heavy	Calm	Sharp	Tense	Warm	Interesting
R	-.177	.013	.044	.030	.097	-.149	-.278	.111	.091
P	.409	.951	.838	.890	.653	.487	.188	.604	.672

Table 3-8: Pearson correlations between emotions and reading performance in the yellow/vivid condition (N = 24)

	Dark	Pleasant	Fresh	Heavy	Calm	Sharp	Tense	Warm	Interesting
R	.145	-.121	-.331	-.008	.220	.194	.283	-.171	-.401
P	.498	.573	.114	.971	.301	.364	.180	.424	.052

Table 3-9: Pearson correlations between emotions and reading performance in the blue/vivid condition (N = 24)

	Dark	Pleasant	Fresh	Heavy	Calm	Sharp	Tense	Warm	Interesting
R	-.087	-.250	-.143	-.146	.045	-.205	-.111	-.401	.006
P	.688	.240	.506	.496	.835	.338	.604	.052	.978

3.3.4 Analysing Data and Results of Interviews

At the end of each session in the experiment, each participant was interviewed for five minutes. The purpose of this interview was to discover specifics about the motivational power of colour in terms of learning activity. For each of the six colours, participants were asked "Does this colour motivate you to study and help you to focus? Why?" Responses to this question provided subjective data regarding the colour's impact on learning performance, and general reactions to the colour. Participants were briefed by information sheet before the interview so that they fully understood its purpose and the topics that would be covered.

3.3.4.1 Data Analysis

As described in Chapter 1, Section 1.6 about the steps for analysis of the qualitative data, three steps were identified for analysis. After arranging and transcribing all the data, the key points were identified from the data to enable the researcher to focus on specific issues. Then a coding process was used to label and categorise he data to facilitate analysis and make the data more manageable. Creswell (2008) states that the purpose of the coding process is to commence the process of breaking data down into concepts, events, behavioural actions, thoughts, ideas and meaning.

In this study, the transcriptions were reviewed and broken down into phrases and sentences representing the participants' main ideas or meaningful experiences. Statements and responses relating to the key colour in the individual study room were highlighted manually and coded using Microsoft Word document. Through the process of comparing the codes for similarities and differences, codes were then grouped into themes, or abstract explanatory terms. The goal of the coding step was to create a list of themes regarding the experiences and perceptions of the participants about the influence of colour in the learning environment. The following table shows examples of how the codes and themes were identified for the light blue colour in Table 3-11.

Table 3-10: Examples of the coding process

Themes	Codes	Transcription
Bodily responses	-Distraction for mind. -Reduction in energy. -Increasing drowsiness.	This colour **distracts my mind**, because it is **less active** and **makes me sleepy**. It is a cool and very relaxed colour, so I cannot concentrate on the reading task, I want to relax.
Emotional response	-Feeling cool. -Very relaxed colour.	This colour distracts my mind, because it is less active and makes me sleepy. It is a **cool** and **very relaxed** colour, so I cannot concentrate on the reading task, I want to relax.
Intellectual activity	Difficulty concentrating	This colour distracts my mind, because it is less active and makes me sleepy. It is a cool and very relaxed colour, **so I cannot concentrate** on the reading task, I want to relax.

The meaning of the codes is quite broad, in recognition of the complexity of the concepts; however, through the thematic process the meaning become more focused. Examples of codes identified from the one quotation transcribed in Table 3-11 are, “the experience of distraction for the mind,” “decline in energy,” and “the experience of drowsiness.” These codes, as highlighted in Table 3-11, relate to the effects of colour on the human body; therefore, these codes were grouped under the theme “bodily impact.” In the second part of the same quotation, the codes are “feeling cool” and “experience very relaxed colour,” these codes were grouped under the theme “emotional response.” In the last part of this quotation, one code was found to be “difficulty concentrating” and it was grouped under the theme “intellectual activity.”

Qualitative findings were categorised into seven themes: emotional, bodily impact, associative properties, spatial perception, motivation, intellectual activity and personal connections (Table 3-12). The qualitative analysis provided an insight into the participant's perspective on the colour's impact.

Table 3-11: The main themes emerging from the data

Main Themes	Codes
1. Intellectual impact	stimulates memory affects concentration ability to focus and think
2. Motivating properties	encouraging people to study stimulates interests activates
3. Emotional response	relaxation, calmness happiness feeling settled depression boredom
4. Associative properties	associations with nature associations with learning places, objects associations with a culture or country association with a room type or function
5. Bodily responses	impact on the physical state of students impact on performance impact on nervous system impact on eyes
6. Personal connections	personal preference favourite colour
7. Spatial perception	dimensions of space

3.3.4.2 Interview Results for Light Colours

The results indicated that colours with a higher level of whiteness such as light blue and light yellow evoked the more active emotions, and had a more positive impact on bodily responses, motivation, intellectual activity, associative properties and spatial properties. For example, 70% of participants believed that light blue was associated with calmness, happiness, relaxation, comfort and peacefulness, because it is related to the calming aspects of nature such as the sky and water. In addition, most participants thought that light blue made them active, motivated them for study and increased their concentration levels. The participants made similar comments regarding light blue:

> I feel excited with this colour because it is associated with nature like sky and water… I feel I am in an open space, maybe it is a cool and peaceful colour. It did increase my concentration on the reading task ... so it motivates me to study. (Participant 8)

> It is a calm, relaxed colour and motivates for study…it helps me to concentrate on my work… I feel comfortable and active. It also makes the space bigger. (Participant 6)

In addition, 58% of the respondents also believed that light yellow had a positive effect on learning performance. It was associated with positive feelings such as happiness, cheerfulness, and relaxation. The participants described it as a sun, a source of light, and said that it made them feel active, and enlarged the space; and that it increased their focus on the reading task and motivated them to study:

> I feel good… it is a very motivating colour for study because this colour brings light… and I like shiny colours. It helps me to be active and alert… more focus on reading task. (Participant 21)

> It is a light colour and it is quite exciting colour that helps me to focus and makes me alert and active… yes I think it is motivating colour for study. (Participant 4)

However, the minority of the responses indicated that the light colours such as light blue and light yellow gave rise to feelings of calmness, relaxation and comfort, but they commented that these feelings have negative effects on learning activity. Although the light blue and light yellow conditions were considered calm and relaxed, they decreased their activity level. Specifically, 29% of participants said that light blue made them feel sleepy and less energetic; and 41% of participants reported that the light yellow made them feel nervous, tired and distracted. They agreed that light colours did not help them to concentrate and study well, and they commented:

> I feel sleepy and inactive with this colour [light blue] because it is too calm... I feel also bored… and it does not motivate to study. (Participant 3)

> I feel nervous because it [light yellow] is too light and it distracted me when I read… so [I] concentrated less and [it did] not motivate me to study. (Participant 8)

66% of the responses indicated that light red was considered boring, annoying, bright, warm and uncomfortable, because it was believed to increase nervousness, tiredness and distraction. In addition, the participants saw light red as a very feminine colour, suitable for bed rooms but not for learning environments. As a result, most participants agreed that light red did not motivate them to study or focus on the reading task:

> It is a distracting colour… I cannot focus on the reading task… I think it is not suitable for a learning activity. (Participant 22)

> It is a tense colour… I cannot focus with it because it is slightly bright … and it is a girly colour. (Participant 11)

> This colour makes me feel nervous and stressed because it is slightly bright and there is a strong reflection that causes distraction when I read. I cannot focus and it does not motivate me to study… it may be appropriate for a party activity. (Participant 2)

On the other hand, a minority of the participants, about 33%, believed that light red had a positive impact on learning activity because it was considered inviting, fresh, comfortable and exciting. These effects kept them active and awake, and also motivated them to study and focus. The participants commented on light red as follows:

> It is inviting and fresh… so it helps me to focus and also encourages me to study. (Participant 24)

> I feel so excited maybe I like this colour… I feel more active and it is a comfortable colour… It helps me to focus. (Participant 7)

3.3.4.3 Interview Results for Vivid Colours

The majority of participants agreed that vivid red and vivid yellow were not suitable colours for individual study areas because they had a negative impact on their emotional state, bodily impact, intellectual activity, associative properties, and motivation. For example, 66% of participants reported that vivid red was associated with depression, annoyance, discomfort, warmness, and with negative concepts such as blood, war, and danger. Furthermore, the participants felt nervous and stressed, and said that the colour vivid red distracted their vision because it is considered very bright colour. The participants agreed that vivid red did not motivate them to study for any length of time, and they found it difficult to focus on the reading task. Most of the participants made similar comments about vivid red:

> I feel uncomfortable with this colour because it is a dark colour … doesn't help me to focus because it is a distracting colour and causes eye fatigue… It is very active but it doesn't encourage me to study. (Participant 4)

> It is gloomy because it is very dark and annoying colour… it is a distracting colour, I could not focus… It doesn't motivate me to study at all. (Participant 18)

> It doesn't help me to study because it is related to war, blood, and danger... it's too vivid so I cannot focus on the reading task. (Participant 17)

Likewise, vivid yellow was considered an uncomfortable colour for studying. It was perceived as a very bright, annoying and strong colour. Moreover, 75% of the participants reported that vivid yellow increased their discomfort level. This occurred, the participants believed, because vivid yellow has a negative effect on the body. Participants also thought that the vivid yellow was distracting because it reflected too much light, caused eye fatigue, and made them feel nervous, tired and hot. In addition, it was reported that vivid yellow was very arousing and they believed that it may be suitable for tasks that demand a high level of activity such as sport. Furthermore, the participants confirmed that it was difficult to concentrate on the reading task, and therefore, not ideal for motivating them to study:

> It is so a bright colour… I feel hotness with this colour it is like a sun… It is an unmotivating colour for study maybe it is good for sports activity or for kids' places. (Participant 6)

> It is a distracting and annoying colour… uncomfortable for the eyes because it reflects too much light. It does not motivate me to study. (Participant 22)

A few participants, 25%, however, associated vivid yellow with positive memories and feelings:

> I feel so happy with this pure yellow because it makes me so excited and I had wonderful memories with this colour when I was in the high school, I was preeminent in my school; therefore, in the graduation ceremony I did wear a black robe with a yellow stripe in order to be distinct from other students. Also it is motivating for study because it is an active and bright colour and a natural colour. (Participant 8)

> It is a shiny colour, it helps me to read clearly and concentrate on the reading task… It is active, a more energetic and natural colour like a light day. (Participant 3)

In contrast, vivid blue was considered an appropriate colour for learning environments. 62% of the participants thought that it had positive effects on their emotions, performance, bodily impact, and concentration levels. It was perceived as a calming, cool, bright and comfortable colour, and related to aspects of nature such as the sky, beach and summer. Many participants reported that vivid blue made them awake and active, and helped them to concentrate. They commented:

> It is comfortable and it makes me awake and active because it is related to clear sky and sea water and I really like this atmosphere to study… [I was] more concentrated. (Participant 3)

> "It is a motivated colour for study because it is a bright and very calm and comfortable colour for reading activity… more natural that helps me to be relaxed and have clear ideas and more focus. (Participant 4)

On the other hand, 38% of participants related vivid blue to negative feelings such as depression, annoyance and discomfort; they believed that it was a distracting colour that made them less active, more stressed and sleepy:

> It is not motivating colour for study… because it distracts my mind. It is good for relaxing more than for a study activity… So I feel less concentrated with this colour… and I feel tired. (Participant 16)

> It is not motivating colour for study because it is a strong not soft colour… It impacts passively on my mood… I feel depression. (Participant 17)

3.4 Cycle 2 (Reflection 2): Discussion of Results

The main goal of the present research is to investigate the effects of different colours on students' reading comprehension, emotional responses and heart rate within the individual study areas of university libraries. The study took place in a full scale space that was designed to simulate a typical space for individual study in the university library. The implications of the findings will now be discussed in relation to the use of colour in the library learning areas.

3.4.1 Reading Comprehension

Participants were required to read articles on a variety of topics during exposure to each of the colour conditions. Reading comprehension was assessed after each condition by a series of multiple choices questions. Reading performance varied across the different colours. Specifically, the whiteness dimension (but not the hue) had a significant effect on reading comprehension. Reading comprehension scores were higher for the vivid colours compared to the light colours. These findings agree with the findings of Kwallek et al. (1996) which showed that participants made more errors in the lighter coloured offices than in the darker coloured offices. This effect seemed to be related to the whiteness of colours. Light colours may, in some sense, be more distracting than vivid colours because they reflect more light. This suggests that the nuance of a colour rather than hue has an important effect on students' learning performance.

The findings are also consistent with the notion that strong colours increase arousal of the central nervous system (Küller, Mikellides and Janssens 2009). If the reading tasks are difficult, therefore, the vivid colour conditions may increase arousal to optimum levels, thereby enhancing learning performance. This finding supports the Yerkes-Dodson Law about the relationship between arousal and performance (Yerkes and Dodson 1908). Another explanation for this finding is that the vivid colours were considered as more distracting than the light colours because of their higher chromaticness; perhaps participants become more focused on the reading tasks in an attempt to ignore the distracting stimulus. Interestingly, participants who felt positive in the light colour conditions showed enhanced learning in the vivid colour conditions.

3.4.2 Heart Rate Responses

Baseline heart rate was recorded in the waiting room (grey colour condition), and then recorded again during the experimental session after five-minute exposure to each of the six coloured panels. The results indicated that changes in heart rate did not differ significantly between light colours and vivid colours. However, hue induced significant changes in heart rate. Red and yellow increased the heart rate whereas blue decreased the heart rate. Heart rate increased to the same degree in the red and yellow conditions (p = .315); there was a significant difference between the heart rate decrease in the blue condition and the heart rate increases in the red condition ($p < .001$) and the yellow condition ($p < .001$). This finding supports the notion that colour has a strong impact on the physiology of people who stay in a coloured room for long time (Küller, Mikellides and Janssens 2009). In addition, several colour studies have indicated that long wavelength colours such as red and yellow are more arousing than short wavelength colours such as blue and green (Caldwell and Jones 1985; Venolia 1988).

It seems that warm colours such as vivid and light red and yellow, regardless of nuance, have arousing properties that stimulate people and make them feel more active, producing increases in heart rate; while blue conditions produce decreases in heart rate. The colours (particularly hue) actually had an impact on the heart rate of those who faced the coloured panels.

3.4.3 Emotional Responses to Colour

Consistent with the findings of Küller, Mikellides, and Janssens (2009), the results clearly show that both hue and nuance had a strong impact on the participants' emotional responses. The participants felt more positive in the light colour conditions compared to the vivid colour conditions, because light colours were perceived to be pleasant, fresh, calm, relaxed, light, cool and less sharp. These findings are consistent with those of Manav (2007), which showed that light colours with high Munsell value were associated with positive emotional responses in residence interiors.

Hue also had an impact on emotional response. Emotional ratings differed significantly across the three hues. These findings are contrary to previous findings which showed that hue did not have a significant impact on emotion (Ainsworth, Simpson and Cassell 1993). It was found that blue (vivid and light) put the participants in a more positive state, because it was perceived to be more pleasant, fresher, calming, relaxing, cooler, lighter, more interesting and less sharp compared to the other two hues. This result agrees with the finding in Stone's (2001; 2003) studies, which found that blue was associated with positive feelings in the study environment.

There were no relationships between reading performance and changes in heart rate, and between reading performance and emotional responses. This means that when the colour makes changes in heart rate, the reading performance will not be affected. Further, when the emotional response to colour is affected, the reading performance will not be affected. Therefore, colour can impact directly on reading comprehension activity, emotional response and heart rate.

3.4.4 Interviews

The participants were interviewed individually for five minutes and asked about the impact of each colour on their performance in the reading task, and how a certain colour motivated them to study in the individual study space. They reported that in addition to the effect of colour on the emotions, colour can impact on the bodily responses, motivation, intellectual activity and perceived spatial properties of the environment. In general the blue colours, whether light or vivid, were considered appropriate colours for learning in the individual study area. The blues were perceived to be relaxing and calm because of their association with the calming aspects of nature such as the sea and sky.

The blues were also found to be comfortable for vision and made the space seem bigger, because they were considered cool and calm. Compared to light blue, vivid blue helped participants remain alert, active and focused for a longer time. This finding for vivid blue is consistent with the results of the reading comprehension test, which confirmed that reading scores were higher in the vivid colour conditions compared to the light colour conditions. If the reading task requires careful attention, then vivid colours such as vivid blue can help students to be more focused on their tasks. In contrast, light blue can be helpful for tasks that require a high level of concentration such as creative or mathematical tasks. Perhaps subjects in the vivid blue condition attempted to ignore the vivid surrounding colour by concentrating more on the test, thereby making fewer errors.

Light yellow was also perceived as a more suitable colour for studying in the individual study room than vivid yellow. The participants reported that light yellow had a positive impact on their learning performance and it was a colour that motivated them to study. They agreed that it is related to positive emotions such as happiness, cheerfulness and relaxation. The results corroborate previous research concerning the qualities of yellow. For example, Clarke and Costall (2008) and Ballast (2002) found that yellow was associated with smiling, cheerfulness and joviality. The participants reported also that light yellow is like the sun, it reflects light and made them feel active and awake, which helped them focus on the reading tasks and motivated them to study.

However, these subjective reports are inconsistent with the objective data, which showed that performance on the comprehension task was poorer in the light colour conditions compared to the vivid colour conditions.

In regard to red conditions, the results suggest that vivid red and light red are unsuitable for learning, having a negative impact on intellectual activity.

Specifically, participants reported that these colours impaired their concentration. They claimed that vivid and light red increased stress and nervous levels because they strongly reflected light, were distracting and over stimulating. This finding is also inconsistent with the comprehension test results for the vivid conditions. In general, most participants believed that light colours with high whiteness (specifically in yellow and blue conditions) would be appropriate colour schemes in learning environments because they were considered calm and relaxing.

However, the calmness and relaxation aspects may not help students to be alert and active. The participants performed better in the vivid colour conditions; this is may be that these colours have arousing properties that stimulate neural activity. According to Draper and Brooks (1979), colours should arouse and activate the brain in order to help students undertake activities in the learning environment within the library.

3.5 Conclusion

The results of Cycle 2 (Study A) show that the colour dimensions have a significant impact on reading comprehension, emotional response and heart rate changes. The nuance dimension had a strong impact on participants' performance, because vivid colours supported reading performance compared to light colours, whereas the hue dimension had no impact on reading performance. It can be concluded that colours with high chromaticness can improve reading performance. That means that there is no specific colour that can improve reading comprehension.

In contrast, the hue dimension made significant changes in heart rates of participants; there were increases in heart rates in red and yellow conditions whether light or vivid. It is concluded that heart rates increase in warm colour conditions whether in light or vivid conditions. However, the nuance dimension had no impact on participants' heart rate.

On the other hand, both hue and nuance had significant impacts on participants' emotional response. Emotional responses to colours were positive in light colour conditions compared to vivid colour conditions. As for hue, blue (vivid and light) put the participants in a more positive state, because it was rated to be more pleasant, fresher, calming, relaxing, cooler, lighter, more interesting and less sharp compared to the other two hues. The emotional response and heart rate did not mediate the relationship between colour and reading comprehension in the individual study room; that means this relationship would impact indirectly on reading comprehension.

Reading tasks require a high level of concentration, and students should be awake and active to be able to focus and understand the materials. Colours with a high level of chromaticness improve students' reading activity, as these colours are considered active, thereby motivating study and focusing attention. Tables 3-12 and 3-13 show the main finding of the effects of hue and nuance on reading comprehension, emotional response and heart rate.

Table 3-12: The impact of hue on the reading comprehension, heart rates, and emotions results

Hue Dimension	Reading Comprehension	Heart Rate	Emotional Response
Red	No effect	Increases in HR	Less fresh, heavy, unpleasant, less calm, more tense, warm, less interesting, dark.
Blue	No effect	Decreases in HR	Pleasant, calm, less tense, cool, fresh, interesting, light, less dark.
Yellow	No effect	Increases in HR	Unpleasant, fresh, light, less calm, tense, warm, less interesting.

Table 3-13: The impact of nuance on the reading comprehension, heart rates and emotions results

Nuance Dimension	Reading Comprehension	Heart Rate	Emotional Response
Light colours	Low scores	No effects	More pleasant, fresh, calm, relaxed, cool, light.
Vivid colours	High scores	No effects	Less pleasant, less fresh, tense, dark, less calm, warm.

The interview results also suggested that the hue and nuance dimensions of colour play a significant role in determining the effects of colour on reading comprehension. For instance, both light and vivid blue were associated with positive feelings, which makes blue a suitable colour for reading activity. As for nuance, light yellow was considered to be a more suitable colour for reading activity than vivid yellow, because it was associated with positive feelings and it impacted positively on students' attention, motivation and bodily responses. The qualitative data agrees with some literature in regard to yellow and blue, but disagrees with the literature in regard to the colour red. Table 3–14 summarises the results of interview data.

Table 3-14: Summary of results of interviews

Colours	Light	Vivid
Blue	Motivates study, comfortable for eyes, facilitates concentration.	Active, relaxed, helps to focus attention on study.
Red	Distracting, does not motivate for study, does not focus attention, and induces feelings of stress and nervousness.	Tense, annoying, does not motivate for study and does not facilitate concentration.
Yellow	Comfortable for eyes, active, motivates for study, helps to focus attention.	Does not motivate for study, less focus, distracting colour, increases feeling of heat.

In addition, the qualitative results were inconsistent with the quantitative results in terms of reading comprehension. In regard to the quantitative results, the reading comprehension was better in the vivid colour conditions (colours with high chromaticness), and poorer in the light colour conditions (colours with high whiteness). On the other hand, the qualitative results suggested that participants considered both vivid and light blue, and light yellow (colour with high whiteness) to be suitable colours for reading comprehension in the individual study room. The reason for the contradictory findings might be that the qualitative results are subjective responses, and these responses depend on participants' experiences and knowledge of colours.

Another explanation for the contradiction relates to the participants' interpretations of the effects of colour on learning. According to previous research (Kennedy 2005; Kwallek et al. 1996; Stone 2003), there are different types of performance and each task needs a different colour; for example, colours with high whiteness (light colours) can be suitable for creative tasks, providing an appropriate atmosphere for meditation and thinking, while colours with high chromaticness (vivid colours) can be suitable for high attention like the comprehension reading task, by helping to keep students active and alert, thereby enhancing concentration. Table 3-15 shows the main results per colour with different methods in regard to the reading task.

Table 3-15: The main results per colour with different methods in regard reading task

Colours	Quantitative Method (Reading task)	Qualitative Method (Reading task)
Vivid Red	Good	Bad
Vivid Yellow	Good	Bad
Vivid Blue	Good	Good
Light Red	Bad	Bad
Light Yellow	Bad	Good
Light Blue	Bad	Medium
Conclusion	Vivid colours with high chromaticness support reading task	Blues (vivid and light) and light yellow support reading task

This study Cycle 2 (Study A) led the researcher to investigate the effect of other colours that are not mentioned or examined in the literature in the field of learning environments especially in regard to individual study areas. Therefore, in the next cycle, colours were chosen based on the students' perceptions and perspectives regarding suitable colours for learning performance in the individual study spaces in the library, ascertained from focus group discussions in Cycle 3 (Study B) in Chapter 4. Thus, the results of Cycle 3 (Study B) decided which colours should be tested in Cycle 4 (Study C) in Chapter 5. Figure 3–17 shows the main findings of Cycle 2 (Study A).

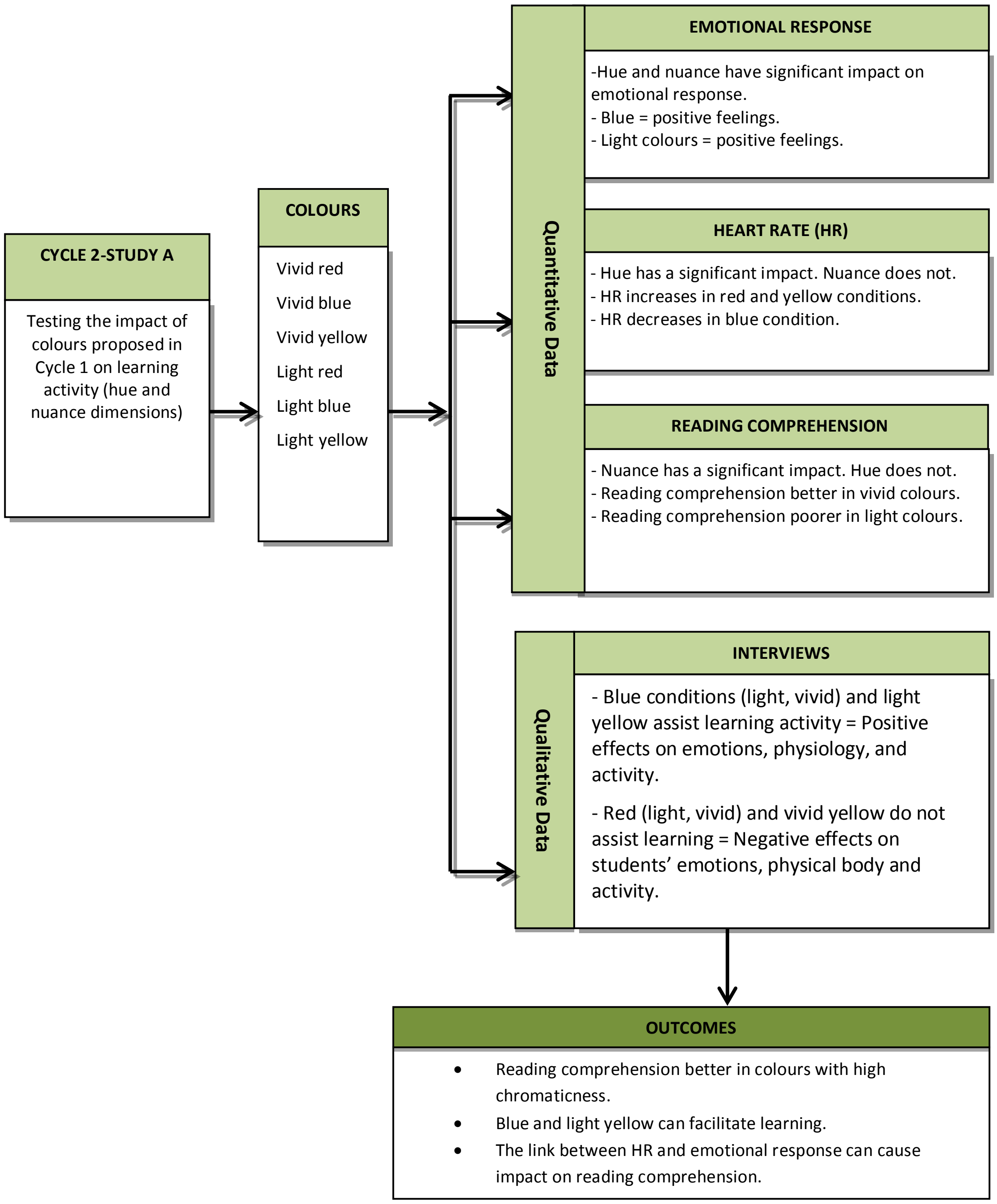


Figure 3-17: Outcomes of Cycle 2 (Study A)

4 CHAPTER 4: CYCLE 3 (STUDY B)

This chapter describes the aim and procedure of Cycle 3 (Study B). Study B is divided into two stages. Stage 1 involved three focus groups and included a facilitated discussion amongst participants in each group session (details in Section 4.1). Stage 2 involved a survey based on the findings of the first stage; the survey was conducted within the Robertson Library, asking students which colour is most suitable for the individual study space; the details are described in Section 4-5. Figure 4–1 illustrates the map of Cycle 3 (Study B).

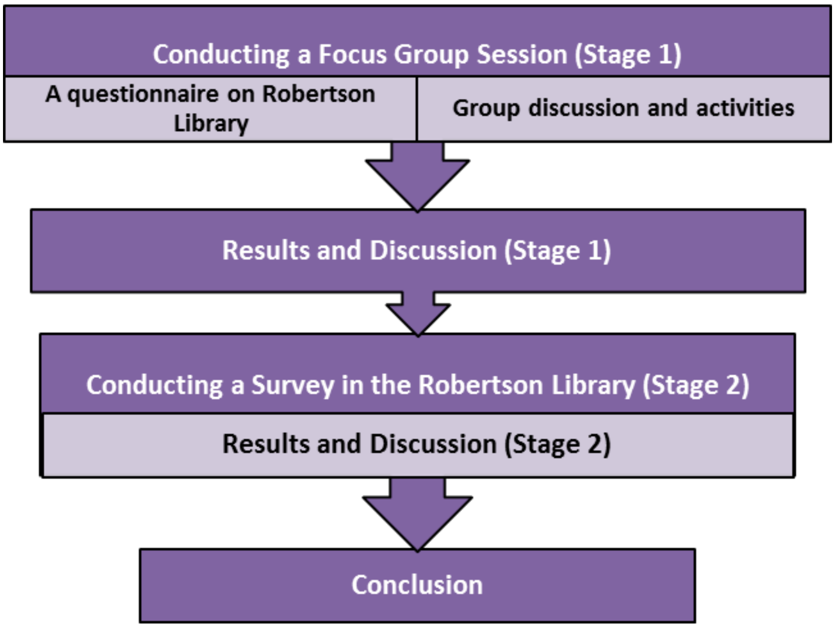


Figure 4-1: The Map of Cycle 3 (Study B)

4.1 Cycle 3 (Plan 3): The Aim of Study B (Stage 1): Focus Group

As mentioned previously, the selection of colours tested in Cycle 2 (Study A) was based on preceding studies which found that some colours such as yellow, red and blue are recommended for learning environments. The aim of Cycle 3 (Study B) was to select new colours for a new test in a rational and valid way by using a focus group method to explore in detail the participants' experiences of library learning spaces and to investigate what people think and how they feel regarding specific colours in the individual study room.

4.1.1 Focus Group Method

Over the past decade, focus groups have become a favoured technique for collecting qualitative data in the social sciences and a wide range of other academic research areas, as qualitative methodology has had wide acceptance in these disciplines (Hennink 2007). Wilkinson (2004) defines a focus group as an informal discussion among a group of selected individuals which is intended to examine a specific topic. The main aim of the focus group is to provide a range of opinions and rich information about perceptions, feelings, thoughts and impressions of people in their own words on particular research issues, and to gain an understanding of a specific issue from the group participants' perspective (Liamputtong 2009). The focus group is a flexible research tool, as the approach can be applied to gather information about any topic from various groups of people and various settings (Stewart, Shamdasani and Rook 2007).

A focus group aims to generate meaningful discussions among a group of six to eight individuals who share similar cultures, backgrounds or experiences, and hold a shared perspective on the research topic. They group together for one or two hours to discuss a specific issue with the help of a skilled moderator in a setting that provides a comfortable ambience (Hennink 2007).

A focus group method enables the researcher to examine people's different perspectives across several focus groups as they function within a social network, and participants discuss the issue with one another. The interactions among participants in a group discussion were expected to provide valuable data for the present study. In addition, this approach provided an opportunity for participants to express the logic that underpinned their opinions regarding suitable colour selections for learning activities in the learning spaces in the library, and their emotional reactions toward colours. It also gave participants an opportunity to discuss how colours might motivate students to study in the individual study spaces and to choose suitable colours for individual study rooms in university libraries.

Finally, Study B explored whether there is consistency between colours selected in Study A and the colours mentioned in the literature. Stage 1 focus group activities included a questionnaire about the Robertson Library and a series of questions to guide the discussion, followed by some activities.

4.2 Cycle 3 (Act 3): Preparation for Stage 1 (Focus Group)

As mentioned, the purpose of Cycle 3 (Study B) was to ask the participants to suggest suitable colours for learning in the individual study rooms in the library, and explain how colours affect their psychological and physiological states and learning activity.

4.2.1 Participants

Three focus groups were conducted involving a total of 17 students, to get their opinions about the impact of colour on their learning activity, and to suggest colours for the individual study area in the library building which would facilitate their learning. Small groups with five to seven participants per group were organised in order to facilitate an in-depth exploration of the issues. The size of the groups complied with Liamputtong's (2011) and Krueger and Casey's (2000) suggestions, as being the ideal size for enabling easy control and making sure everyone has an opportunity to share insights.

The participants chosen were university students (undergraduate and postgraduate) at Curtin University. University students were chosen for this study because the present study investigated the impact of colour on learning performance in the university libraries; therefore, students' perspectives are valuable, because they use library spaces for study frequently and they have knowledge and context. Borkan et al. (1995) argue that purposive sampling as opposed to random sampling in a focus group will provide the best information, add strength to focus group research and generate the relevant data for the topic investigated.

In addition, participants were from different populations in terms of gender and culture. Participants were recruited by written invitation after this research project was introduced to undergraduate and postgraduate students via the researcher's colleagues' networks.

4.2.2 Colour samples

Forty colour samples were chosen from British Paints and matched to the NCS Colour Atlas to be used in the focus group, by placing colour samples in the NCS colour atlas. The size of each colour sample was 10cm × 10cm; the colours used in the focus groups are illustrated in Figure 4–2. There are five nuances of each for eight hues. The central row includes colours of high chromaticness (vivid) that include the elementary hues (yellow, red, blue and green) and secondary hues (orange, purple, blue-green and green-yellow). In the top two rows the colours have increasing blackness (strong and deep) and the bottom rows have increasing whiteness (light and pale) (see Table 4–1 for NCS Atlas Notations of the Colour Samples). The researcher provided seven colours samples for each colour in order to ensure there were enough colour samples for all participants if they chose the same hue.

The terms were adopted from everyday language (Green-Armytage 2002) (see Figure 4–3). The colours vivid yellow, light yellow, vivid blue, light blue, vivid red and light red in this study were also used in Cycle 2 (Study A).

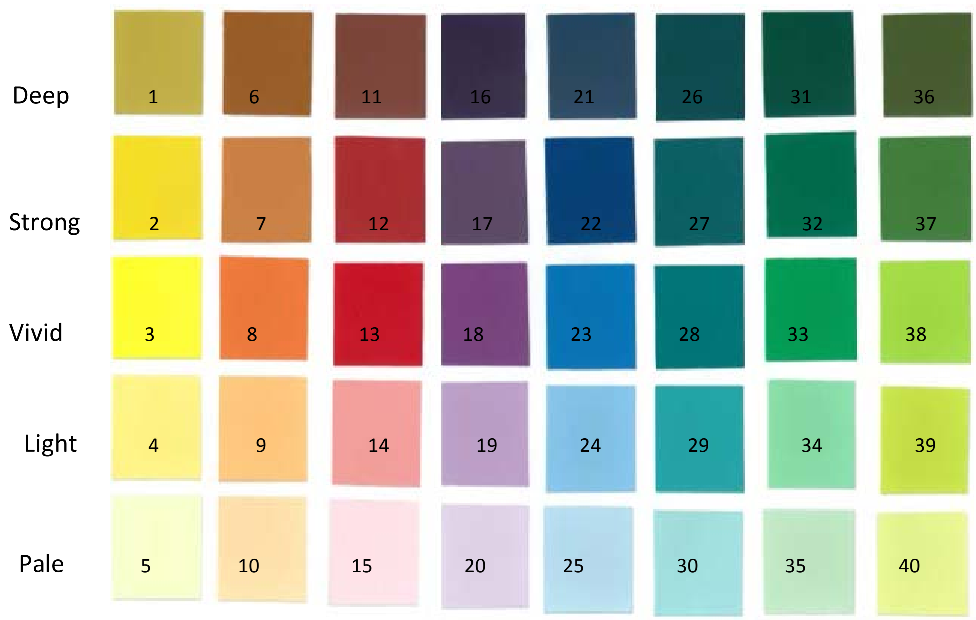


Figure 4-2: The Colour Samples Used in the Focus Group

(Al-Ayash 2013)

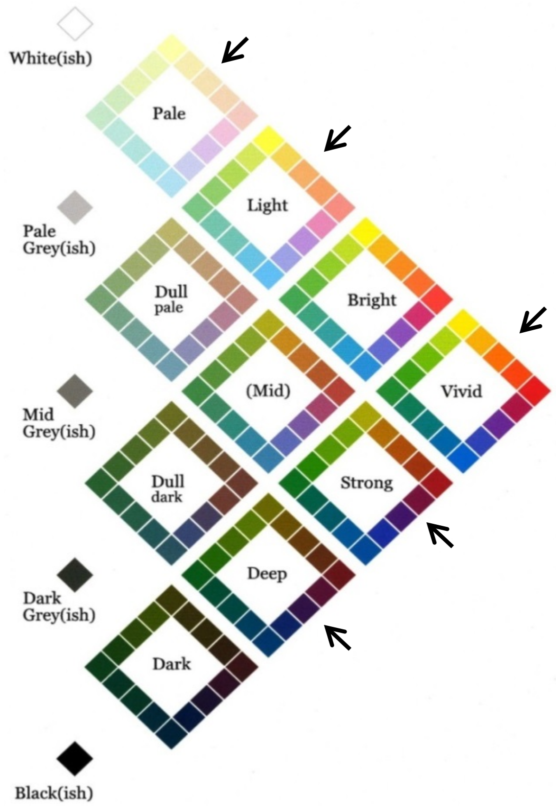


Figure 4-3: Colours chosen from the vivid, light, pale, strong and deep zones of the Colour Zones System

(Green-Armytage 2007, 9)

Table 4-1: NCS Atlas Notations of the Colour Samples

Colour Samples Number	NCS Atlas Notations
1	S 3060-Y (deep)
2	S 1080-Y (strong)
3	S 0580-Y (vivid)
4	S 0540-Y (light)
5	S 0520-Y (pale)
6	S 4050-Y50R (deep)
7	S 3060-Y50R (strong)
8	S 0585-Y50R (vivid)
9	S 0540-Y50R (light)
10	S 0520-Y50R (pale)
11	S 5040-R (deep)
12	S 3060-R (strong)
13	S 1080-R (vivid)
14	S 0540-R (light)
15	S 0520-R (pale)
16	S 7020-R50B (deep)
17	S 5040-R50B (strong)
18	S 3055-R50B (vivid)
19	S 1040-R50B (light)
20	S 0520-R50B (pale)
21	S 5040-B (deep)
22	S 3060-B (strong)
23	S 1565-B (vivid)
24	S 0540-B (light)
25	S 0520-B (pale)
26	S 7020-B50G (deep)
27	S 5040-B50G (strong)
28	S 2060-B50G (vivid)
29	S 1040-B50G (light)
30	S 0520-B50G (pale)
31	S 6030-G (deep)
32	S 4050-G (strong)
33	S 1565-G (vivid)
34	S 0540-G (light)
35	S 0520-G (pale)
36	S 6030-G50Y (deep)
37	S 4550-G50Y (strong)
38	S 0565-G50Y (vivid)
39	S 0550-G50Y (light)
40	S 0520-G50Y (pale)

4.2.3 Instruments

The five instruments used to collect data during the focus groups are described in the following sections.

4.2.3.1 Questionnaire

A questionnaire is an instrument that consists of the questions that are asked by the researcher directly (in face-to-face interactions) or indirectly (using papers) (O'Toole and Beckett 2010). There are three formats of a questionnaire based on question responses: closed questions, open questions, or both. Closed questions are difficult to construct but easy to analyse, whereas open questions are easy to construct but difficult to analysis (Sarantakos 2005). In this study, the researcher used a questionnaire including both closed and open questions.

The background questionnaire was about the Robertson Library at Curtin University and included three sections. The first section related to "demographic profile," the second section to "studying in the Robertson Library," and the third section to "the interior design of the library" (see Appendix 6).

4.2.3.2 Scale-Model of Individual Study Room

The model is a three-dimensional representation of an individual study space from the Robertson Library, made from Foam Board. The space is 2m wide x 2m long x 2.50m high, represented at scale 1:20, with three white walls and a dark grey floor. There was one white desk and a light grey chair (see Fig. 4–4).

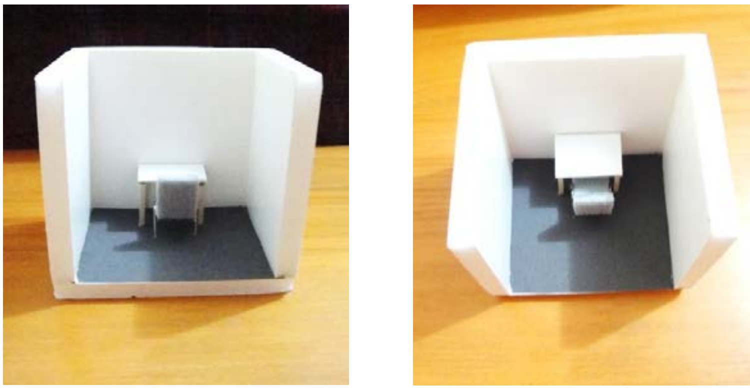


Figure 4-4: Simulated Model of Individual Study Room
(Al-Ayash 2013)

4.2.3.3 Adobe Photoshop CS5.1 Program

Participants were asked to test their chosen colours to design a colour scheme for the individual study space by using this program. A photograph was taken of the individual study room at Curtin library and used as the base image in this program.

4.2.3.4 Digital Tape Recording

In order to record the discussion and follow up the conversation of the focus group session, the researcher used a digital tape recorder.

4.2.3.5 Video Recording

A video recorder was used in the focus group sessions to record the particular body language and expression of the participants and also to accurately identify which colour samples the participants were referring to during their discussion.

4.2.4 Procedure

The focus group sessions were carried out at Curtin University in a conference room in the School of Built Environment. The participants were invited to attend and participate in focus groups. These focus groups were facilitated by an academic from the discipline of Interior Architecture. The facilitator began each of the focus group sessions by describing the purpose of the sessions, providing ground rules for the discussion, and introducing various questions for discussion. The researcher recorded the focus group sessions and wrote notes.

As is common in focus group research, the discussion format moved from the general to the specific in order to prevent narrowing of participants' dialogue too early. Each session lasted two hours. The sessions were recorded by digital recorder and video camera, and then transcribed.

After the topic was briefly presented by the facilitator, the process of the focus group was as follows:

1. Firstly, the participants were asked to spend 10 minutes answering a questionnaire about the Robertson Library at Curtin University. The purpose of this was to identify the participants' profiles, such as gender, age, study level and nationality, and to hear their opinions about the colour scheme in the Robertson Library and how it affects their learning activity.

2. Secondly, the participants were asked to give their opinions verbally regarding the importance of environmental colour in the learning spaces within the university library.

3. Thirdly, the participants were asked to select three appropriate colours for the individual study room from a wide range of colour samples presented to them on the table (see Fig. 4–5), and then write down their selections on a paper with the code number of each colour. This task was done individually although at a communal table.

Figure 4-5: Selecting three colours from a range of colour samples by participants

(Al-Ayash 2013)

4. Fourthly, the participants were asked to consider the placement of their selected colours in the model on one wall (the front wall of the desk) and select one colour from the three colours (in step 3) that they considered to be the most suitable for studying in the individual study area (see Fig. 4-6).

Figure 4-6: The participants examine the three colours inside model to choose a suitable colour for individual study room

(Al-Ayash 2013)

5. Fifthly, students were asked to give reasons for their colour selections, and they were asked about how the selected colours could motivate them to study and help them to concentrate. This step of the process involved an open discussion among participants.

6. Finally, the participants were asked to apply their selected colours (the colour placed in small model) in the image of the individual study room of the library via an Adobe Photoshop CS5.1 program, in order to allow them to see their selections of colours on a big screen and comment on each colour together and then select the best one. There was discussion between them throughout this process. They commenced

with the colours chosen in Step 4 but these were manipulated and changed with the computer program; the participants were asked to place the colours on the front wall over the desk because this is the main variable. In addition, they were invited to be free to use other colours from the first selection in step 3 on the side walls if they like.

Images were projected onto a screen to facilitate the process and discussion. The original image of the individual study room in the Robertson Library (see Fig. 5−7) was modified and layers with neutral colours were used in the Adobe Photoshop Program (see Fig. 4−8) to cover walls, ceiling, floor and desk. The NCS Swatches were downloaded for the Adobe Photoshop Program to select accurate notations of NCS colours. Figure 4–9 shows a number of questions identified to help direct the discussion.

Figure 4-7: Original image of individual study room at Robertson Library (Al-Ayash 2013)

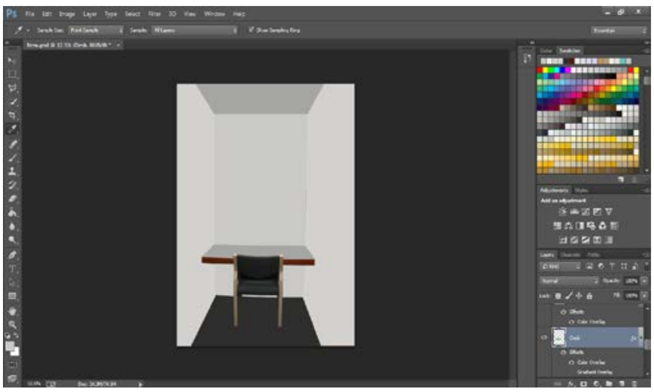


Figure 4-8: Image of individual study room at Robertson Library after modification using Photoshop program (Al-Ayash 2013)

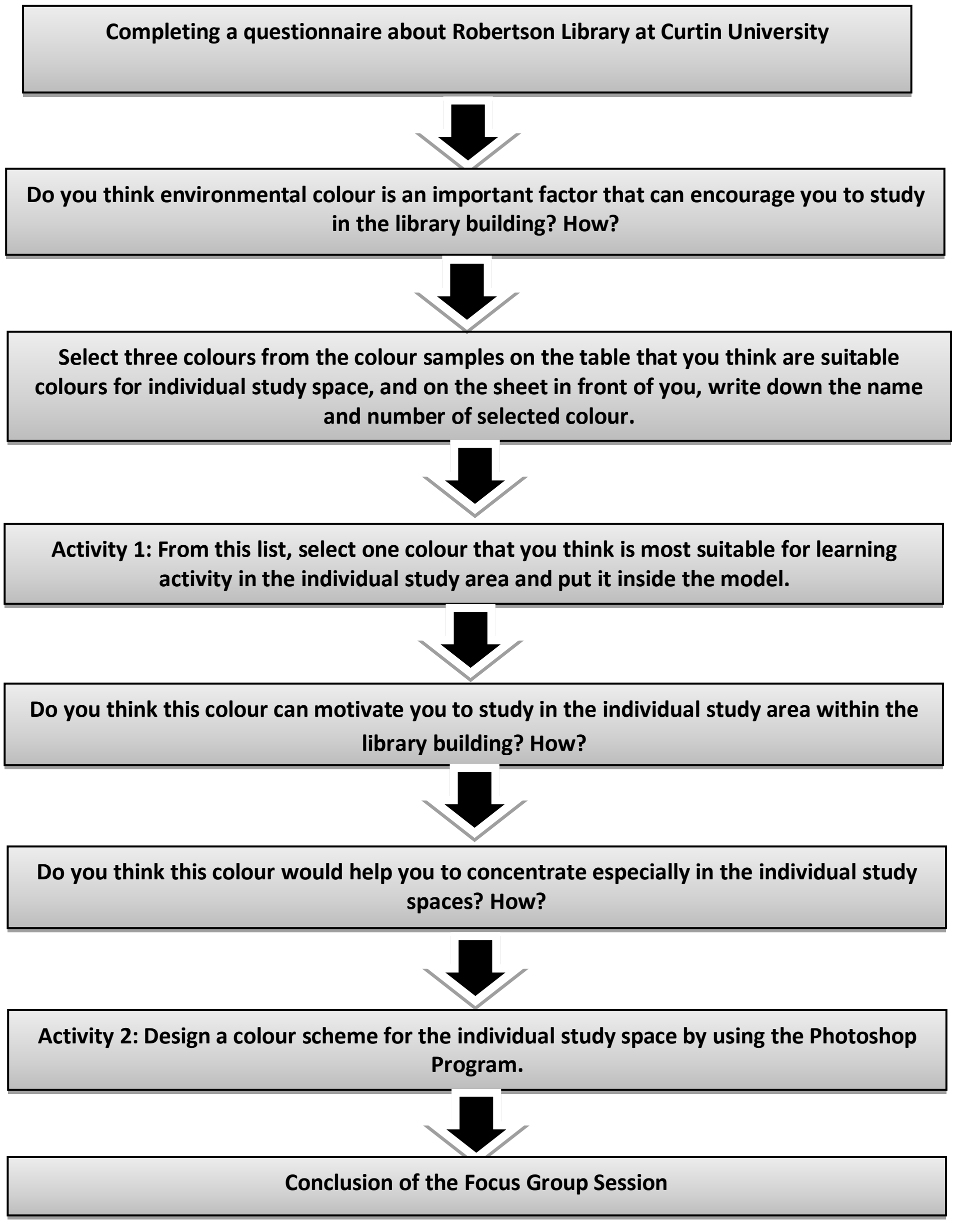


Figure 4-9: The questions and prompts used to guide a focus group discussion (Al-Ayash 2013)

4.3 Cycle 3 (Observe 3): Results of Stage 1: Focus Group

This section shows the results of Cycle 3 (Study B-Stage 1) of the focus group discussion which took place in two parts. The first part was a questionnaire about the Robertson Library. The second part involved group discussion and activities.

As in Cycle 2 (Study A), the same data analysis process was used in Cycle 3 (Study B) to analyse the qualitative data (see Chapter 3, Section 3.3.5 for more details). Each transcript was analysed using qualitative methods to identify key issues and themes. Statements and responses relating to the key colour in the individual study room and library spaces were highlighted manually and grouped. Codes were allocated for key themes and applied to the transcripts. The dominant themes to emerge from the findings of the focus groups were that participants believed that colour does impact on their experience in the following ways, influencing: emotions, associative properties, bodily responses, spatial perception, motivation, personal connections, and intellectual activity. The name of participants were coded and kept confidential.

The following sections report the findings from the focus group data and offer some general comments on suitable colours for individual study areas in the library, and how they can encourage students to engage in their learning.

4.3.1 Part 1: Results of Background Questionnaire of the Robertson Library

The purpose of using this questionnaire during the focus group session was to: a) gain information about participants' level of study, gender, age and nationality; b) learn how the students spend their time and what activities they do in the Robertson Library; and c) obtain students' opinions, perspectives and experiences about colours used in the library and their impacts on their emotions and learning.

There were three focus groups (A, B and C) consisting of seventeen academic students from different departments, seven undergraduate students and 10 postgraduate students, with 12 females and five males. Their ages were 22-35. Seven participants were Australian, one participant was Japanese, and nine students was from the Middle East. The characteristics of the participants in the focus groups are summarised in Table 4-2.

Table 4-2: Characteristics of Focus Groups

Focus Groups	No. of participants	Average age	Gender	Study level	Nationality	Field of Study
A	7	22-and 33	7 F	Undergraduate (6) Postgraduate (1)	Australia (6) Iraq (1)	Interior Architecture (6) Architecture (1)
B	5	22- and 35	3 M 2 F	Postgraduate (5)	Iraq (3) Saudi Arabia (1) Libya (1)	Architecture (1) Civil Engineering (2) Interior Architecture (1) Chemical Engineering (1)
C	5	22-and 35	2 M 3 F	Undergraduate (1) Postgraduate (4)	Japan (1) Iraq (3) Australia (1)	Nursing (1) Pharmacy (1) Environment and Agriculture (2) Media (1)

58% of the participants reported that they spent about one to two hours per day in the library building. As for study mode, 64% of the participants preferred studying alone and reading printed books rather than reading via computer or listening to lectures. In addition, they preferred to study in private rooms for more focus.

In regard to the impact of the interior design of the library on learning activity, the results revealed that 94% of the participants believed that interior design can impact on their learning performance. Firstly, the participants confirmed that interior design can impact on behaviour, such as encouraging interactions between students, controlling movement and influencing social behaviour; for example:

> A well designed space can encourage interaction among students to study. (Group #A, Participant 5)
>
> Interior design can impact on people's behaviour and interaction in the space to control movement and it influences people's comfort or study or being social. (Group #A, Participant 7)

> The interior design gives the first impression about the library and study environment that can affect the ability to continue studying. (Group #C, Participant 15)

> If the design is good that will help visiting library continuously. (Group #C, Participant 17)

Secondly, interior design can impact on emotion and mood; the participants reported that it would influence relaxation and calmness levels. Thirdly, they indicated that interior design can affect intellectual activity by affecting the concentration level of students; they asserted that good interior design can help students to focus on their tasks in the library building. They made comments such as:

> By use of different design elements such as materials, patterns, textures and colours, that will create calm and relaxed spaces to facilitate learning. (Group #A, Participant 6)

> A well designed environment gives good feelings and comfortable atmosphere to study. (Group #B, Participant 8)

> Lighting, acoustics or furniture can help students to focus and study. Also there are probably colours that better facilitate learning than others e.g. may be more calm colours. (Group #A, Participant 1)

When questioned about the impact of colour on learning performance in the library building, all participants asserted that colour had an important impact on students’ learning activity in the library building. They mentioned that colour can impact directly or indirectly on learning activities by affecting their emotions, bodily responses, and intellectual activity. They made comments such as:

> Colour affects mood, for example light colours make me feel positive more awake and focused. (Group #A, Participant 7)

> I think moderate colours are good for learning. Sometimes warm colours help to stimulate my thinking and creativity, while cold colours make me feel calm and relaxed. (Group #C, Participant 16)

Some participants reported that colour influences comfort level, duration of using the space and motivation; they made similar comments, such as:

> Colours influence your comfort levels, more comfort means more effective study and [you are] more likely to use space for longer. (Group #A, Participant 3)

> Colours can impact on my focus and the period of study. E.g. too much bright colours can make me feel tired and they upset me, so I cannot stay for a long time to study in this space. (Group #B, Participant 9)

> Colour has an impact on individuals' learning as it can increase concentration, motivation and could be a reason for how ideas are developed. (Group #A, Participant 6)

The participants were questioned on their satisfaction level with the existing colour schemes in the group study room (Fig. 4–10) and the individual study room (Fig. 4–11) in the library building at Curtin University. The respondents were not satisfied with the existing colour schemes of these rooms. The colours used in these rooms as shown in Figures 4-10 and 4-11 are light grey for the walls and dark grey for the floor in focus group study rooms, while light beige and timber for walls and dark grey for floor in the individual study rooms.

The results show that 58% of the participants believed that the existing colours in the group study rooms have negative effects on their emotions and bodily responses. They were perceived as gloomy, very dull, cold, depressing and boring, making students feel less active, tired, sleepy and promoting eye strain. Further, the respondents considered the existing colours in the group study rooms to be associated with institutional spaces. The participants commented:

> Very dull and uncomfortable [colours] for eyes. It makes me feel tired. (Group #A, Participant 2)

> It is like a very traditional type of learning environment. It seems less inviting and interesting. (Group #A, Participant 6)

> Very neutral colours and I feel bored and sleepy. (Group #B, Participant 10)

> Very dull and less stimulating. (Group #A, Participant 5)

However, 41% of participants believed that the colour scheme of the group study rooms had a positive impact on their emotions, intellectual activity and performance. They reported that the plain and neutral colours of these rooms made them feel relaxed and active, which increased their concentration and encouraged them to study for a long time. For example, the participants commented:

> It encourages students to continue [for a] longer time to study or discuss their topics. (Group #C, Participant 17)

> Although it is a plain colour, the walls give a neutral feel, students can feel relaxed not distracted by bold colours. (Group #C, Participant 13)

> I feel more relaxed in this room; the white colour is good for concentration and discussion. (Group #C, Participant 14)

82% of participants were also dissatisfied with the colour scheme of the individual study rooms (Fig. 4–11). It was believed that the colours used in these rooms had a negative influence on their emotions, because they were perceived as depressing, warm, boring, dull, dark and gloomy. In addition, it was believed that colours used in these areas were distracting and made them feel trapped and restricted in a small space. Therefore, the participants emphasised that the existing colours did not encourage them to study for a long time because they could not focus on their tasks and the colours impacted passively on their bodily responses.

> All surrounding wood makes me feel very restricted and boxed in. (Group #A, Participant 5)

> Not interesting colours and very gloomy, very institutional. (Group #B, Participant 10)

> It is quite dull and boring to study. (Group #A, Participant 6)

> It is not efficient and it does not help to focus, it causes eye fatigue and headache. (Group #A, Participant 1)

Figure 4-10: Colour scheme in the group study room
in Robertson Library at Curtin University
(Al-Ayash 2013)

Figure 4-11: Colour scheme in the individual study room
in Robertson Library at Curtin University
(Al-Ayash 2013)

As for emotional state, 76% of the participants asserted that their emotions were affected by colour schemes while studying in the library building, whether in negative or positive ways. The results indicate that most participants did not like to study in the spaces of the library building because they found them unstimulating, uninviting and very formal.

> The colours of study areas are cold and uninviting, that makes me feel bored. (Group #A, Participant 3)

> When I did study in a yellow corner on Level 5, I felt nervous, because there is bright yellow. (Group #B, Participant 9)

> The colours of Level 2 make me feel happy and relaxed. So I prefer to study there with my friends because it puts me in positive mood. (Group #A, Participant 7)

The participants were asked to identify a space in the Robertson Library building that has a suitable colour scheme for study. The results indicate that Level 2 has an appropriate colour scheme for study activities, because it is perceived as an interesting, exciting and inviting space (Fig. 4-12). As shown in figure 4-12, the spaces are colourful, with warm and cool colours such as orange, red-blue, green and purple used. 60% of the participants reported that the colours used in Level 2 are nice, vibrant, friendly and active. The participants made similar comments:

> The main floor [Level 2] in open space has vibrant colours which makes the space interesting and exciting. (Group #A, Participant 2)

> Level 2 is good because it has different colours and that suits everyone who may use the library. (Group #C, Participant 15)

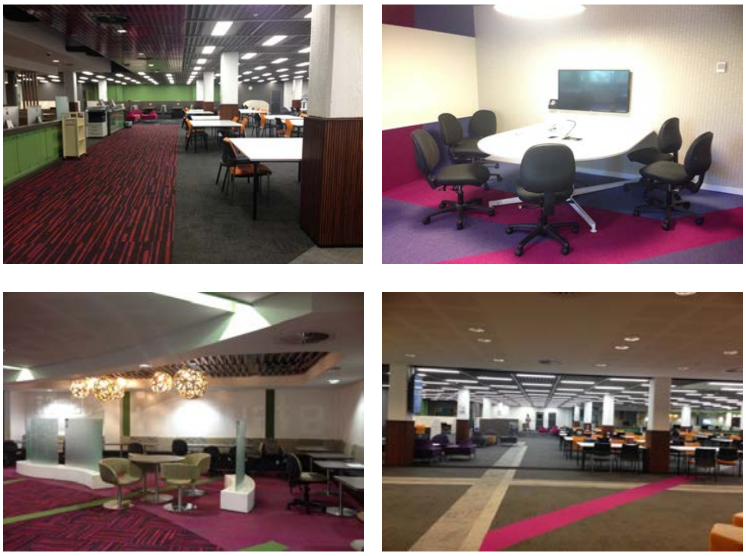


Figure 4-12: Level 2 in Curtin Library

(Al-Ayash 2013)

In addition, the participants were asked to identify spaces in the Robertson Library building that have unsuitable colour schemes for study. The participants confirmed again that the individual study rooms (see Fig. 4-11) have unsuitable colour schemes, because the colour of timber used in these areas was depressing, boring, heavy and gloomy.

> The individual study spaces are really boring and depressing because the colour of the timber is too heavy and stuffy. (Group #A, Participant 1)

> Individual study room is boring and it does not encourage me to study more. (Group #C, Participant 16)

Moreover, other participants confirmed that the upper levels' colour schemes are not good because they have the same light grey colour (Fig. 4-13). They were considered too neutral, less active and not interesting. The participants made comments such as:

> Level 4, 5 and 6, they are all one colour scheme and are not interesting or appealing. (Group #A, Participant 6)

> Level 3 and 6, they are too neutral and very depressing. (Group #A, Participant 7)

Figure 4-13: Upper levels in Robertson Library

(Al-Ayash 2013)

4.3.2 Part 2: Focus Group Discussion Results

The results are described for each question following the sequence set out in Figure 4-9. The results were discussed according to the themes identified in Section 4.3.

Prompt 1: Do you think environmental colour is an important factor that can encourage you to study in the library building? How?

Overall, participants in all three groups agreed that environmental colour plays an important role in the learning environment within the library building by encouraging students to study and enjoy being in the spaces. In addition, they reported that colours can impact on their learning performance negatively or positively in different ways.

Many students mentioned that colour might affect their moods, emotions and behaviour:

> I know there are some colours are more relaxing than others… helping [one to] engage more than others… that is what I really know. (Group #A, Participant 1)

> I spent a lot of time last semester in the library building to do my thesis. I think you do not think about colour much when you in there to study, but I think if you go back in you reflect on why you were that specific mood, and you think that maybe the interiors of the space had some effect on how you behave. I can remember I was specifically positive when I was in the quiet area in Level 6 you can look out and look at the weather, therefore, colour can impact on how we feel especially having natural light, and it is stimulating for me. (Group #A, Participant 7)

> Yes, I think colour plays an essential role in the interior spaces because it can impact psychological and physiological aspects of people… e.g: it can change our moods… warm colours like red, yellow and orange can make us excited, while cool colours like blue and green make us relaxed and calm. Therefore, it is an important factor to encourage us. (Group #B, Participant 10)

Some students indicated that colours can impact on concentration level, motivation and performance. For example, one student stated that she experienced a distinct level of discomfort when she was studying at home because of the unsuitable colour scheme used there. As she explained:

> In fact, there is a difference between studying in the library and at home because the colours are different… in the library I feel more comfortable because the colour scheme looks normal and comfortable and encourages me to think, and it activates and motivates me to work and focus on what I am studying… not distract me or take me away. (Group #C, Participant 16)

The students also recalled their experiences of colour effects and associations in the library building:

> I remember back a few years ago. We had to study… we went to the library doing some group. There were horrible boxes, blue carpet, blue light it was like a mental asylum… wanted to go home it was horrible. (Group #A, Participant 3)
> I think if I feel happy with certain colours that will help me to stay and continue to study for a longer time. As I mentioned in the survey, one day when I was studying in the engineering department… actually I felt nervous while I was studying because the place had a strong colour; it was red, and I couldn't stay to study for one hour… I did leave the space and I went to the library to study there. So, yes colour can impact on the student's performance in the library. (Group #C, Participant 17)

> I totally agree, that colour can encourage students to study; I think white or light colours are good for studying, for example, a few days ago I went with my friend to study in the library and the room had dark colours… I couldn't stay and I asked my friend to find another room with light colours. (Group #B, Participant 8)

One participant mentioned that colour can be used to navigate within the library building so that students can easily find certain areas:

> I think it is also interesting to know that when you go in there [library building] … people find difficult to navigate around the space especially plan levels, inquiry level, or regular books or the study rooms. People in the library help you find your area, actually doing that by using colour coding would be easier for students to find the specific area, because students do not know where they are or where

> [they are] supposed to look, especially for first year students. (Group #A, Participant 5)

Another student commented that colour might influence spatial perception, such as the size of a space:

> Colour can impact on the size of the space, make it bigger or smaller. (Group #B, Participant 11)

Prompt 2: Select three colours from the colour samples on the table that you think are suitable colours for an individual study space, and on the sheet in front of you, write down the name and number of selected colours.

Each participant selected three colours from colour samples that were available on the table that they thought were suitable colours for an individual study area (see Table 4–3).

Table 4-3: The three selected colours and their NCS notations

Group No.	Participants	Colour 1	Colour 2	Colour 3
A	1	4= S 0540-Y	9= S 0540-Y50R	40= S 0520-G50Y
	2	40= S 0520-G50Y	3= S 0580-Y	9= S 0540-Y50R
	3	3= S 0580-Y	5= S 0520-Y	40= S 0520-G50Y
	4	40= S 0520-G50Y	4= S 0540-Y	9= S 0540-Y50R
	5	28= S 2060-B50G	29= S 1040-B50G	24= S 0540-B
	6	9= S 0540-Y50R	4= S 0540-Y	20= S 0520-R50B
	7	4= S 0540-Y	20= S 0520-R50B	30= S 0520-B50G
B	8	4= S 0540-Y	5= S 0520-Y	40= S 0520-G50Y
	9	15= S 0520-R	5= S 0520-Y	9= S 0540-Y50R
	10	1= S 3060-Y	15= S 0520-R	9= S 0540-Y50R
	11	38= S 0565-G50Y	40= S 0520-G50Y	9= S 0540-Y50R
	12	5= S 0520-Y	4= S 0540-Y	40= S 0520-G50Y
C	13	40= S 0520-G50Y	4= S 0540-Y	15= S 0520-R
	14	30= S 0520-B50G	5= S 0520-Y	35= S 0520-G
	15	9= S 0540-Y50R	1= S 3060-Y	24= S 0540-B
	16	24= S 0540-B	5= S 0520-Y	35= S 0520-G
	17	30= S 0520-B50G	5= S 0520-Y	35= S 0520-G

The results revealed that 90% of the participants selected colours with a high level of whiteness and less chromaticness (see Table 4-4). The colours chosen by participants as suitable colours for individual study rooms were as follows: Light orange (no. 9) and pale green-yellow (no. 40) were deemed appropriate colours among participants in all three groups. Two different colour samples of yellow (light yellow no .4, pale yellow no. 5) were their second choice. Light blue (no. 24), pale pink (no. 15), pale green (no. 35) and pale blue-green (no. 30) were less preferred than the previous colours. Vivid yellow (no. 3), deep yellow (no. 1), vivid blue-green (no. 28), vivid green-yellow (no. 38), pale purple (no. 20) and light blue-green (no. 29) were even less preferred by participants. Refer to Figure 4–14 for the colours selected by participants in all three groups and their position in the NCS triangle. Figure 4-15 shows the chosen colours in the NCS colour circle.

Table 4-4: The percentage of chosen colours

Colours Chosen	NCS Notations	Number of participants
Deep yellow (1)	S 3060-Y	2
Vivid yellow (3)	S 0580-Y	2
Light yellow (4)	S 0540-Y	7
Pale yellow (5)	S 0520-Y	7
Light orange (9)	S 0540-Y50R	8
Pale pink (15)	S 0520-R	3
Pale purple (20)	S 0520-G50Y	2
Light blue 24	S 0540-B	3
Vivid blue-green (28)	S 2060-B50G	1
Light blue-green (29)	S 1040-B50G	1
Pale blue-green (30)	S 0520-B50G	3
Pale green (35)	S 0520-G	3
Vivid green-yellow (38)	S 0565-G50Y	1
Pale green-yellow (40)	S 0520-G50Y	8

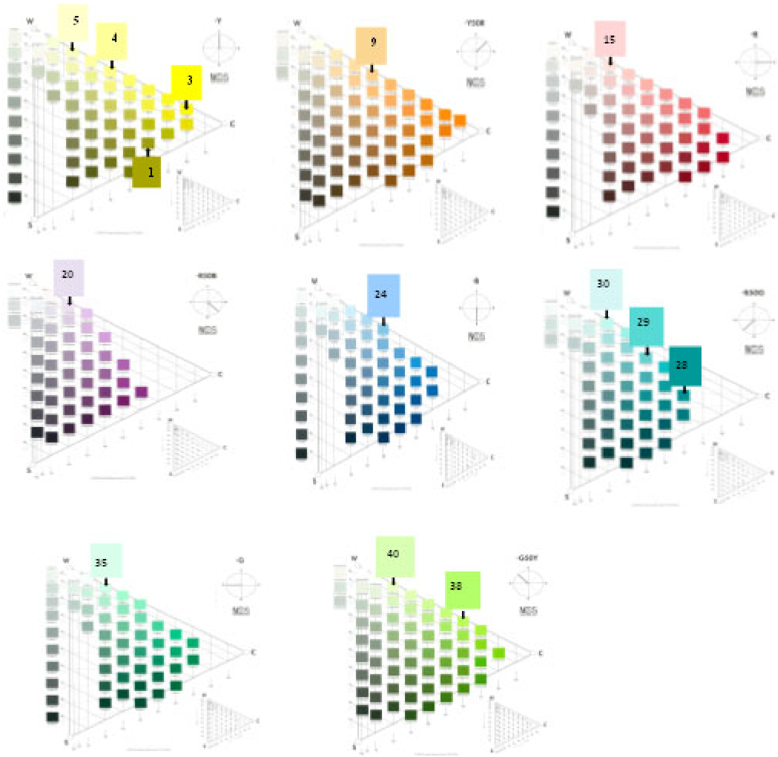


Figure 4-14: First selection of colours by participants in all three groups (Al-Ayash, 2013)

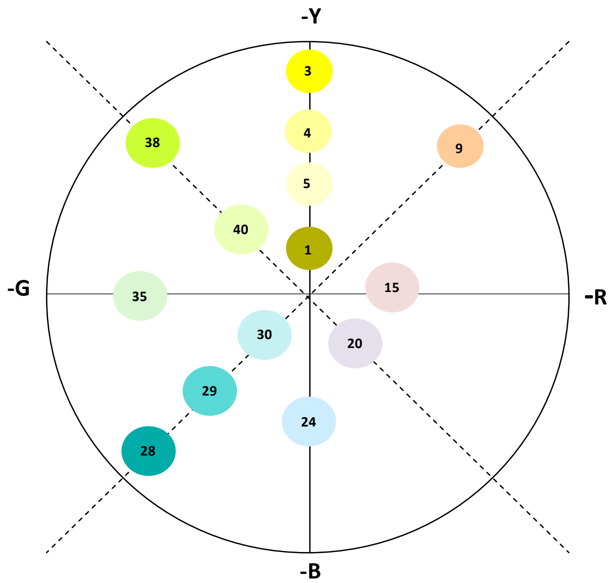


Figure 4-15: First selection of colours by participants in all three groups and their positions in the NCS colour circle

(Al-Ayash 2013)

Prompt 3: Activity 1: From this list, select one colour that you think is most suitable for studying activity in the individual study area and put it inside the model.

As previously described, in this activity the participants were asked to experiment with the three selected colours in the small model to choose one colour (for the front wall of the desk) that they thought was more suitable for learning activities in the individual study space. The small model depicts the original individual study space in the library building (refer to Fig. 4–4 for simulated model). The participants worked individually for this activity.

Six colours were chosen by participants across the three groups as appropriate colours for individual study areas in the library building (see Table 4-5). These are pale green-yellow, pale yellow, light orange, light blue-green, deep yellow and pale purple (see Figs. 4–16 and 4–17). Pale yellow (no. 5) and pale green-yellow (no. 40), both colour samples with high whiteness and low chromaticness levels, were chosen by a high number of participants as suitable colours for learning activities in the individual study area in the library; 35% of the participants chose pale yellow, and 30% of the participants chose pale green-yellow.

Table 4-5: Second selection of colours for one colour by participants in all three groups

Colours Chosen	NCS Notations	Number of participants
Pale green-yellow (40)	S 0520-G50Y	5
Pale yellow (5)	S 0520-Y	6
Light orange (9)	S 0540-Y50R	3
Light blue-green (29)	S 1040-B50G	1
Deep yellow (1)	S 3060-Y	1
Pale purple (20)	S 0520-G50Y	1

The main reasons given for choosing pale yellow were that the colour stimulates memory processes and assists concentration. For example, pale yellow reminded the respondents of the yellow walls of educational environments such as their classrooms and old books. Also, one participant pointed out that pale yellow is associated with aspects of nature like the desert. As three focus group participants explained:

> I remember when I studied 15 years ago; our classroom was like this colour [pale yellow]… maybe our country has a big desert area, and I remember people had good memories with this colour, may be they come from the desert. Another reason is old books have this colour, and so that's why I think this colour is the best for learning. (Group #B, Participant12)

> Because I am a civil engineer and I see this colour [pale yellow] in many places especially in educational spaces… so I think it is suitable for students and schools. In addition, I like this colour. (Group #B, Participant 9)

> I selected light yellow [pale yellow] as well, because it is similar to my country's wall colours. In Japan, you can see like this colour [pale yellow] in many places in my country to paint walls, and also it is comfortable for me and it's easy to concentrate on my studying. (Group #C, Participant 14)

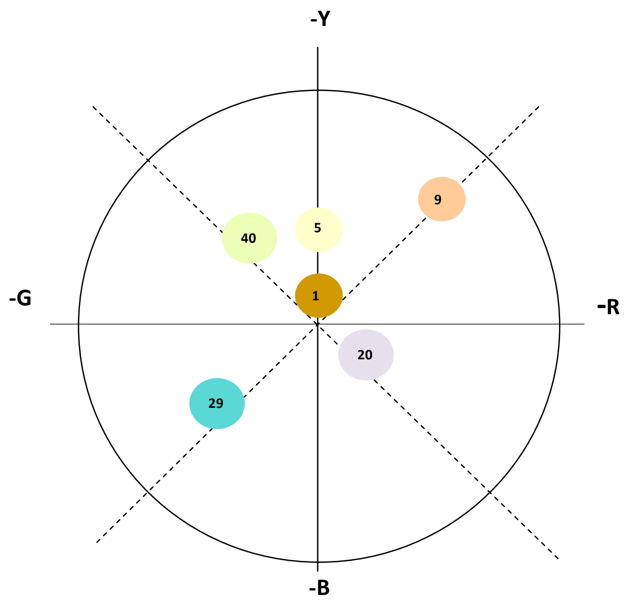


Figure 4-16: Second selection of colours by participants in all three groups and their positions in the NCS colour circle

(Al-Ayash 2013)

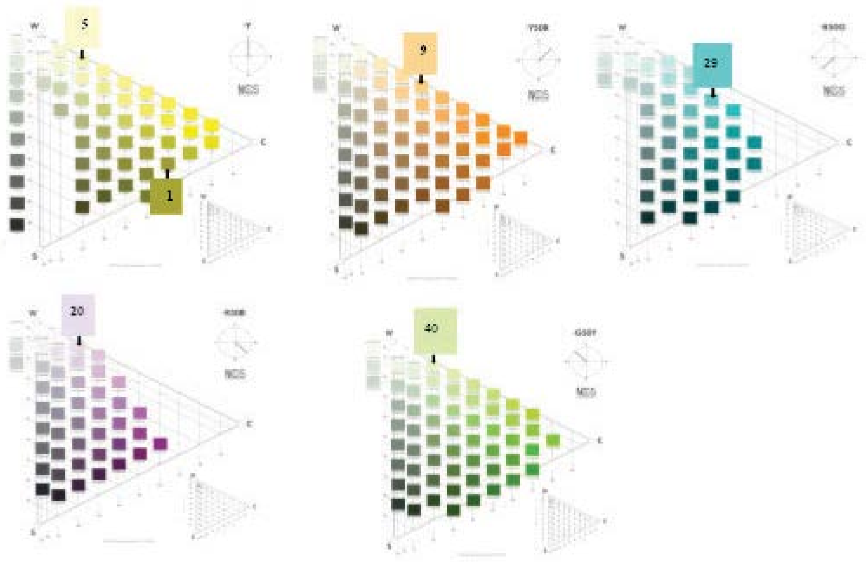


Figure 4-17: Second selection of colours by participants in all three groups and their positions in the NCS triangle (Al-Ayash 2013)

As for pale green-yellow (no. 40), the participants who chose this colour mentioned different reasons. Some participants chose it as a personal preference. For instance, two participants mentioned that the colour green is their favourite colour and they liked it because it is associated with positive emotions such as relaxation, happiness and calmness. In addition, they believed that pale green-yellow can impact on the bodily state of students in a positive way, because it is considered comfortable for the eyes and not distracting. They commented:

> To be honest, I like the colour green and it is my favourite colour. I think it makes me feel happy and it is not too bright and not distracting, also it makes me feel calm, but I generally like green. (Group #C, Participant 13)

> For me I like green colour, but I think light green [pale green-yellow] is suitable for study rooms, it is comfortable for my eyes and I feel relaxed, and helps me to focus on my work. (Group #B, Participant 11)

Other participants believed that pale green-yellow has positive effects on thinking and performance. In addition, it was considered to be related to natural aspects such as grass and outdoors. The participants made comments such as:

> Basically the existing colours in the library are depressing me. So, I chose this colour [pale green-yellow] that best depicted what I see through the window like sun, a few trees and sky. (Group #A, Participant 1)

> I think it [pale green-yellow] is a nice colour, because it is vibrant, not too strong, cheerful and quite bright but not overpowering, but if all the walls are covered in it, I am not gonna feel good…Also it is suitable for male and female, and I think it is easy to match with the furniture theme. (Group #A, Participant 2)

> Uh… same colour, it is a natural colour, and it is nice and light and quite warm colour or warm green; it is comfortable, it can stimulate [me to] think well. (Group #A, Participant 3)

The light orange colour sample (no. 9) with medium whiteness and medium levels of chromaticness was chosen by 18% of participants as an appropriate colour for studying in the individual study area. The main reason given for choosing light orange was that it stimulates emotions of comfort and calmness. Also, it can impact on intellectual activity and bodily response in a positive way. The participants explained that:

> I selected light orange because I feel it is comfortable for me if I will study there. Sometimes I feel bored from studying… so this colour is light one and maybe helps me to focus and doesn't disperse my mind. I think it will be good for studying and make me more awake, but some colours like too light colours make me like to sleep. (Group #C, Participant 15)

> I have chosen this colour [light orange]… I think it is quite calm and not too bright, quite settled and comfortable. (Group #A, Participant 6)

As for other colours, deep yellow (no. 1), light blue-green (no. 29), and pale purple (no. 20), they were considered suitable colours for learning spaces by a few students; each colour was chosen by one participant in two groups. The participants confirmed that these colours can motivate them to study and help to focus because they have a positive impact on their emotions, and are also comfortable for their eyes. The participants explained:

> I picked [light blue-green] because it's sort of like teal blue-green colour and I think it is easy colour for eyes and comfortable, and that is good for concentration, and also it is a calm and nice colour… umm and not a distracting colour. (Group #A, Participant 5)

> I chose this one [pale purple], because doesn't take away the focus but is more subtle and I like it. (Group #A, Participant 7)

> I selected a colour mix between yellow and green [deep yellow], and this colour makes me awake… and quite relaxed and [I can] keep studying. It is a stimulating colour… and also makes space seems spacious. It is interesting for me. (Group #B, Participant 10)

Prompt 4 and 5: Combining two questions related to motivation and concentration

When the participants were questioned about the ability of the selected colours to motivate students to study and help them to concentrate, all students asserted that their selected colours motivated them to study and helped them to focus in different ways. The participants believed positive emotions, a natural aspect and a level of comfort can motivate them to study and assist concentration. The participants made comments such as:

> I think if I don't feel comfortable in the study space I cannot stay and I cannot concentrate… it depends on my emotion. If I feel happy in the specific space that would help me to study… and the space will be motivating. (Group #C, Participant 17)

> In fact I prefer looking on a more natural colour as well if I am studying rather than something too vibrant or a kind of artificial colour, because I want to concentrate on what I am doing and it makes me feel relaxed. This sort of colour [light green-yellow] is fairly natural, more than beiges or browns and I think that would motivate me because I do not feel like I am in a booth but it is a kind of natural environment and colour can reflect that. (Group #A, Participant 2)

Other students talked about the impact of colour on spatial perception. For example, one participant explained that:

> I believe colour is an important factor to motivate me to study especially in this area [individual study room] because it is a small

> and enclosed area and you just face a solid wall, so it needs to be more comfortable, and a nice place to be motivated to study and colour can reflect that because sometimes we feel bored from studying, and this links to motivation. As well, I think motivation and concentration are linked together, because if you are motivated to study you can concentrate well. (Group #C, Participant 15)

However, there were contrary opinions about the aspects of motivation. Some students believed that relaxation and calm feelings might motivate students to study and enhance their concentration levels.

> In fact, deep yellow is very depressing, that is not going to motivate me to study… it does not help me to focus or concentrate because I feel bad and uncomfortable with this colour… while light green [pale green-yellow] will help because it creates a relaxed environment and when I feel relaxed I can focus on my reading or work. (Group #B, Participant 11)

Other students saw the opposite; they stated that relaxation and calm feelings would make students less active and sleepy, which would impact negatively on their concentration. For instance, one participant commented:

> For pale yellow, it looks like a neutral colour and boring, because it is too light and I cannot concentrate with this colour… it does not motivate me to study, but my colour [deep yellow] is a stimulating colour to study and interesting; it can influence my nervous system, I feel comfortable with it. So I will concentrate well… but for light green [pale green-yellow] it makes me feel too relaxed and calm, and I want to sleep… so I cannot focus on my work with light green, it is good for relaxation not for studying. (Group #B, Participant 10)

Prompt 6: Activity 2: Designing colour scheme for individual study room via Photoshop program on the computer.

After each participant selected one colour from the three colours by applying it in the small model individually, then the participants were asked to use the colours they selected for the model (second selection) and apply these selected colours to the image of the individual study room of the library via Adobe Photoshop CS5.1 on the computer. The decision were reached through discussion and working as a group. The front wall of the desk was the main focus as the students face this wall when they study in the individual study room, and it has a dominant impact. The participants of the three groups were asked in this stage to place the colour on the wall in front of the desk, but they could use more than one colour applied to other walls if they found this suitable.

This activity gave the participants a chance to see their selections of colours on a big screen and make comments on each colour together. They were also asked to discuss amongst the group the selection of suitable colours for learning activities in the indivual study room, and to explain how their selected colours might impact on their study.

Group A:

All participants in Group A preferred to apply their selected colours on one wall (the wall in front of the desk), because they believed it would be too much and very distracting if they used their selected colours on all walls. They suggested that using the colour off-white for the side walls would make the area appear more spacious. The selected colours for the small model in a group A were pale green-yellow, light orange, light blue-green and pale purple.

The participants of Group A started with pale green-yellow (no. 40) which was applied to the wall in front of the desk in the individual study room. The side walls were coloured green-yellow off-white with a dark brown desk, dark grey floor and light grey ceiling (Fig. 4−18).

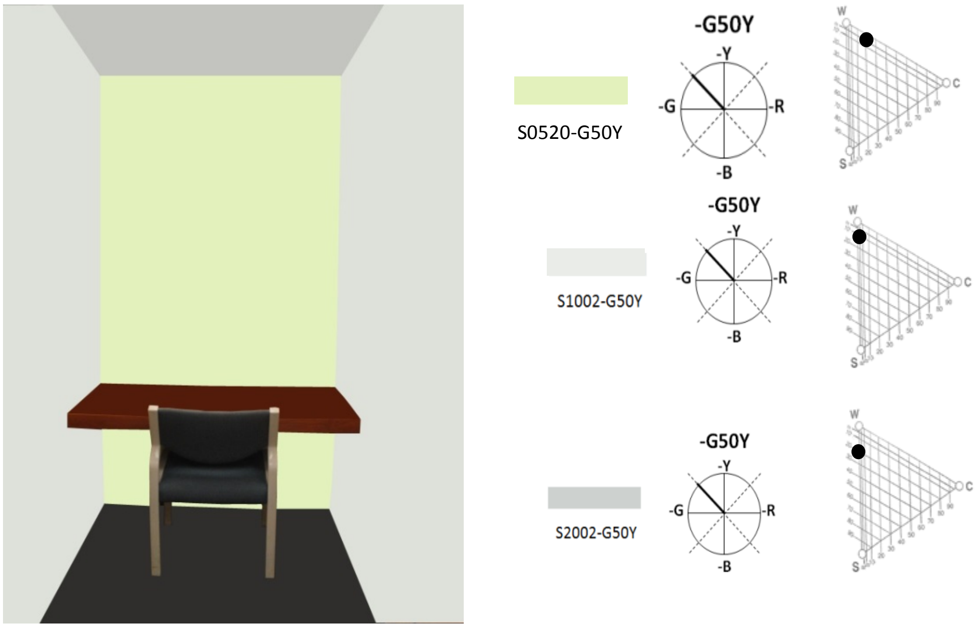


Figure 4-18: Testing pale green-yellow scheme in Photoshop program by participants, and locations of the colours within NCS colour space

Participants suggested off-white for the side walls and dark brown for the desk in order to make a nice contrast in this space to increase attention and reduce reflection of light from the desk. They made similar comments such as:

> The contrast with desk colour and walls is good for attention, because if we use a light colour for the desk with pale green-yellow on the front wall, it will be very close. So I think the contrast is good with books papers and it increases attention. (Group #A, Participant1)

> I agree with GV-1 that the colour of desk should be dark, because using very light colours may cause distraction. (Group #A, Participant 5)

As can be seen in Figure 4−19, light orange (no. 9) was used for the wall in front of the desk; the participants used orange off-white for the side walls with dark brown desk, dark grey floor and light grey ceiling.

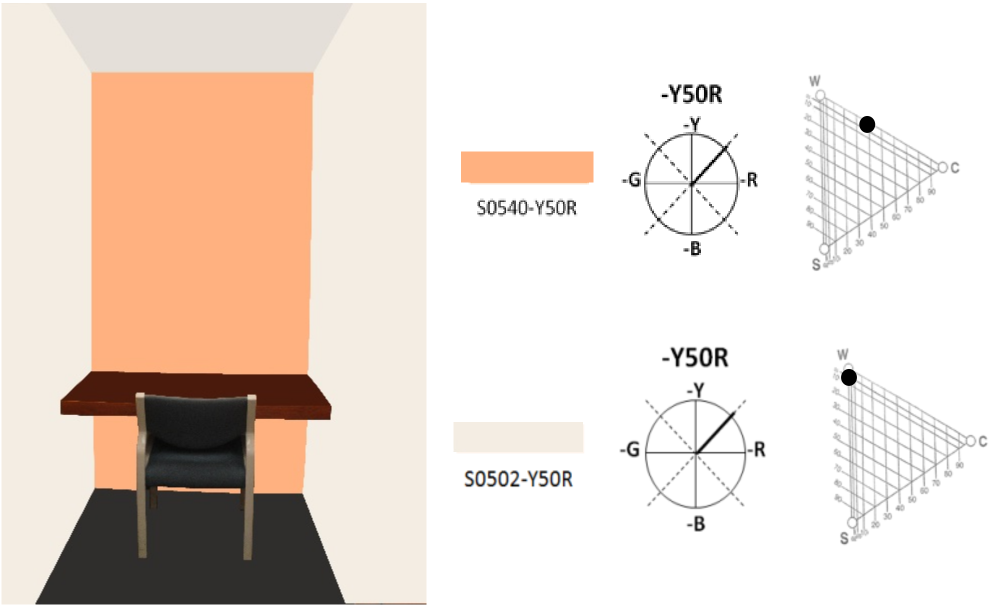


Figure 4-19: Testing light orange scheme in Photoshop program by participants, and locations of colours within NCS colour space

Most Group A participants believed light orange is a less motivating colour than pale green-yellow. They described this colour as a distracting and depressing colour. They commented:

> I will not go to a space like that [light orange], because it looks like a book shop and it strain my eyes and feels depressing. The green is nicer. (Group #A, Participant 5)

> I like the green one [pale green-yellow]… I think it is good for the eyes. And orange is very distracting. (Group #A, Participant 7)

The participants moved to another colour scheme, light blue-green (no. 29) (see Fig. 4−20). This colour was applied on the wall in front of the desk with orange off-white on the side walls. The colour of the desk and carpet was changed to light brown.

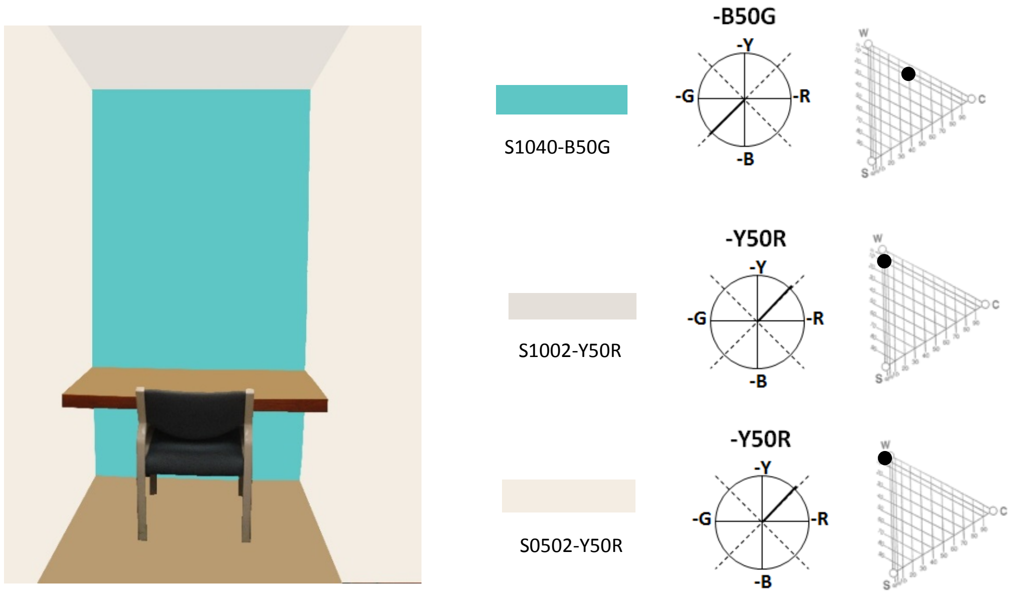


Figure 4-20: Testing light blue-green scheme in Photoshop program by participants, and locations of colours within NCS colour space

In general, responses to the colour light blue-green were negative. The majority of the participants reported that light blue-green is not a suitable colour for a learning environment, particularly in the individual study area; it was perceived as an uncomfortable colour for the eyes and for studying. They made comments such as:

> I think it’s not comfortable… it’s dark and so close to my eyes. (Group #A, Participant 4)

> Personally, I don’t like this colour… it is beautiful colour, may be good for open areas but not good for close individual study room; it looks artificial and I would rather be in a natural space with natural colour. (Group #A, Participant 2)

In regard to pale purple (No. 20), it was suggested that this colour should be on the wall in front of the desk and the other walls should be purple off-white, with grey and dark brown for the desk (see Fig. 4–21). After applying this colour in the computer program (Photoshop) the participants reported that it was not a suitable colour for learning activities because it made them feel sleepy and less active:

> Yes I think I will sleep in the purple space… it looks like a spa area. (Group #A, Participant 3)

> It is good for relaxing and good for a bedroom… I think it is not good for study. (Group #A, Participant 6)

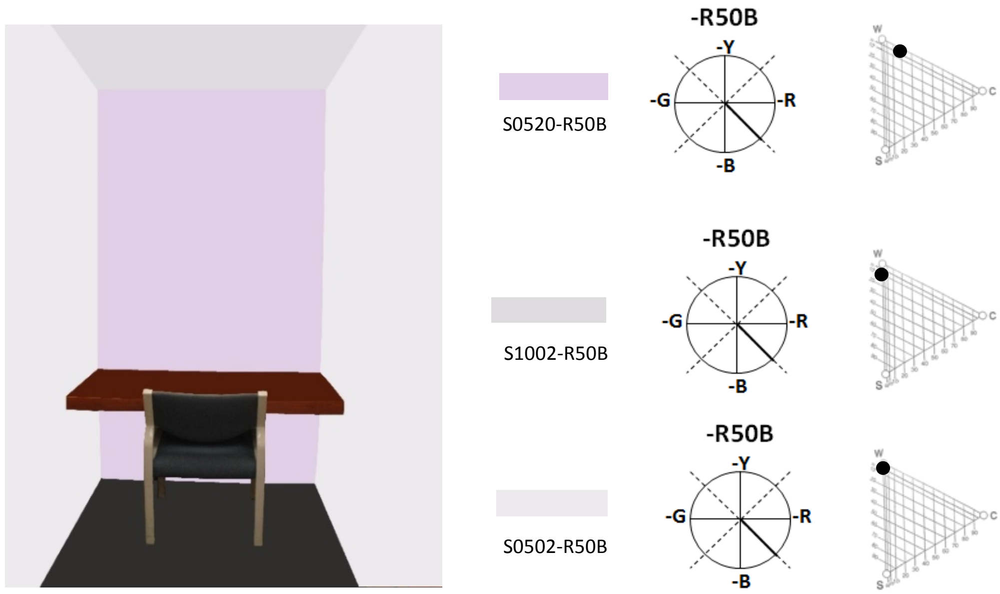


Figure 4-21: Testing pale purple scheme in Photoshop program by participants and locations of colours within NCS colour space

In the end, all the participants voted for the pale green-yellow scheme (Fig. 4−18) as an appropriate colour scheme for long-term study in the individual study area, and the light orange scheme (Fig. 4−19) was voted best for short time study. They decided that the other colours were nice but not good for study, because purple was perceived as less active and sleepy, and blue-green was perceived as too dark.

Group B:

The participants in Group B chose three colour schemes for the individual study room. They used their selected colours mixed with other colours. The participants used two colours to design the colour scheme for the individual study area to be more active and impact positively on their emotions. The first colour scheme used was pale green-yellow (no. 40) for the wall in front of the desk, light orange (no. 9) for the side walls, and light orange off-white for the ceiling (see Fig. 4−22). Some participants were happy with this colour scheme and they made similar comments such as:

> For me now I like this colour scheme [pale green-yellow + light orange]… first thing when I look at the front wall [pale green-yellow] I can study more… if I need to relax I will change to look at the other side [light orange]. (Group #B, Participant 12)

However, other participants disliked this colour scheme because they believed it would be very distracting and unsuitable for a study environment. One participant explained that:

> For this room [pale green-yellow+ light orange]… it really makes me feel happy and cheerful… but I think it doesn't help me to concentrate… it would distract my mind. (Group #B, Participant10)

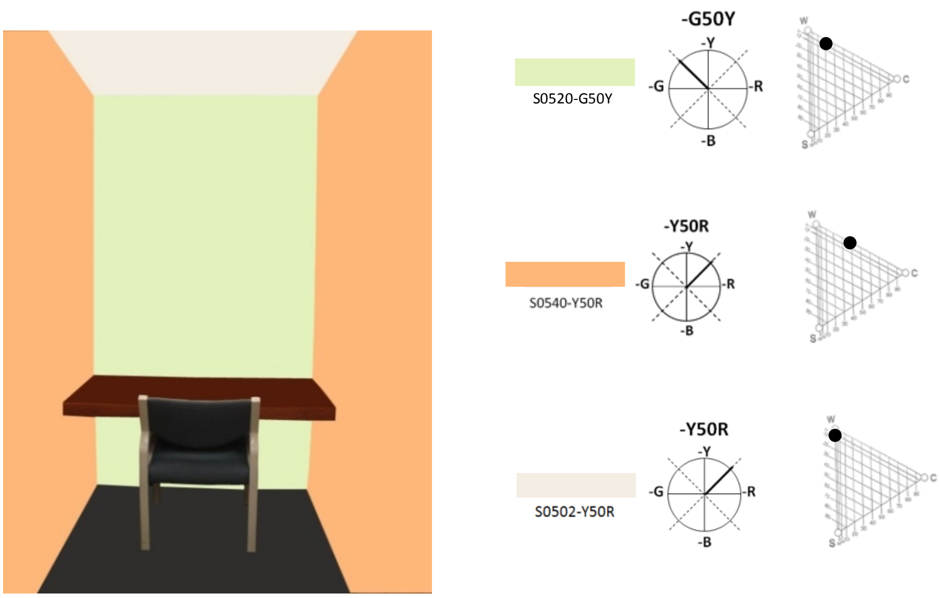


Figure 4-22: Testing pale green-yellow and light orange scheme in Photoshop program by participants and locations of colours within NCS colour space

The second colour scheme was light orange (no. 9) for side walls and pale yellow (no. 5) for the wall in front of the desk, with pale yellow off-white for the ceiling and a dark brown desk (see Fig. 4–23). This colour scheme was also considered unsuitable for a study space, because the participants perceived the colours as distracting and bright, they said using two colours was not a good idea in this closed room.

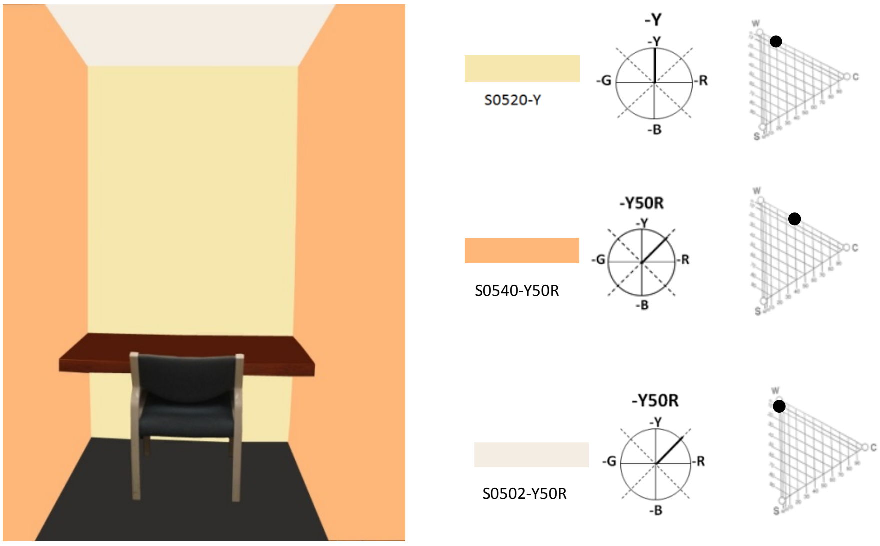


Figure 4-23: Testing light orange and pale yellow scheme in Photoshop program by participants and locations of colours within NCS colour space

When the participants used deep yellow to create a colour scheme for the individual study area, they felt it was very suitable for a learning environment. They suggested deep yellow (no. 1) for the side walls and pale yellow (no. 5) for the wall in front of the desk, with light brown for the desk and light grey for the ceiling (S 0300-N) (see Fig. 4–24).

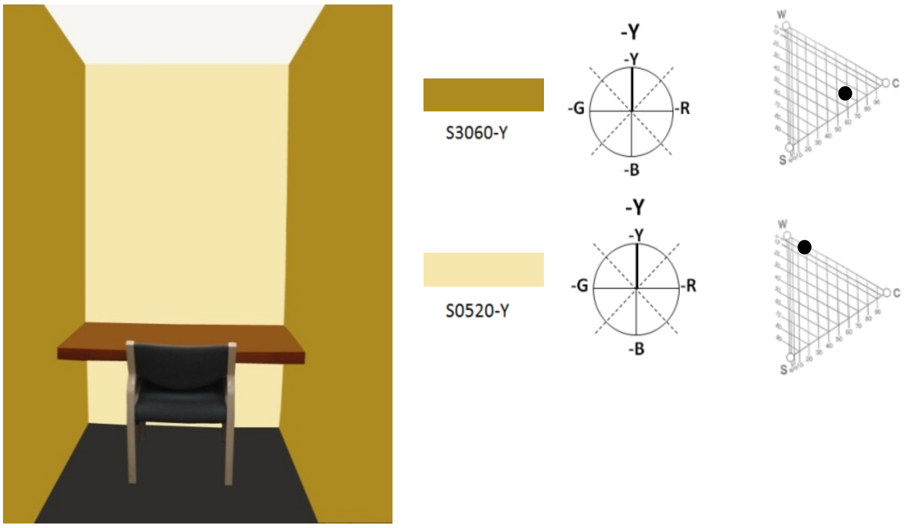


Figure 4-24: Testing deep yellow and pale yellow scheme in Photoshop program by participants and locations of colours within NCS colour space

At the end of the session the participants were satisfied with the third colour scheme (deep yellow and pale yellow) (Fig. 4–24) because they felt more comfortable and positive with this combination. Therefore, they voted for it as a suitable colour scheme for the individual study room.

Group C:

Two colour schemes were designed by Group C; the participants applied the chosen colours in the Photoshop program. They started with pale yellow (no. 5), but when this colour was applied to the wall in front of the desk, the participants did not like it, because the room appeared very neutral, so they suggested adding other colours. For example, one participant suggested:

> I think it needs to add other colours to be better, may be dark green for the sides and light yellow [pale yellow] for the front wall. (Group #C, Participant 15)

Other students disagreed with him because they felt this colour scheme made the space smaller:

> No I don't agree… this dark green makes the space smaller… maybe light green will be better. (Group #C, Participant 13)

Some participants preferred to use two nuances of one hue because they believed using two different hues would distract students. They suggested light yellow (no. 4) for the front wall of the desk and pale yellow (no. 5) for the side walls, with a light brown desk and neutral colour for the ceiling (S 0300-N) (see Fig. 4‒25).

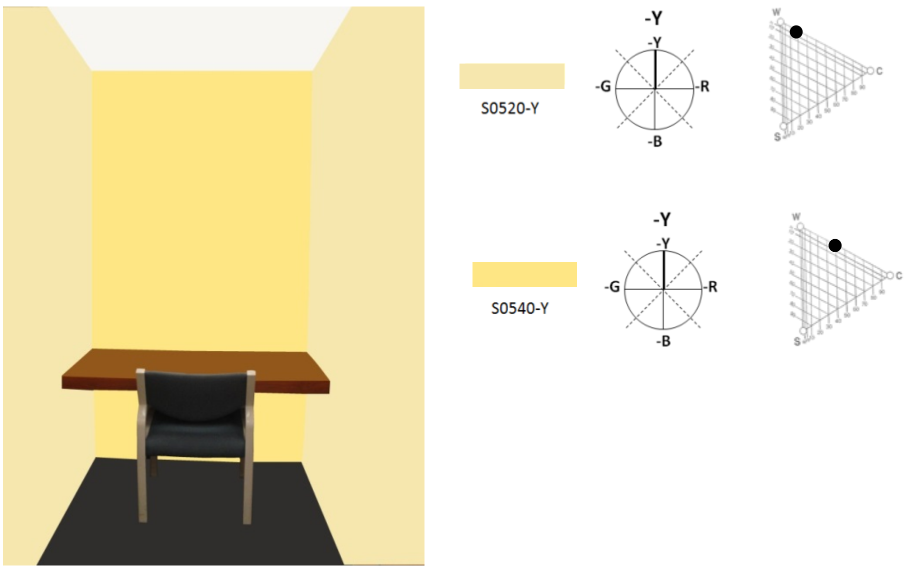


Figure 4-25: Testing light yellow and pale yellow scheme in Photoshop program by participants and locations of colours within NCS colour space

The second colour scheme was vivid green-yellow (no. 38) for the side walls, pale green-yellow (no. 40) for the wall in front of the desk, and pale yellow (no. 5) for the ceiling, with light brown for the desk (see Fig. 4‒26).

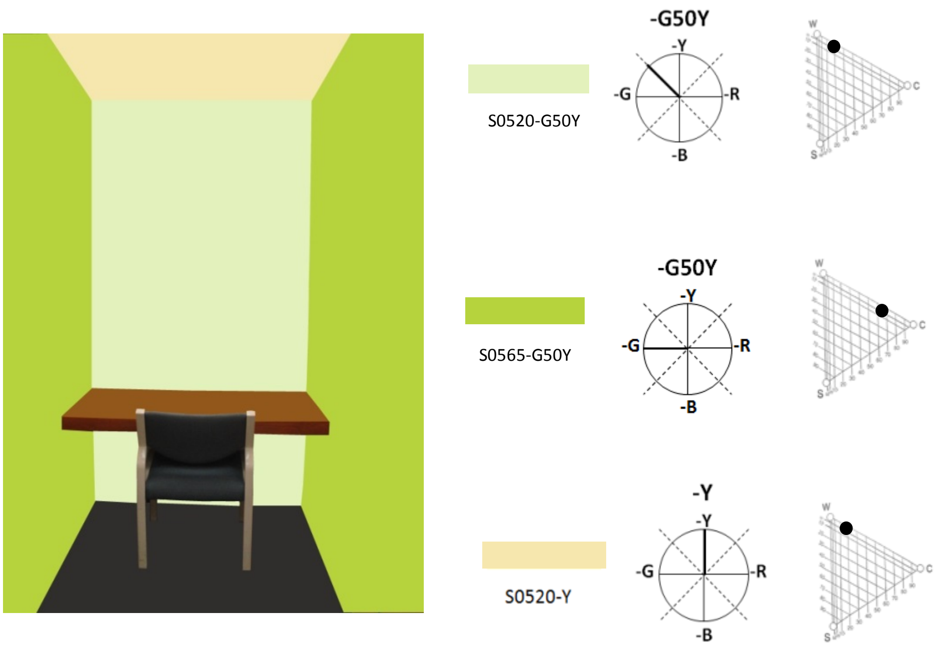


Figure 4-26: Testing light green and pale green-yellow scheme in Photoshop program by participants and locations of colours within NCS colour space

The participants were asked to vote for the colour scheme that they thought was more suitable for the individual study space. Most of the participants voted for the light yellow and pale yellow scheme (Fig. 4–25), because they considered this scheme to be fresh and comfortable. In addition, they felt this scheme would help them to concentrate on their study. While the green scheme (Fig. 4–26) might be activating and energizing, they felt it might be distracting if they were there for too long a time. The participants made similar comments to each other:

> I think the light yellow one is most suitable for study, because this colour scheme is mixed between warm and cool colours, I mean it is moderate, it makes a reasonable environment. The light yellow in the front really makes me feel comfortable and happy and that helps me to stay and study in this area… and for both sides [pale yellow] makes me more fresh and it makes a balance between colours in the space. Compared to the green one, it is not bad, it is very calm but it is not good for study for a long time, because it makes me feel bored, dizzy or sleepy. (Group #C, Participant16)

> The green one is good, but the yellow one is better and more suitable for me, because it is simple and it helps me to focus on my study, but the green one is too many colours and so bright that will disperse my mind. (Group #C, Participant 14)

Prompt 7: Conclusion of Focus Group Discussions

The participants of the three focus groups voted at the end of the sessions for the following colour schemes: light yellow with pale yellow, deep yellow with pale yellow, light orange with orange off-white, and pale green-yellow with green-yellow off-white. The responses to the colours in the focus group discussions demonstrated that for that particular group no colour was seen alone and that for them spatial colour design always includes several colours that affect and interact with each other. Therefore, the participants' choices and responses to the different rooms' colouring refer to colour combinations. These colours were chosen as suitable colours for a learning environment, especially for an individual study room. They were selected due to their positive impact on the participants' emotions, bodily responses, and intellectual activity. Other reasons for selecting these colours were the participants' colour associations and cultural backgrounds. Table 4–6 summarises the results of the focus group discussions.

Table 4-6: Summary of Results of Focus Groups

Colour Schemes	Description
Light yellow with pale yellow	Fresh, comfortable, facilitates concentration and study. Provokes memories, and associated with natural aspects.
Deep yellow with pale yellow	Not distracting, comfortable, and facilitates concentration and study.
Light orange with orange off-white	Comfortable for eyes, calm, active, exciting, helps to focus attention and motivates study, good colour for short time study.
Pale green-yellow with green-yellow off-white	Induces feelings of relaxation, happiness, calmness, comfortable for eyes, motivates study, and helps to focus attention, good colour for long-term study.
Pale purple with purple off-white	Less active, does not motivate study, nor help to focus attention.
Light blue-green with orange off-white	Uncomfortable colour for eyes, dark, does not motivate study.

4.4 Cycle 3 (Reflection 3): Discussion of Results

The main aim of Cycle 3 (Study B) was to explore students' perceptions and experiences of colours in the learning environment, as well as to choose new colour sets for testing in the next experiment. This goal was achieved by using the focus group method and asking participants to discuss how colours can influence their learning performance in the individual study space, in order to get their opinions about what colours are suitable for learning activities. The results of the focus groups are summarised and discussed in this section.

4.4.1 Part 1: Background Questionnaire

The results from the questionnaire about the Robertson Library at Curtin University revealed that most of the participants visit the library some of the time for studying for at least one to two hours, and they prefer to study in a private room reading printed books. In addition, they believed that the elements of interior design such as colours, lighting and furniture have an important impact on their learning performance by influencing their behaviour and emotions. Furthermore, they perceived that the atmosphere of the environment impacted on their concentration levels. It is well documented in the literature that there is a significant relationship between the interior design of the built environment and learning activity, and the design of space has an important role in supporting students' learning (Jamieson 2008; Temple 2008; Woolner et al. 2007).

As for the impact of colour on learning activity, the majority of participants believed that colour plays an important role in the learning environment, and it can influence students' learning activity. This can be by affecting students' emotions, bodily responses (e.g. distraction for the eyes, personal activity), intellectual activity (e.g. concentration level, thinking) and performance. These findings are consistent with a number of past studies, which indicate that environmental colour can influence human psychology, physiology and performance (Küller, Mikellides and Janssens 2009; Öztürk, Yılmazer and Ural 2012; Stone 2001).

Generally, results from Study B (Stage 1) indicate that most participants in this study agreed that the existing colour schemes used in the individual study rooms and group study rooms in the Robertson Library building are regarded as unsuitable for a learning environment. The participants mentioned colour combinations of these spaces not specific colours. The majority of the respondents claimed that using dull and neutral colours like light grey for walls, light beige for tables and blue-grey for furniture in the group study rooms creates a gloomy and less stimulating space. Further, using dark brown for the walls in the individual study rooms does not encourage students to focus on their study, because of its negative impact on their emotional and physiological states. According to Kwallek et al. 1996, less chromatic colours cause levels of depression, anger and confusion. These findings confirm that students' emotions are affected by colour schemes while studying in the library building.

The results show that the majority of participants prefer to study in an environment that has warm colours with middle whiteness and middle chromaticness, which can create a stimulating atmosphere, rather than in an environment that has neutral colours such as white, grey or beige. Participants dislike studying in the spaces of the Robertson Library building because of the lack of colour in its study spaces, especially on the upper levels, resulting in uninviting, less stimulating and very formal spaces in the learning environment.

4.4.2 Part 2: Focus Group Discussion and Activities

This study offers an important window into the academic students' perspective of the role of colour in the learning environment within the university library, and provides suggestions for suitable colours for learning activities in the individual study rooms. Although the methods used in Study B, such as small colour samples, a small model and a Photoshop program work reasonably well, the limitations of each method are discussed in this section. The main concern is the colour appearance in different scales when using these methods (small colour samples and colour applied on screen). A study by Stahre, Hårleman and Billger (2004) addressed the issue of colour appearance change between a small size colour chip and the same colour applied to a real room. They found that the colours in a real room were perceived as stronger and they arouse much stronger emotions than a colour chip. Another study by Xiao et al. (2010) used three experiments to investigate the colour appearance changes between different sample sizes using various media or viewing conditions. Experiment 1 assessed small colour sample cards in a viewing cabinet against a mid-grey background. In experiment 2, large sized pieces of cardboard were painted with different colours and placed on the one side wall in a room. All four walls were painted mid-grey. Experiment 3 assessed colour samples displayed on the centre of a 46 Son LCD TV against a mid-grey background. The results showed that when the colour sample size increases, the colour appears lighter and more colourful. This is what happened in this study; when the participants applied the colour in a small model and then on the big screen, the colours were perceived as more colourful and brighter.

The focus group participants mentioned many times how they perceived colour impacting on their learning activities in different ways. A number of themes related to colour effects clearly emerged, such as emotion, colour association, bodily impact, spatial properties, sensation, preference, intellectual activity and the duration of the study.

It is interesting to note that the findings indicate that most of the hues selected as suitable colours for the individual study rooms were colours with roughly equal resemblance to two NCS elementary colours (orange, green-yellow, blue-green, purple), with only one NCS elementary colour (yellow) being chosen. It is observed from the results that colours such as red or blue, whether vivid or light, were not chosen as suitable for learning activity. These results are partly consistent with Kaya and Crosby’s (2006) study, which found that the colours yellow and red are the colours most associated with educational buildings. From participants’ perspectives, vivid blue and red were perceived as depressing, gloomy and uncomfortable colours for studying. This association with blue is supported by Mahnke’s (1996) results, which indicated that blue is associated with a depressive state. In this study blue was not selected as a suitable colour for a learning activity, as it is associated with negative emotions such as depression; however, in Study A, blue (light or vivid) was perceived as a suitable colour for studying in the individual study rooms because it was associated with feelings of relaxation and activation.

Furthermore, the results from the focus groups showed that colours with more whiteness than blackness were considered more suitable for study in the individual study room. The present findings are consistent with past research, which found that arousal increases strongly with more chromatic colours but decreases with an increase in Munsell value (Valdez and Mehrabian 1994). The participants preferred a relaxed atmosphere for learning environments and, therefore, they chose the less arousing, less chromatic and more whitish colours. In addition, according to the participants, more whitish colours tend to create feelings of openness and cheerfulness.

In this respect, these findings are consistent with the results of Study A on the effect of colours on emotion, which revealed that light colours were associated with positive feelings. However, these results are inconsistent with the learning performance results of Cycle 2 (Study A), which indicated that vivid colours with a high level of chromaticness are appropriate for learning performance.

The present findings support those of other researchers who showed that colour associations are subjective and seem to depend on an individual's previous knowledge and experience (Kaya and Crosby 2006). Participants recalled the colour schemes of the institutional buildings such as the schools in which they were educated. For instance, some participants linked the colour pale yellow (no. 5) with feelings of comfort and relaxation, because they associated the colour with educational buildings and old books.

The colour pale green-yellow (no. 40) was suggested by a high number of participants as a suitable colour for an individual study room. It was associated with feelings of relaxation, happiness, calmness and natural aspects. It was also considered a motivating colour, one that is comfortable for the eyes, helps concentration, and is good for long-term study.

Light orange (no. 9) was also considered a suitable colour for learning activities by most of the participants. It was perceived as a stimulating colour that helps students to focus and work, and it was considered a good colour for short-term study but a distracting colour for long-term study. Participants also perceived that it brings life to the space, particularly in the individual study area, because it is a small area with solid walls.

The colour light yellow (no. 4) was not selected by participants in the second activity, but it was chosen during work on the Photoshop program to create a colour scheme for individual study area. It was used to design colour schemes for the individual study area, to create harmony in this room and make it more interesting.

Light blue-green (no. 29) and pale purple (no. 20) they were suggested by a few participants in two groups as suitable colours for study in the individual study area, but they were rejected quite strongly by other participants because they were perceived as inactive colours and they did not encourage students to study. Although deep yellow (no. 1) was selected only by one participant in all the groups, it was considered by other participants as a suitable colour for learning activities when it was applied via the Photoshop program. It is observed from the results that most colours suggested were colours with a high and medium level of whiteness, except for deep yellow which had a medium level of blackness. In addition, all colours chosen were warm colours, perhaps because they are perceived as stimulating colours and they create a suitable atmosphere for study.

4.5 Study B (Stage 2): Robertson Library Survey

In Stage 2, the researcher conducted a survey in the Robertson Library at Curtin University to ask students to select the best colour scheme that would encourage and motivate them to study. As mentioned, the participants in Stage 1 of Study B contributed to the Adobe Photoshop CS5.1 program activity to design a suitable colour scheme for an individual study space by using their selected colours. At the end of each session the participants voted for the four colour schemes.

4.5.1 Method

The aim of this survey was to obtain the opinions of other students (not the same participants as in Stage 1 of Study B) about the colour schemes chosen in Stage 1 (focus group discussion) by conducting a survey in the Robertson Library. The researcher visited the library and asked students randomly there to participate in a quick survey. Participants were then asked to choose one of the four final selected colour schemes as an appropriate one for the individual study space and give the reason for their selections (see Fig. 4–25).

The survey contains four questions; the first three questions were demographic (gender, nationality and study level). The fourth question was “which colour scheme do you think is suitable for an individual study room in the library building? Why?” (see Appendix 5).

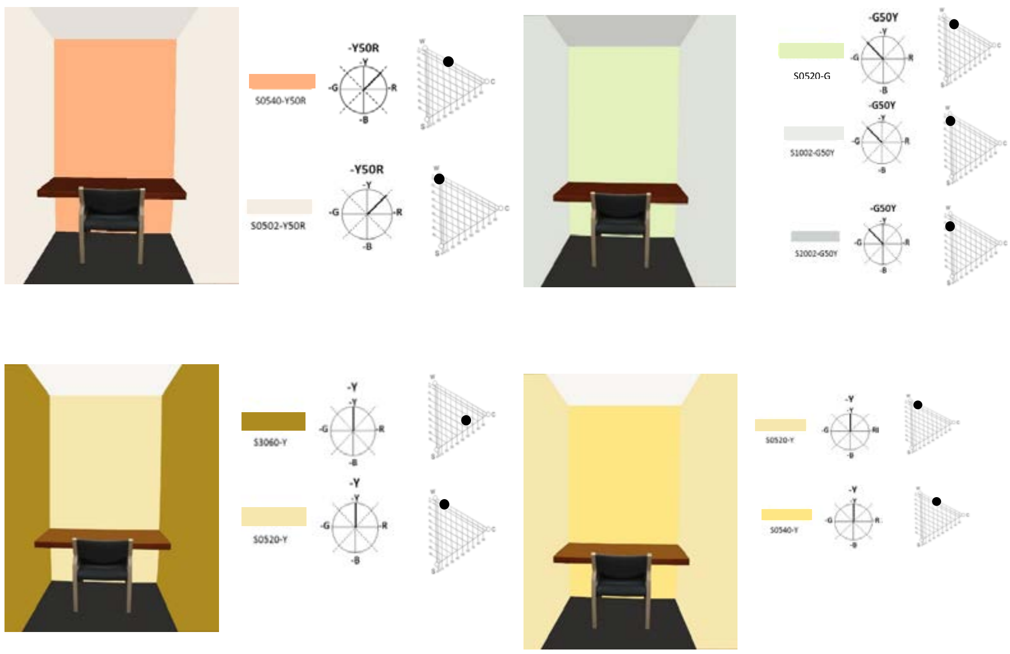


Figure 4-27: The colour schemes selected in the focus group and their locations in colour space of NCS

4.5.2 Stage 2: Participants

Twenty students from Curtin University participated in this survey. They were recruited randomly when the researcher went to the Robertson Library and asked students to participate in the quick survey. They were 11 females and 9 males. Sixteen were Australian, one from Malaysia, one from the Philippines, and two students from China. Most of them were undergraduate students. The participants’ ages ranged between 20 to 30 years. Table 4‒7 shows the composition of the survey participants.

Table 4-7: Composition of Survey Participants

Gender	Study Level	Nationality
Female: 11 Male: 9	Undergraduate: 17 Postgraduate: 3	Australian: 16 Malaysian: 1 Filipino: 1 Chinese: 2

4.5.3 Cycle 3 (Study B-Stage 2): Survey Results

The data were coded and subjected to a thematic analysis. The themes were identified for each response by using qualitative methodology. The survey findings were analysed according to the following aspects: emotions, colour preferences, colour associations, bodily impact, intellectual activity, motivation, and spatial properties.

The results reveal that nine participants chose Colour Scheme 2 (pale green-yellow) and eight participants chose Colour Scheme 1 (light orange) as suitable colours for learning in the individual study room. The participants believed that these colour schemes would have a positive impact on their emotions, bodily impact and intellectual activity. For example, the colour schemes light orange and pale green-yellow were perceived as nice, pleasing, and warm colours that would increase the level of pleasure. The participants made similar comments for the light orange colour scheme:

> Nice and classy feature wall, pleasing to the eye. (RB-16)
>
> Looks nice and pleasant colour … (DA-4)

As for the colour scheme pale green-yellow, the participants commented:

> Feeling happy and cool, it helps to study. (SH-6)

> I think it is a relaxing colour and pleasing. (MK-8)

In addition, the participants thought that the colour schemes light orange and pale green-yellow would keep them more active, more focused and willing to study and think. They made similar comments for both colour schemes:

> There is a feature wall with one colour [light orange], easy to concentrate. (ICH-17)
>
> This colour [light orange] makes me active and awake. (TO-2)
>
> Brighter colour [pale green-yellow] in front of me would force me to focus ahead on my work, instead of being focused on what was behind me. (PN-19)
>
> Focus point (bright colour) [pale-green-yellow] was right in front of the seat. It keeps me alert. (PHA-15)

Furthermore, the participants referred to colour associations in their comments for both colour schemes; for instance:

> … It [pale green-yellow] would help me to focus and study and it is like being in the countryside. (MK-8)
>
> Feeling happy with this colour [light orange]… it looks like a fruit and it pushes me to study. (TR-13)

Some participants mentioned that light orange and pale green-yellow colour schemes would influence the spatial properties and make the space bigger. They commented:

> The room looks spacious, and the colour [light orange] does not seem too bright which is suitable for me to study. (IR-18)
>
> Cool and nice colour [pale green-yellow], it makes the space more spacious. (PL-3)

As for Colour Schemes 3 (deep yellow with pale yellow) and 4 (light yellow with pale yellow), they were selected by few participants. For example, Colour Scheme 3 was chosen by one participant, while Colour Scheme 4 was chosen by two participants. Deep yellow and pale yellow (3) was perceived as an appropriate colour for learning activities because it is not bright, and it is associated with the earth's colours. The participant commented:

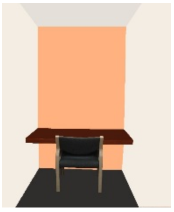
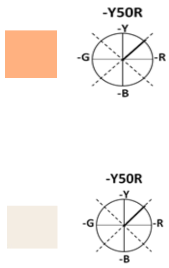
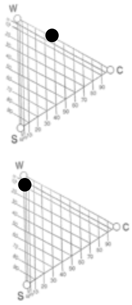
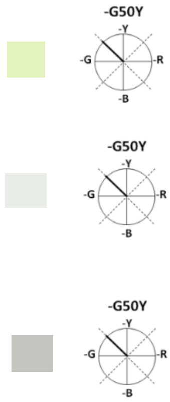
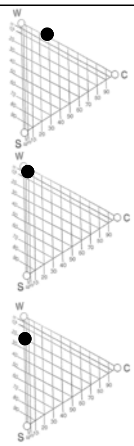
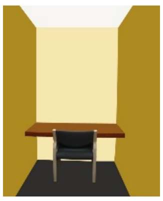
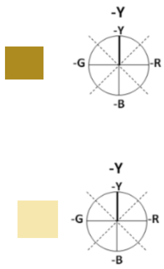
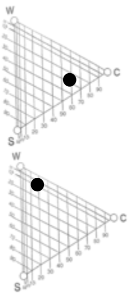
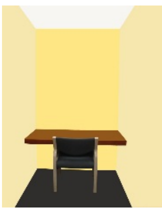
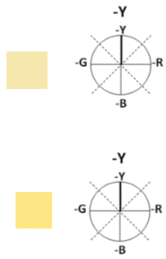
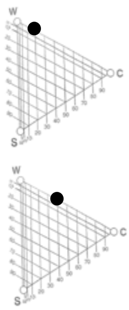
> It is not too bright and not too dull just appropriate for learning. The colour tone is just right like earthy colours. (KR-12)

The light yellow and pale yellow colour scheme was perceived as a positive colour for their emotions and their study performance. They commented:

> Yellow is bright and relaxing, and I would feel more inclined to study and happier. (JB-11)
>
> The bright yellow makes me feel more excited. (EL-7)

Table 4–8 shows the main findings of the survey in the Robertson Library regarding the colour schemes.

Table 4-8: Main findings of the survey the Robertson Library

Colour Scheme	Colour Name	Colour Circle	Colour Space	Responses no.	Summary
 (1)	S0540-Y50R S0502-Y50R			8	Pleasing, warm, nice, active, more focused, motivates study, fruity
 (2)	S0520-G50Y S1002-G50Y S2002-G50Y			9	Pleasing, warm, nice, related to countryside
 (3)	S3060-Y S0520-Y			1	Not bright, earthy colour, suitable for learning
 (4)	S0520-Y S0540-Y			2	Positive colour for study, relaxed, excited, happy

4.5.4 Cycle 3 (Study B-Stage 2): Discussion of Results

The data from the survey reveals that the colour schemes light orange and pale green-yellow were chosen by a high number of participants as appropriate colours for the individual study room in the Robertson Library. They were associated with positive feelings such as relaxation, pleasure and happiness, and the participants confirmed that these colours would push and encourage them to study and help them focus. These findings are consistent with the previous results in Stage 1, which found that colour schemes light orange and pale green-yellow were more suitable for learning.

The data confirm that warm colours such as light orange with a medium level of chromaticness and a high level of whiteness are associated with energy and motivation; this colour was highly favoured by participants for a learning environment. One possible reason is that learning activities need to be supported by stimulating colours to help the students be alert and focused. In general, green is considered a cool colour, but the colour pale green-yellow can be considered a warm colour because it contains the colour yellow, which makes it a warm colour. This suggests that pale green-yellow is also a stimulating colour and can evoke active feelings. In addition, the lighter nuance tends to stimulate feelings of openness and joy.

The results of the survey show that very few participants selected the colour schemes deep yellow with pale yellow and light yellow with pale yellow. A possible reason is that deep yellow might be perceived as dark and a less bright colour. The participants who selected the colour schemes light orange and pale green-yellow confirmed that using one colour on the front wall and neutral colours for the side walls would help them to focus on the task more than using different colours in the individual study room. Therefore, Colour Schemes 3 and 4 were not chosen as suitable for learning performance. They were perceived as too colourful which could cause distraction in the study room.

4.6 Conclusion

The results of Cycle 3 (Study B) provide an important insight into individual differences in responses to the effects of wall colour on learning performance in learning spaces, particularly in the individual study space. The results of Cycle 3 (Study B) show that warm colours with high and medium whiteness and medium chromaticness are considered suitable colours for learning performance as they can assist students to study and focus. In contrast, the quantitative results in Cycle 2 (Study A) revealed that colours with high chromaticness colours support reading comprehension, while in Cycle 3 (Study B) they were not.

The data reveals that the participants did not choose blue or red as appropriate colours for learning activities and they did not choose any vivid colours. These findings are partly inconsistent with the results of Cycle 1 (literature review) which proposed that red and blue are suitable colours for learning environments. However, these findings agree with the literature review in finding the colour yellow a suitable colour for learning areas.

This difference in the results is because of the participants in Study B selected colours based on their emotional response and preferences, and these colours were selected for general learning activity not for specific type of learning activity. Therefore, it can be concluded that vivid colours in Cycle 2 (Study A) are suitable for a certain type of learning like reading comprehension task and not suitable for other task such as math tasks or writing task.

These findings also disagree with the qualitative results in Cycle 2 (Study A) in regard to the colour blue. Blue was associated with positive effects, therefore, it was perceived as a suitable colour for a learning environment, whereas in Study B it was rejected by participants and perceived as a depressing colour.

The choice of colours for learning activities was influenced by students' preferences and cultural backgrounds. For example, pale yellow was selected as a suitable colour for individual study spaces, because some students consider it a traditional and institutional colour that is used in educational spaces in their countries such as Japan and Iraq. Another student selected this colour because it is related to the colour of the desert in his country, Saudi Arabia. Overall, the selection of colours was associated with the observer's emotional state and intellectual activity, and the colour's impact on the body.

The results of Cycle 3 (Study B-Stages 1 and 2) show that the light orange and pale green-yellow colour schemes were perceived as suitable colours for learning performance in the individual study room. There was consistency in the results across Stages 1 and 2 in Cycle 3 (Study B). It was found that these colours are perceived as motivating to study and as stimulating positive feelings in the students and improving their concentration and attention. It can be concluded that colours with medium chromaticness and medium or high whiteness can encourage students to study and create a suitable atmosphere for learning activity. In addition, hue was found to be a more important dimension than whiteness in determining suitable colours to support learning performance.

It is obvious from the results that colours are never seen in isolation, but always presented together with other colours. Therefore, the participants in Study B (Stage 1) focused on colour combinations when they were asked to apply their selections of colours in the individual study room via the Adobe Photoshop program whether applying their colours chosen with achromatic colours or chromatic colours. As a result, four colour schemes were selected by the three groups: light orange with orange off-white, pale green-yellow with pale green-off white, deep yellow with pale yellow, and light yellow with pale yellow.

The different methods used in this study proved useful in many ways and complemented each other. For example, the small scale-model and Photoshop program assisted the participants to imagine the colour in the indoor spaces and how to select and design a colour scheme for the individual study room. Using photos and small models as clarification tools can tell us more than words, and they are easy to use in the study. Utilising simulation images such as colour photographs, slides and motion images (two-dimensional videos) is acceptable in environmental psychology studies, according to the empirical and theoretical studies of several researchers (Dijkstra 2009; Marans and Stokols 2013; Stamps 1990). Using the questionnaire in the focus group provided valuable information about colours used in the library through participants' perspectives. The focus group discussions provided more nuanced answers and more thorough explanations.

Cycle 3 (Study B) findings helped the researcher to select a new set of colours to be examined in the next study, which investigates how these colours perceived as suitable by the university students will impact on students' learning performance in the individual study rooms within university libraries. As this thesis focuses on single colours' effects on students' learning performance, it was decided to select single colours to be examined in the next experiment and exclude the colours that are very whitish (off-white) because they are very neutral colours. In addition, this research focuses only on one wall colour effect (the wall in front of the desk) as it is the dominant wall in the individual study room; the students sit at the desk and face the wall in front of them rather than the side walls.

The colours examined in the next experiment are pale yellow, light yellow, deep yellow, pale green-yellow and light orange. The colour pale purple was added to form a set of six colours to be examined in the next experiment. Pale purple was chosen in order to cover ¾ the circle colour. Light yellow was tested again in the second experiment to determine whether there was consistency in the results of the two studies. Figure 4-28 illustrates the colours used in the next experiment. Figure 4-29 illustrates the outcome of Cycle 3 (Study B).

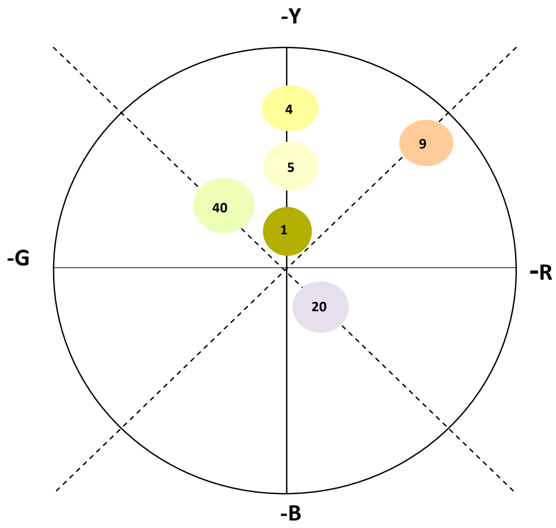


Figure 4-28: Colours chosen from Cycle 3 (Study B)

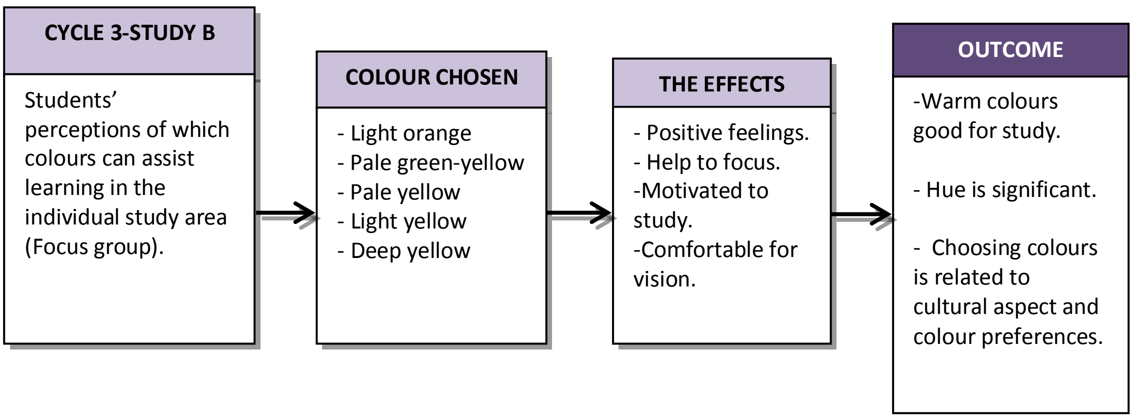


Figure 4-29: The Outcome of Cycle 3 (Study B)

5 CHAPTER 5: CYCLE 4 (STUDY C)

5.1 Cycle 4 (Plan 4): The Aim of Study C

Cycle 4 (Study C) was designed to extend the results of Cycle 2 (Study A) by using different colours. The purpose of Cycle 4 (Study C) is to examine the impact of six colours selected from the focus groups on learning performance.

As in Cycle 2 (Study A), three outcomes were assessed across six colour conditions: reading comprehension, emotional response and heart rate. This study also focused on the individual study areas. Three hues were tested in Cycle 2 (Study A): vivid red, vivid yellow and vivid blue, as well as one colour from each hue with a higher level of whiteness (light red, light yellow and light blue).

According to the focus group results, the colours with a high level of whiteness and one colour with a medium level of blackness were considered suitable colours for the individual study area in the library buildings. Therefore, it was decided to test these colours to discover if they have any effect on learning performance (see Fig. 5−1). The experimental setting, participant recruitment, instruments used to collect data, and the design of the experimental room, were the same as for Cycle 2 (Study A); only the colours were different.

This experimental study was conducted to answer the questions identified in Chapter 1:

1. To what extent do the hue and nuance dimensions of colour influence reading comprehension in the individual study room?

2. To what extent do the hue and nuance dimensions of colour influence heart rate and emotional response to colour in the individual study room?

3. To what extent do emotional response to colour and heart rate mediate the relationship between colour and reading comprehension in the individual study room?

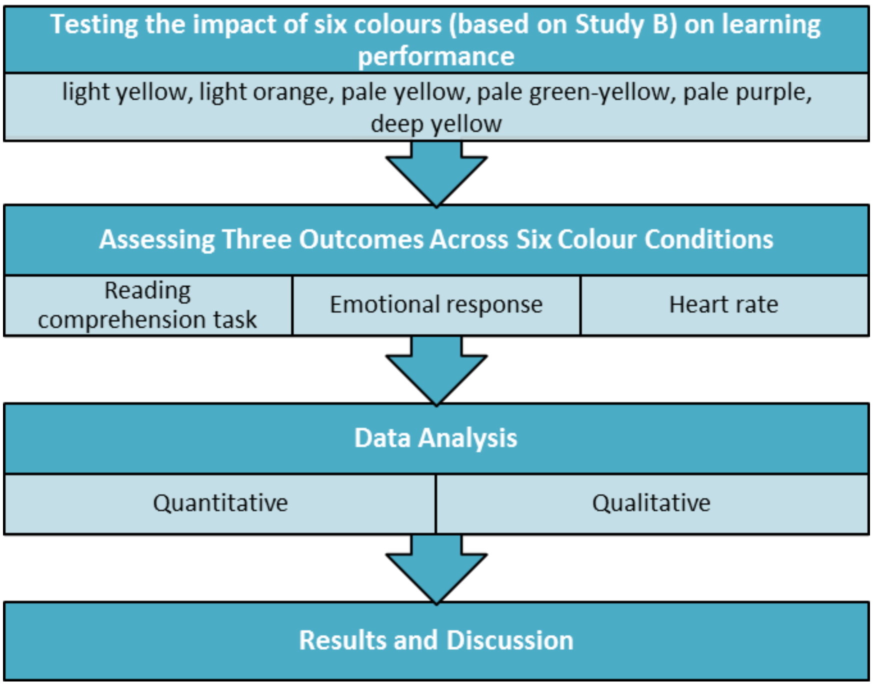


Figure 5-1: The Map of Cycle 4 (Study C)

5.2 Cycle 4 (Act 4): Preparation for Study C

This section will describe the experimental setting, the number of participants, the colour samples and the instruments used in this experiment, and explain the experimental procedure of Cycle 4 (Study C).

5.2.1 Participants

Studies A and C shared the same instrumentation, but differed in terms of design. Cycle 2 (Study A), included one nominal random effect (participant) and two categorical fixed effects (hues: red, yellow, blue; and nuances: vivid, light). Cycle 4 (Study C) included one nominal random effect (participant), but unlike Cycle 2 (Study A), it had only one fixed effect (colour: light yellow, pale yellow, deep yellow, pale green-yellow, light orange, pale purple). According to G*Power Version 3.1.2, a power analysis program for a variety of statistical tests (Faul et al. 2009), at least 24 participants are required to capture a ‘moderate’ colour effect – this is the same sample size estimate as Cycle 2 (Study A), but participants were not the same as those who participated in Cycle 2 (Study A).

There were eight males and 16 females recruited from the undergraduate and postgraduate students of Curtin University in Western Australia. Their ages ranged between 20 and 38 years. None of the participants had defective vision, as verified with Ishihara Colour Blindness Test (ICBT). Participants were also asked to complete a Learning Channel Preference Questionnaire (O'Brien 1989) which revealed that all participants were visual learners.

5.2.2 Colour Samples

The colours used in this study were chosen from the NCS Colour Atlas which orders colours according to hue and nuance. The colours used in this experiment were: light yellow (S 0540-Y), pale yellow (S 0520-Y), deep yellow (S 3060-Y), pale green-yellow (S 0530-G50Y), light orange (S 0540-Y50R), pale purple (S 0520-R50B). The neutral colour white (S 0300-N) was used for the two sides walls (see Fig. 5−2).

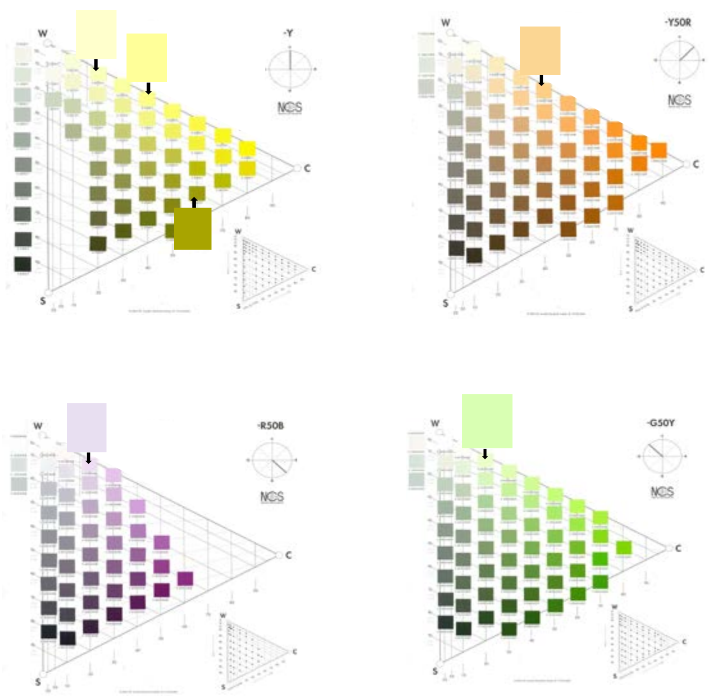


Figure 5-2: Chosen colours in position in the NCS triangles

(Al-Ayash 2013)

5.2.3 Instruments

As in Cycle 2 (Study A), the same instruments were used in Cycle 4 (Study C) (see Section 3.2.3 in Chapter 3 for further information).

5.2.3.1 Colour Blindness Test

The Ishihara Colour Blindness Test (ICBT) was used to test colour vision (Ishihara 1993).

5.2.3.2 Learning Channel Preference Questionnaire

This questionnaire was formulated by O’Brien (1989).

5.2.3.3 Emotional Response Scales to Colour

Nine bipolar colour-emotion scales were used to assess the emotional response to colours across the experimental conditions. The bipolar scales referred to dark/light, pleasant/unpleasant, fresh/stale, heavy/light, calm/exciting, dull/sharp, tense/relaxed, warm/cool, and interesting/boring. For more details see Section 3.2.3.3 in Chapter 3, p.130.

5.2.3.4 Physiological recordings

The Fingertip Pulse Oximeter was used to record heart rate.

5.2.3.5 Performance assessment

A reading comprehension test was used to assess the learning performance of the participants across the six experimental conditions.

5.2.3.6 Interviews

As in Cycle 2 (Study A), an unstructured interview was used as qualitative data in Cycle 4 (Study C) after completing the experiment for each colour condition. The unstructured interview is like a guided conversation than a strict structured interview. It contains open-ended questions, and it is more flexible, as questions can be adapted and changed depending on the respondent’s answers (Fontana and Prokos 2010). In addition, it increases validity because it gives the interviewer the opportunity to check for a deeper understanding. The participants were asked “does this colour motivate you to study and help you to focus? Why?” This method was used to obtain more in-depth qualitative data.

5.2.4 Experimental Room Design

As in Cycle 2 (Study A), two rooms were set up in the School of Built Environment at Curtin University for the experimental phase of the study. The same rooms were used in Cycle 4 (Study C) as for Cycle 2 (Study A). Refer to Section 3.2.4 for further information about the set-up of the two rooms used in Cycle 4 (Study C) (see Fig. 3‒3 and Fig. 3‒4 for the interior set up of Rooms 1and 2).

As mentioned above, the setting and conditions of the experimental room were similar to those used in Cycle 2 (Study A). Colours were manipulated by hanging Corflute panels 180cm × 180cm × 2mm thick, which were painted light yellow S

0540-Y, pale yellow S 0520-Y, deep yellow S 3060-Y, pale green-yellow S 0530-G50Y, light orange S 0540-Y50R and pale purple S 0520-R50B. The wall behind the coloured panel, the side walls and the ceiling were painted white (S 0300-N).

Similar to Cycle 2 (Study A), each coloured panel was hung on the wall so that it extended 1.70m above the top of the desk. Thus, if the students looked about, they could see the top of the white wall behind the panel as well as the white side walls and ceiling. The room was furnished with a white student desk (90cm long × 60cm wide × 72 high) and one grey chair (S7502-B) (see Fig. 5−3). The desk was centred along the wall, and faced the coloured panel. In addition, the experimenter's desk was located behind the participant on the left side (see Fig. 3−4 in Chapter 3). The experimenter checked the time and recorded the heart rate (HR) of the participants during the experimental session.

Ambient temperatures of Rooms 1 and 2 were also recorded on several occasions on different days; the temperatures of both rooms were a constant 25˚C. The rooms were located in the basement of a multi-level building, therefore their temperature and humidity varied little throughout the year. The test room was illuminated with four Osram fluorescent tubes (36 W), having a correlated colour temperature (CCT) of 3500˚ and a colour rendering index (CRI) of 75-82; and 3350 lumens. The average illuminance was 360 Lux; illuminance and luminance were measured using a digital light meter, model Lutron LM-81LX.

Figure 5-3: Room 2: six interior colours
(Al-Ayash 2013)

5.2.5 Experimental Procedure

As in Cycle 2 (Study A) participants were not forewarned concerning the exact colours to which they would be exposed. The procedure of Cycle 4 (Study C) was similar to that used in Cycle 2 (Study A). As in Cycle 2 (Study A), a Balanced Latin Square design was used to control order effects, which ensured that each experimental condition appears an equal number of times in each row and column of the square (please refer to Section 3.2.5 for further information in Chapter 3).

5.3 Cycle 4 (Observe 4): Results

This section reports the quantitative and qualitative results of Study C. As in Study A, a series of Generalised Linear Mixed Models (GLMMs) were tested in order to determine whether the participant's emotional state, physiological state and comprehension test performance varied as a function of colour. The GLMMs were once again implemented with the Statistical Package for Social Science (SPSS Version 20).

5.3.1 Reading Comprehension

The order effect did not interact with the colour effect ($F[25, 108] = 0.65$, $p = .892$). The main effect for colour was not significant ($F[5,138] = 1.01$, $p = .412$), indicating that there was no effect of colour on reading performance (see Fig. 5-4).

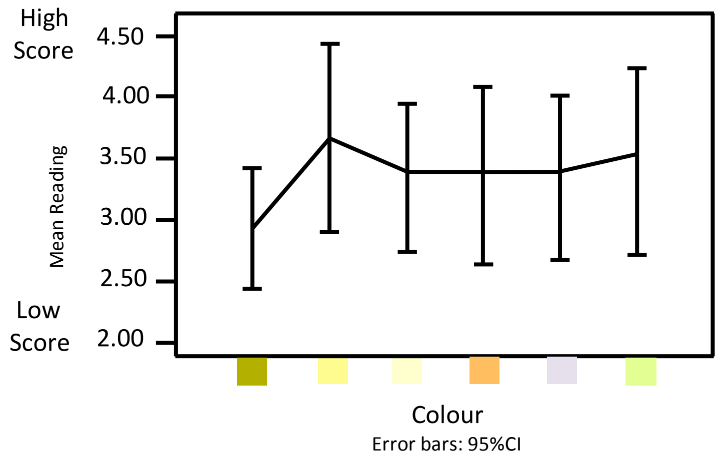


Figure 5-4: Reading Test

5.3.2 Heart Rate Response

The impact of the experimental conditions on physiological responses was examined by recording heart rates on two separate occasions, once before each experiment session and then again during each experiment session. The results found that the order effect did not interact with the colour effect ($F[25, 108] = 1.05$, $p = .417$). The main effect for colour was significant ($F[5,138] = 7.66$, $p < .001$) indicating that there was an effect of colour on heart rate change. The graph shows an interesting trend in which an increase in heart rate alternates with a decrease in heart rate across the six colours (see Fig. 5–5).

LSD (least significant difference) contrasts conducted on the main effect for colour indicated that 10 of the 15 contrasts were significant (p-values for the significant contrasts ranged from .047 to < .001). The significant contrasts are reported in Table 5–1, which reveals that there were significant contrasts between deep yellow and light yellow ($p = .022$), deep yellow and pale purple ($p = .043$), and deep yellow and pale green-yellow ($p = .001$). In addition, there was a significant difference between light yellow and pale yellow ($p = .039$), and light yellow and pale purple ($p < .001$). Significant differences were also found between pale yellow and pale purple ($p = .025$), and pale yellow and pale green-yellow ($p = .001$); there were significant contrasts between light orange and pale purple ($p = .001$), and light orange and pale green-yellow ($p = .047$); and finally, there was a significant difference between pale purple and pale green-yellow ($p = .001$). Figure 5-5 indicates the directions of these differences.

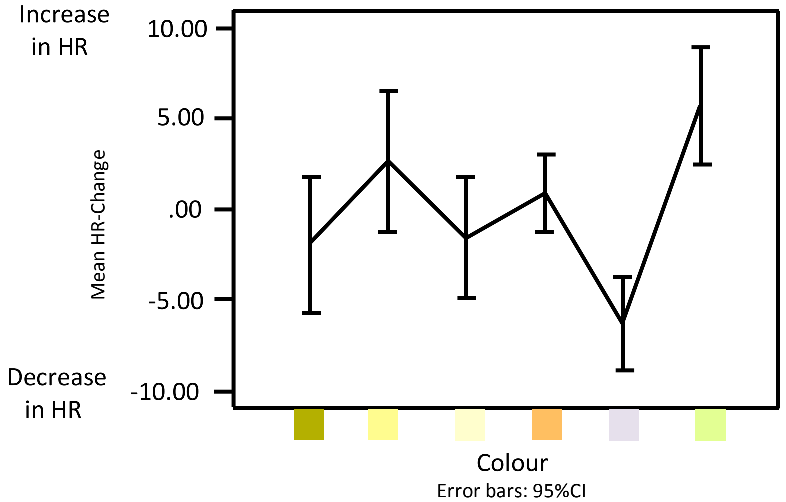


Figure 5-5: Heart Rate

Table 5-1: *P*-values for the Significant Contrasts in Heart Rate Changes

	Deep yellow	Light yellow	Pale yellow	Light orange	Pale purple	Pale green/yellow
Deep yellow	-	$p = .022$	ns	ns	$p = .043$	$p = .001$
Light yellow		-	$p = .039$	ns	$p < .001$	ns
Pale yellow			-	ns	$p = .025$	$p = .001$
Light orange				-	$p = .001$	$p = .047$
Pale purple					-	$p < .001$
Pale green/yellow						-

ns= not significant

5.3.3 Emotional Responses to Colour

As in Study A, the emotional reactions were scored on a 7-point semantic differential rating scale. The results revealed that the order effect did not interact with the colour effect for pleasant/unpleasant (*F*[25, 108] = 0.98, *p* = .502) (see Fig. 5−6), fresh/stale (*F*[25, 108] = 0.99, *p* = .475) (Fig. 5−7), heavy/light (*F*[25, 108] = 1.13, *p* = .327) (Fig. 5−8), calm/exciting (*F*[25, 108] = 1.20, *p* = .259) (Fig. 5−9), dull/sharp (*F*[25, 108] = 1.90, *p* = .098) (Fig. 5−10), tense/relaxed (*F*[25, 108] = 1.01, *p* = .465) (Fig. 5−11), warm/cool (*F*[25, 108] = 0.77, *p* = .767) (Fig. 5−12), interesting/boring (*F*[25, 108] = 1.01, *p* = .459) (Fig. 5−13), and dark/light (*F*[25, 108] = 0.92, *p* = .580) (Fig. 5−14).

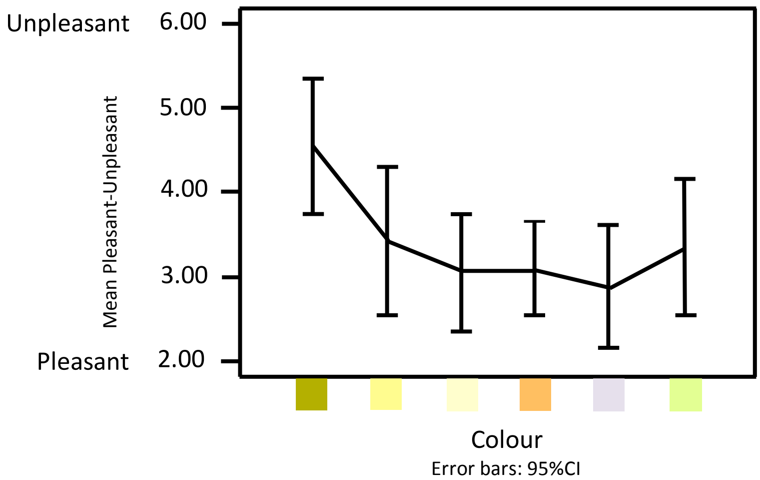


Figure 5-6: Pleasant-Unpleasant

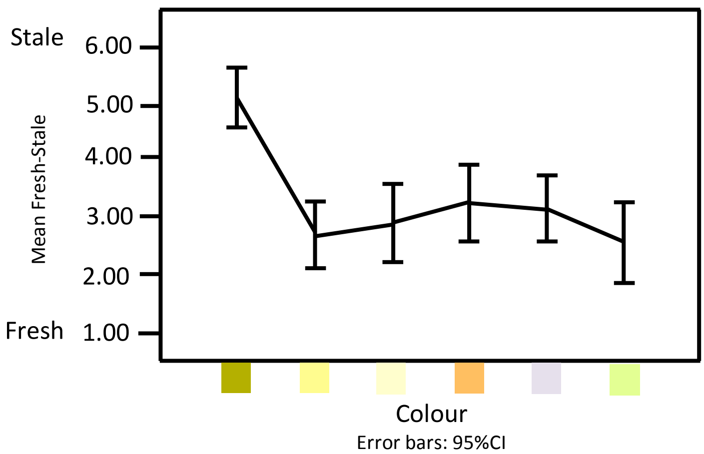


Figure 5-7: Fresh-Stale

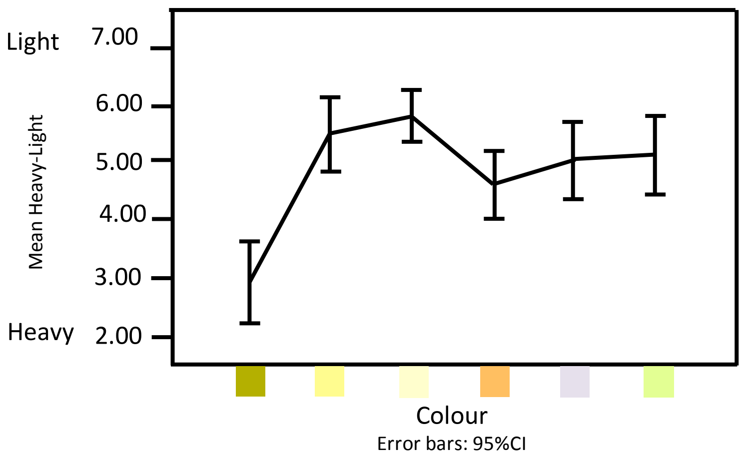


Figure 5-8: Heavy-Light

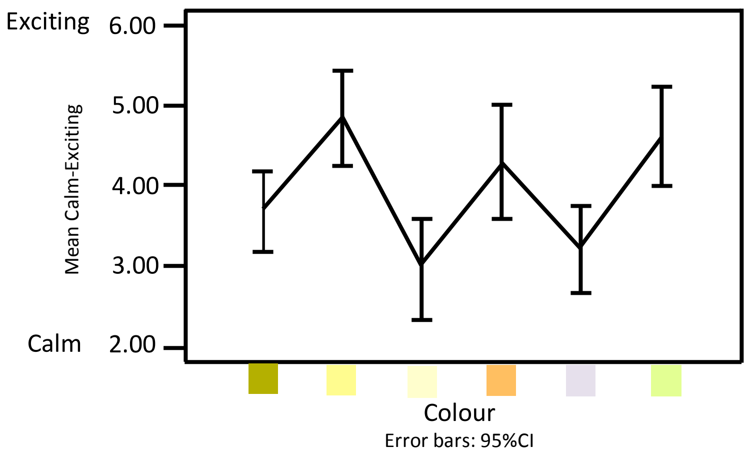


Figure 5-9: Exciting-Calm

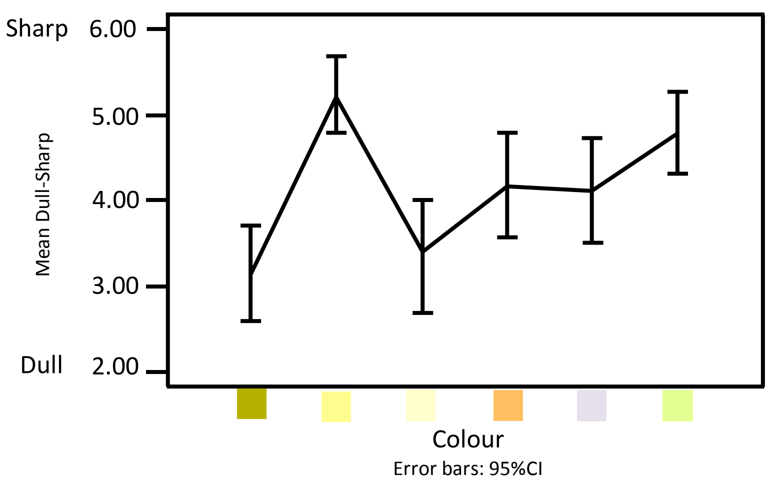


Figure 5-10: Dull-Sharp

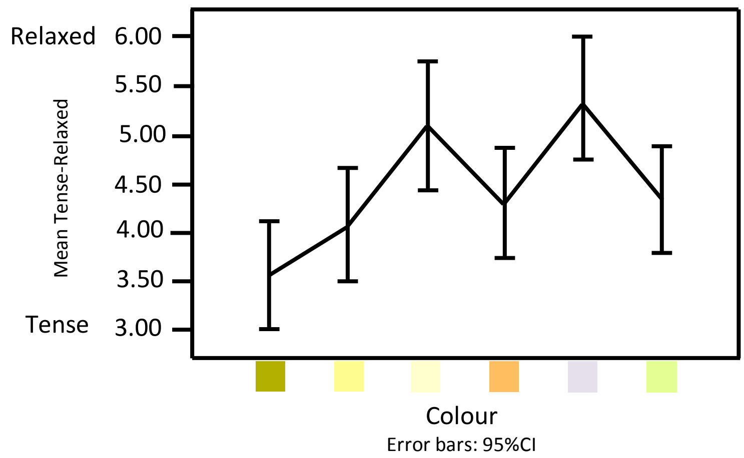


Figure 5-11: Tense-Relaxed

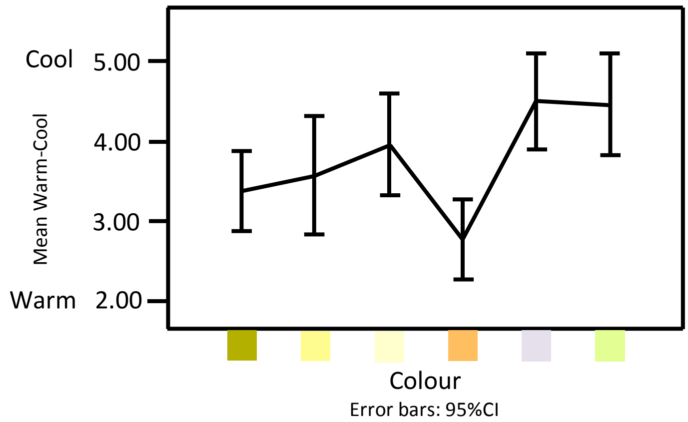


Figure 5-12: Warm-Cool

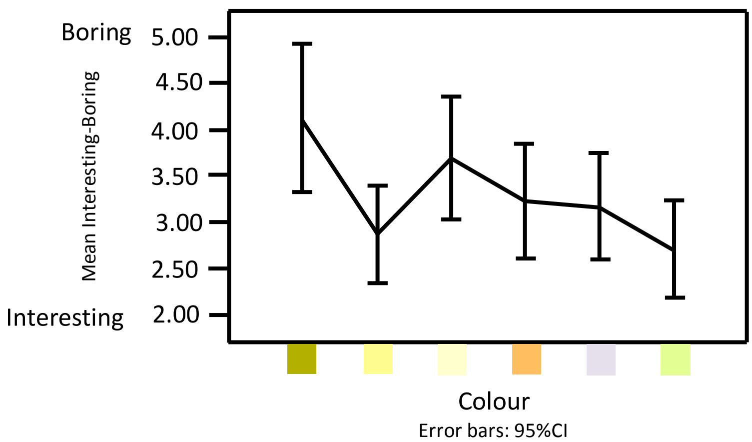


Figure 5-13: Interesting-Boring

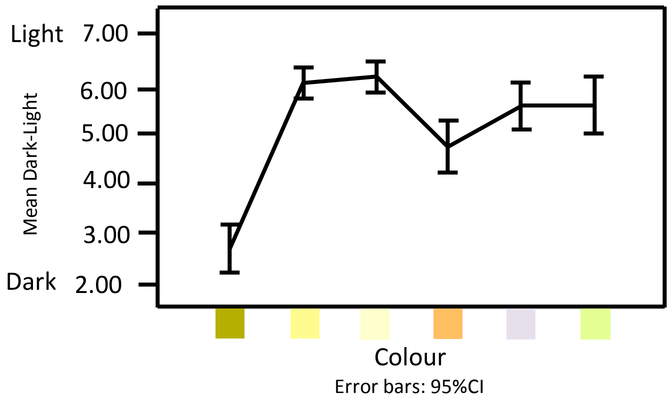


Figure 5-14: Dark-Light

The results showed that the main effect for colour was significant in terms of pleasant/unpleasant ($F[5,138] = 3.91$, $p = .004$), fresh/stale ($F[5,138] = 11.80$, $p < .001$), heavy/light ($F[5,138] = 16.04$, $p < .001$), calm/exciting ($F[5,138] = 7.41$, $p < .001$), dull/sharp ($F[5,138] = 9.10$, $p < .001$), tense/relaxed ($F[5,138] = 5.63$, $p < .001$), warm/cool ($F[5,138] = 6.27$, $p < .001$), interesting/boring ($F[5,138] = 3.49$, $p = .005$), and dark/light ($F[5,138] = 36.94$, $p < .001$). The graphs (5−5, 5−6, 5−7, 5−10, and 5−13) show a trend in which deep yellow is rated towards the unpleasant, stale, heavy, tense, and dark end of the scales, whereas all the other colours are rated towards the pleasant, fresh, light (as opposed to heavy), relaxed and light (as opposed to dark) end of the scales. However, deep yellow has a neutral rating in the interesting/boring scale (Fig. 5−12).

LSD (least significant difference) contrasts conducted on the main effect for colour revealed significant contrasts between the deep yellow and all the other colours. For example, 5 of the 15 contrasts were significant (p-values for the significant contrasts ranged from .014 to < .001) for pleasant/unpleasant (Table 5−2); 6 of the 15 contrast were significant (p-values for the significant contrasts ranged from .048 to < .001) for fresh/stale (Table 5−3); 8 of the 15 contrasts were significant (p-values for the significant contrasts ranged from .018 to < .001) for heavy/light (Table 5−4); 7 of the 15 contrasts were significant (p-values for the significant contrasts ranged from .043 to < .001) for tense/relaxed (Table 5−5); 6 of the 15 contrasts were significant (p-values for the significant contrasts ranged from .045 to < .001) for interesting/boring (Table 5−6); and 10 of the 15 contrasts were significant (*p*-values for the significant contrasts ranged from .039 to < .001) for dark/light (Table 5−7).

Table 5-2: *P*-values for the Significant Contrasts (Pleasant/Unpleasant)

	Deep yellow	Light yellow	Pale yellow	Light orange	Pale purple	Pale green/yellow
Deep yellow	-	$p = .014$	$p = .001$	$p = .001$	$p < .001$	$p = .014$
Light yellow		ns	ns	ns	ns	ns
Pale yellow			-	ns	ns	ns
Light orange				-	ns	ns
Pale purple					-	ns
Pale green/yellow						-

Table 5-3: *P*-values for the Significant Contrasts (Fresh/Stale)

	Deep yellow	Light yellow	Pale yellow	Light orange	Pale purple	Pale green/yello w
Deep yellow	-	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$
Light yellow		ns	ns	ns	ns	ns
Pale yellow			-	ns	ns	ns
Light orange				-	ns	$p = .048$
Pale purple					-	ns
Pale green/yellow						-

Table 5-4: *P*-values for the Significant Contrasts (Heavy/Light)

	Deep yellow	Light yellow	Pale yellow	Light orange	Pale purple	Pale green/yello w
Deep yellow	-	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$
Light yellow		ns	ns	$p = .013$	ns	ns
Pale yellow			-	$p < .001$	$p = .018$	ns
Light orange				-	ns	ns
Pale purple					-	ns
Pale green/yellow						-

Table 5-5: *P*-values for the Significant Contrasts (Tense/Relaxed)

	Deep yellow	Light yellow	Pale yellow	Light orange	Pale purple	Pale green/yellow
Deep yellow	-	ns	$p < .001$	ns	$p < .001$	ns
Light yellow		-	$p = .011$	ns	$p = .002$	ns
Pale yellow			-	$p = .043$	ns	ns
Light orange				-	$p = .008$	ns
Pale purple					-	$p = .011$
Pale green/yellow						-

Table 5-6: *P*-values for the Significant Contrasts (Interesting/Boring)

	Deep yellow	Light yellow	Pale yellow	Light orange	Pale purple	Pale green/yellow
Deep yellow	-	$p = .002$	ns	$p = .021$	$p = .016$	$p = .001$
Light yellow		-	$p = .045$	ns	ns	ns
Pale yellow			-	ns	ns	$p = .016$
Light orange				-	ns	ns
Pale purple					-	ns
Pale green/yellow						-

Table 5-7: *P*-values for the Significant Contrasts (Dark/Light)

	Deep yellow	Light yellow	Pale yellow	Light orange	Pale purple	Pale green/yellow
Deep yellow	-	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$
Light yellow		-	ns	$p < .001$	ns	ns
Pale yellow			-	$p < .001$	ns	$p = .039$
Light orange				-	.006	$p = .009$
Pale purple					-	ns
Pale green/yellow						-

As for the calm-exciting scale, Figure 5−8 shows an interesting trend, in which ratings of calmness alternate with ratings of excitement across the six colours. The results show a trend in which pale purple, pale yellow and deep yellow are rated towards the calm end of the scale, whereas other colours (light yellow, light orange, pale green-yellow) are rated towards the exciting end of the scale.

LSD (least significant difference) contrasts conducted on the main effect for colour indicated that 8 of the 15 contrasts were significant (*p*-values for the significant contrasts ranged from .029 to < .001). Table 5−8 shows that there were significant contrasts between deep yellow and light yellow, deep yellow and pale green/yellow, light yellow and pale yellow, light yellow and pale purple, pale yellow and light orange, pale yellow and pale green/yellow, light orange and pale purple, and finally between pale purple and pale green/yellow.

Table 5-8: *P*-values for the Significant Contrasts (Calm/Exciting)

	Deep yellow	Light yellow	Pale yellow	Light orange	Pale purple	Pale green/yellow
Deep yellow	-	$p = .004$	ns	ns	ns	$p = .029$
Light yellow		-	$p < .001$	ns	$p < .001$	ns
Pale yellow			-	$p = .001$	ns	$p < .001$
Light orange				-	$p = .006$	ns
Pale purple					-	$p = .001$
Pale green/yellow						-

In the graph of the dull/sharp scale, Figure (5−9), the results show a trend in which dark yellow and pale yellow are rated towards the dull end of the scale, whereas all the other colours are rated towards the sharp end of the scale. LSD (least significant difference) contrasts conducted on the main effect for colour indicated that 10 of the 15 contrasts were significant (*p*-values for the significant contrasts ranged from .024 to < .001). The significant contrasts are indicated in Table 5−9. Significant contrasts were found between deep yellow and light yellow, deep yellow and light orange, deep yellow and pale purple, deep yellow and pale green/yellow, light yellow and pale yellow, light yellow and light orange, light yellow and pale purple, pale yellow and light orange, pale yellow and pale purple, and pale yellow and pale green/yellow.

Table 5-9: *P*-values for the Significant Contrasts (Dull/Sharp)

	Deep yellow	Light yellow	Pale yellow	Light orange	Pale purple	Pale green/yellow
Deep yellow	-	$p < .001$	ns	$p = .004$	$p = .005$	$p < .001$
Light yellow		-	$p < .001$	$p = .010$	$p = .008$	ns
Pale yellow			-	$p = .018$	$p = .024$	$p < .001$
Light orange				-	ns	ns
Pale purple					-	ns
Pale green/yellow						-

In regard to the warm/cool scale, the results show a trend in which pale purple and pale green/yellow are rated towards the cool end of the scale, whereas all the other colours (particularly light orange) are rated towards the warm end of the scale. LSD (least significant difference) contrasts conducted on the main effect for colour indicated that 8 of the 15 contrasts were significant (p-values for the significant contrasts ranged from .026 to < .001). The significant contrasts are indicated in Table 5−10.

Table 5-10: *P*-values for the Significant Contrasts (Warm/Cool)

	Deep yellow	Light yellow	Pale yellow	Light orange	Pale purple	Pale green/yellow
Deep yellow	-	ns	ns	ns	$p = .004$	$p = .006$
Light yellow		-	ns	$p = .026$	$p = .019$	$p = .026$
Pale yellow			-	$p = .002$	ns	ns
Light orange				-	$p < .001$	$p < .001$
Pale purple					-	ns
Pale green/yellow						-

In regard to the mediation of emotional response and heart rate in the relationship between colour and reading comprehension, the results show that because there was no relationship between colour and reading performance (F[5,138] = 1.01, p = .412), emotional response and heart rate did not mediate the relationship between the experimental manipulations and reading performance. No further statistical test is required.

5.3.4 Interview Results

The qualitative data provided rich information on the participants' perspective on the role of colour in the learning spaces and its effects on students' learning activity. The participants were interviewed individually after each session in the experiment. They were asked about how and why each colour could help them to focus on their studies in the individual study room. For each of the six colour conditions, participants were asked "does this colour motivate you to study and help you to focus? Why?" During the interview, the investigator recorded the participants' comments about each colour its meaning, associations and general attitudes towards these colours. The responses for each colour condition were reported and analysed for commonalities and differences; analysis of qualitative data for Cycle 4 (Study C) applied the same steps as for Cycle 2 (Study A) (see data analysis Section 3.3.5.1 in Chapter 3). In addition, responses were coded in a thematic analysis. The themes explored in the interviews were as follows:

1. The emotions, colour preferences, bodily impact, motivation, task, association, intellectual activity, duration, and spatial properties.

2. Possible reasons for these associations.

5.3.4.1 Light Yellow and Light Orange

The results indicated that 58% of the participants believed that light yellow could influence learning activity positively and help them to focus and study, while 54% of the participants believed the same for light orange. They also believed that these colours would have a positive impact on their emotions, physical body, motivation and intellectual activity. For instance, light yellow and light orange were associated with feelings such as happiness, pleasantness and comfort. In addition, the participants reported that light yellow and light orange are vibrant, optimistic and powering. Thus, the participants stated that these colours would motivate them to study and make them more active. They commented on light yellow and light orange as follows:

> It [light yellow] is a pleasant colour and it gives energy to study ... I feel active and it helps me to be awake and to focus. (Participant 23)
>
> I like it [light orange]... I feel more excited, comfortable and cheerful… it creates a warm atmosphere and helps to focus. (Participant 16)

Participants mentioned that colours can impact on study duration in the learning space. For example, they reported that light yellow and light orange would assist students to study for long time because they believe these colours are comfortable and active. They commented:

> … I think it [light yellow] is suitable for study especially for long time because it makes me alert and willing to study. (Participant 2)
>
> … it is comfortable for eyes and it is soft… I can study for long time with this colour. (Participant 4)

Participants commented on colour association in regard to light yellow and light orange. For example, these colours were associated with natural and cultural aspects.

> … it [light yellow] is comfortable and looks like sunshine… (Participant 4)
>
> I like it because it [light orange] reminds me of the flag of Ireland… it contains green and orange... it is a fruity colour like a peach… (Participant 17)

However, the results showed that 41% of participants did not believe light yellow is a suitable colour for study, and 45% of participants reported this for light orange as well, because they think these colours can impact passively on their physical body and concentration level by distracting their mind, causing eye fatigue and increasing feelings of tiredness and inactiveness due to their brightness.

> It [light yellow] is a nice colour but it is distracting and uncomfortable for study because it is slightly bright... I get eye tired. (Participant 8)
>
> “It is a distracting colour and also it makes me feel sleepy... less focused… I think it is not a good colour for a learning environment. (Participant 13)

A few participants mentioned the relationship of colours to tasks; for instance, light yellow and light orange were considered nice colours and interesting, but more suitable for other activities, such as sport for light yellow, and entertainment activities for light orange:

> It [light yellow] is not comfortable for study… it is good for sport. (Participant 17)
>
> It [light orange] is a cool colour but I think it is suitable for entertainment spaces ... (Participant 18)

In addition, the results showed that light yellow and light orange are associated with negative emotions. Some participants reported that light yellow and light orange are considered warm, strong, glary, annoying, and less stimulating. They commented:

> It [light yellow] is very bright and annoying colour… (Participant 9)
>
> … it [light orange] is not vibrant, flat, and not dynamic… (Participant 1)

Moreover, it was found that personal colour preferences had an impact on rating light yellow and light orange as inappropriate for learning activities. The participants commented:

> This colour [light yellow] does not encourage me to study because I dislike yellow… it is uncomfortable for study and I cannot focus on the reading task. (Participant 18)
>
> I don't like this colour [light orange] ... (Participant 12)

5.3.4.2 Deep Yellow

The results indicated that 83% of the participants thought the colour deep yellow unsuitable for studying. It was associated with negative feelings such as dark, depressing, unappealing, boring, dirty, annoying, disgusting, unpleasant and heavy. The participants' comments were as follows:

> It is [deep yellow] not an appealing colour, boring, dull and dirty colour … (Participant 5)

> It is [deep yellow] not a nice colour, depressing and disgusting colour… (Participant 8)

In addition, the participants believed that deep yellow influences their physical body in a negative way. For example, they reported that deep yellow made them feel tired, sick, inactive, sleepy, and nervous. Deep yellow was less preferred and not considered a motivating colour to study. The participants made similar comments:

> I don't like this colour because it is a dark and depressing colour… it makes me feel tired and it distracts my concentration… so it is not a motivating colour for study. (Participant 3)

> It is a heavy and negative colour... it is uncomfortable for study, making me feel tired, hot and less active… as well it is distracting so I cannot focus with this colour condition. In general, this colour is not supportive for study. (Participant 16)

One participant reported that deep yellow does not encourage him to study because it is associated with mustard and it is a sickly colour. The comment was as follow:

> It is like mustard… unpleasant and unmotivated colour to study… and uncomfortable colour… sickly. (Participant 17)

However, 16% of the participants believed that deep yellow would be a suitable colour for learning activities. They reported that deep yellow is comfortable, active and interesting, and would help them concentrate on their task. They made similar comments:

> It is settled and interesting colour… feel more comfortable and active with this colour… as well as it helps to concentrate on my reading task. (Participant 1)

> This colour I think is good for study because it is cosy and less bright... so it helps me to focus on what I read… it is very active colour and I feel alert. (Participant 7)

5.3.4.3 Pale Yellow, Pale Green-Yellow and Pale Purple

The data from the interview shows that pale yellow, pale purple and pale green-yellow are considered unsuitable colours for individual study spaces by a high number of the participants. 54% of the participants perceived pale yellow as unsuitable 62% of participants found this for pale green-yellow; and 58% of participants found pale purple unsuitable for leaning activities. It was believed these colours have negative effects on participants' emotions, physical body, intellectual activity and motivation. For example, pale yellow was perceived as less emotional. Participants reported that their emotions were not affected by this colour; it was considered very neutral, dull, boring and under-stimulating because it was perceived as an institutional colour:

> It is [pale yellow] boring and not interesting ... it has no effect on my emotion because it is a very pale colour … I don't like it and I think it is not a suitable colour for learning activity. (Participant 14)
>
> … it [pale yellow] is also a distracting colour and very institutional. (Participant 3)

In addition, pale purple and pale yellow were perceived as very light, calm, relaxing and unpleasant, and these colours were believed to decrease the activity level of the participants. The participants reported that pale purple and pale yellow made them less active, sleepy and tired. Therefore, these colours could not help them focus or study. They commented:

> It [pale purple] is a very light and calm colour... it helps me to sleep more than to read. (Participant 3)
>
> It [pale yellow] is a dull and inactive colour... I feel tired and sleepy so it does not help me to focus. (Participant 6)

Participants believed that pale yellow and pale purple would be more suitable colours for other activities such as relaxation in the living room or dining room, and pale purple was perceived as a suitable colour for a child's bedroom:

> …I think it [pale yellow] is good for relaxing not for learning… (Participant 4)

> … It [pale purple] is good for relaxing. (Participant 16)
>
> … It [pale purple] makes me feel hungry so it would be good for a dining room. (Participant 4)
>
> It [pale purple] is so calm and babyish a colour ... I think it is a good colour for kids' bedroom… (Participant 2)

As for pale green-yellow, 62% of the participants believed this colour is not suitable for learning activities. It was believed that pale green-yellow could impact negatively on their emotions. It was considered very bright, strong and annoying, with a negative impact on the physical body, by causing eye fatigue and nervous states and being mentally distracting. Therefore, the participants felt less motivated to study and believed the colour did not increase their concentration on the reading task. The participants' comments were as follows:

> It [pale green-yellow] does not push me to study because it is distracting and too bright a colour... I feel it is coming on me… so near to me … and hard to look at it and I feel there are dots on the paper when I read the task. (Participant 11)
>
> My eyes are getting tired with this colour [pale green-yellow] because it is bright and reflects too much light... it is not suitable for study. (Participant 18)

Two of the participants mentioned the relation between colour and behaviour by saying that pale green-yellow is highly reflective and that this would not encourage them to stay in the space for a long time. They suggested this colour would be an appropriate colour for entertainment or hospital spaces:

> It [pale green-yellow] does not give me energy to study because there are strong reflections come from it… I cannot stay here to study I want to run away from this space because it is very distracting… this colour is good for relaxing or having fun. (Participant 7)
>
> … I think it [pale-green-yellow] would be good for a hospital… I feel sick with this colour… it does not inspire me or encourage me to study and I cannot stay in this room… it is so strong a colour and not comfortable as well. (Participant 5)

On the other hand, some participants thought that pale yellow, pale purple and pale green-yellow are suitable colours for learning activities, because they believed these colours provoke positive feelings such as happiness, freshness, relaxation and calmness. For example, pale green-yellow and pale yellow were perceived by 37% and 45% of the participants respectively as vibrant, inviting and inspiring colours because they related them to natural aspects; for example, sunshine or daylight was associated with pale yellow, and the countryside with pale green-yellow. Regarding colour associations, one of the participants stated that pale yellow is associated with old books; therefore, he believes that pale yellow can create a comfortable atmosphere for studying. The participants commented:

> It [pale yellow] encourages me to study because it is a bright, alert, powering, inspiring and inviting colour… as well as it is a natural colour and good for focus and study. (Participant 10)
>
> …I like it [pale-green-yellow]… it makes me feel fresh because it is associated with grass and landscape… (Participant 13)
>
> It [pale yellow] is nice and very comfortable colour for study... and it is associated with books especially old books… it helps to focus. (Participant 17)

As for pale purple, 41% of the participants perceived it as a calm and relaxing colour:

> … It [pale purple] is a calm and relaxed colour… (Participant 10)

A few participants, about 10% believed that pale yellow, pale purple and pale green-yellow are comfortable colours for the eyes and enhance their activation and alertness. They felt that these colours would motivate them to study and make them more active. They commented on pale purple, pale-green-yellow and pale yellow as follows:

> [pale green-yellow]… is comfortable for the eyes and it helps me to focus… and it gives energy to study and makes me more awake. (Participant 3)
>
> It [pale yellow] is very comfortable for study and concentration because it is a light and neutral colour… and also it is comfortable for the eyes. (Participant 20)

> This colour [pale purple] is pleasant, alert, comfortable and cold... it helps to focus and study and also comfortable for the eyes. (Participant 17)

5.4 Cycle 4 (Reflection 4): Discussion of Results

The aim of this experiment was to test the impact of colours that were chosen in Cycle 3 (Study B) (focus group) on the students' reading comprehension, emotional response and heart rates in the individual study areas within the university library building. As in Cycle 2 (Study A), this study took place in a full scale space that was designed to simulate a typical space for individual study in the university library. The implications of the findings will now be discussed in relation to use of colour in library learning areas.

5.4.1 Reading Comprehension

In contrast to Cycle 2 (Study A), reading comprehension was not affected by colour conditions in Cycle 4 (Study C). It was obvious from the data that reading performance did not vary across the different colours. There were no significant differences in reading comprehension scores across the different colours. The reason for this finding might be that most colours used in Cycle 4 (Study C) had medium whiteness and medium chromaticness levels (light yellow, light orange), and high whiteness and low chromaticness (pale yellow, pale green-yellow, pale purple), except for one colour which had medium blackness and medium chromaticness (deep yellow). This means the difference between colours nuances was not very high (no contrast colours). The participants did not make a distinction between light colours and pale colours; they considered all colours with high and medium whiteness to be 'light colours.'

Another explanation of this result is that because these colours are considered less stimulating and less arousing, the participants did not achieve significantly different scores when performing the reading comprehension test in the individual study room regardless of its colour — light yellow, deep yellow, pale yellow, pale purple, light orange or pale green-yellow. This finding may also indicate that the effect is too small to be detected or participants need a longer time in the room for the effects to attain statistical significance.

5.4.2 Heart Rate Response

There were changes in the heart rates of participants when exposed to different colours for periods of time that allowed them to adapt to the conditions. The colours with medium levels of whiteness and medium levels of chromaticness such as light yellow and light orange, and with high whiteness and low chromaticness such as pale green-yellow, increased heart rates; pale green-yellow especially was more effective than the others. On the other hand, colours with high whiteness and low chromaticness such as pale purple and pale yellow, and colours with medium blackness and medium chromaticness such as deep yellow, decreased heart rates, especially pale purple. This finding is consistent with a number of previous studies, which showed that colour has a significant effect on heart rate. Researchers found that heart rate increased in response to warm colours such as red and yellow, and decreased in response to cool colours such as blue (Abbas, Kumar and Mclachlan 2006; Ward 1995).

In this respect, these findings are consistent with the heart rate results in Cycle 2 (Study A), which found that heart rate increased in response to warm colours such as red and yellow. Similarly, in Cycle 4 (Study C), heart rate increased in response to warm colours such as pale green-yellow, light orange and light yellow.

5.4.3 Emotional Response to Colour

The emotional responses to colour in Cycle 4 (Study C) revealed that colour has a significant impact on participants’ emotional responses. In addition, the findings are consistent with previous studies which confirmed that colour has a strong impact on emotional responses (Hårleman 2001; Kaya and Epps 2004; Stone 2001), and the results also are consistent with findings of Cycle 2 (Study A).

The data show that the colours light yellow, light orange, pale yellow, pale purple, and pale green-yellow were perceived as pleasant, fresh, light, relaxing, interesting and light. However, the colour deep yellow, with medium blackness and medium chromaticness, was associated with negative emotions; it was perceived as unpleasant, heavy, stale, tense, and dark. The Munsell value has been cited as an important factor for determining colour pleasantness. Guilford and Smith (1959) conducted an investigation rating 316 colour papers. They found that pleasantness increased when the level of the Munsell value increased. A colour preference study by Sivik (1974) investigating the impact of whiteness, blackness and chromaticness on colour preference found that blue was rated a more positive colour than other colours, but across all colours, Sivik found that when blue became a blacker colour, it was rejected. Thus blackness was considered unpleasant. Similarly, pale yellow and light yellow were associated with positive emotions, whereas yellow with some level of blackness was associated with negative emotions.

The results show that deep yellow and pale yellow were perceived as dull colours compared to other colours, and were also perceived as calm, like pale purple, because of the lack of chromaticness in pale yellow and pale purple and an increase of blackness for deep yellow. Participants reported feeling inactive in their presence. In contrast, participants felt more excited in light orange, light yellow and pale green-yellow conditions. One interpretation of this finding may be that colours with high chromaticness make participants feel more active.

As for light yellow, the result was consistent with Manav's findings (2007), which reported that yellow with medium whiteness and medium chromaticness was associated with feelings of excitement. This result is consistent with results for emotional response in Cycle 2 (Study A). As for the warm/cool scale, the results showed that colours with whiteness or blackness dimensions such as deep yellow, light yellow, pale yellow and light orange were considered warm colours, whereas pale purple and pale green-yellow were perceived as cool colours.

The data show that chromaticness, whiteness and blackness (the three components of nuance) have a strong impact on emotions. This is in accordance with the findings stated in Xin et al. (2004), where the effects of the Munsell value and chroma were found to be much more significant than those of hue.

There were no relationships between changes to heart rate and reading performance, and emotional response and reading performance. This means that heart rate changes and emotions cannot mediate the relationship between colour and reading performance.

5.4.4 Interviews

The participants were interviewed individually and asked about the impact of each colour on their emotion and learning performance. A number of themes emerged from the data that are related to colour effects, such as emotion, colour preferences, bodily impact, motivation, task, association, intellectual activity, sensations and spatial properties. In general, the colours light yellow and light orange with medium whiteness and medium chromaticness levels were considered appropriate colours for learning activities in the individual study room. They elicited a high number of responses, including the feelings of happiness and excitement, and were seen as vibrant, empowering, optimistic and comfortable colours. These findings were similar to previous findings, which revealed that yellow and orange are associated with positive emotions (Manav 2007; Clarke and Costall 2008).

Furthermore, light yellow and light orange were associated with natural aspects such as sunshine for light yellow and the fruit peach for light orange; also, light orange was associated with cultural aspects such as the flag of Ireland. As a result, these colours assisted participants to be alert and active, and motivated them to study for a long time and increase their concentration. The findings for light yellow were consistent with the qualitative results in Cycle 2 (Study A). In addition, the results for light orange support the findings in Cycle 3 (Study B) (focus group) which revealed that light orange is a suitable colour for learning activities.

The data reveals that deep yellow was considered an unsuitable colour for learning activities in the individual study room within the university library. The participants reported that deep yellow might impact negatively on their learning performance and it did not motivate them to study. They found deep yellow depressing, dark, unappealing, dirty, annoying, unpleasant, disgusting, heavy and boring. This result corroborated previous research concerning the degree of whiteness and blackness, which revealed that a degree of blackness was associated with negative emotions (Sivik 1974). The participants also reported that deep yellow negatively influenced their bodily responses, making them feel tired, sick, sleepy, inactive and nervous, which decreased their concentration on the reading task and distracted their mind. This finding disagreed with Cycle 3 (Study B) results, where deep yellow was perceived as suitable colour for learning activity.

It is observed from the interview results that pale yellow, pale purple and pale green-yellow were also considered unsuitable for learning activities in the individual study room. They were perceived as under-stimulating colours that did not encourage participants to study. For example, pale yellow was seen as dull, boring, and very neutral because of its lack of chromaticness. Pale yellow and pale purple were also perceived as very light, calm, relaxing and unpleasant colours, and this contributed to making participants feel sleepy and inactive. Therefore, they considered that these colours would not help them to focus or study. This is in accordance with the findings stated in Kwallek et al. (1996) that lighter values appear to be more distracting than darker values.

As for pale green-yellow, it was perceived as a strong, bright, and annoying colour, causing eye fatigue and detrimental to mental activity and focusing. This finding is consistent with a previous study which found that the colour green-yellow was associated with negative emotions and evoked feelings of sickness and disgust (Kaya and Epps 2004). In general, the data reveal that pale green-yellow, pale yellow, and deep yellow were considered unsuitable colours for learning activities; these results did not support the results of Cycle 3 (Study B) in this thesis. In addition, the results of interviews (qualitative data) disagree with the results of the quantitative data (emotional reactions) in regard to the colours with a whiteness dimension. It was found that colours with high and medium level of whiteness were associated with positive feelings in the quantitative data, while only light orange and light yellow were associated with positive feelings and considered suitable colours for learning activities in the qualitative data.

5.5 Conclusion

In Cycle 4 (Study C) the researcher tested the effects of environmental colour on learning activities in learning spaces. Besides the manipulation of wall colours, students' heart rate and emotional responses were investigated to measure their effects on learning performance.

The quantitative results suggest that the colours used in this study have a greater impact on emotional response and heart rate than on reading comprehension. Colours with high and medium whiteness (light yellow, light orange, pale yellow, pale purple, pale green-yellow) were associated with positive feelings compared to a colour with medium blackness and medium chromaticness (deep yellow). As for heart rate, it was found that heart rate increased in response to warm colours with medium whiteness compared to colours with medium blackness (deep yellow) and high whiteness (pale purple and pale yellow).

The results revealed that reading performance was not affected by colour conditions. These findings disagree with Cycle 2 (Study A) findings that reading performance was influenced by colour conditions. It can be concluded that nuance has a more important impact on reading comprehension than hue. Cycle 2 (Study A) used two nuances (light and vivid colours), while in Cycle 4 (Study C) the difference between colours nuances was not very high. Table 5-11 shows the summary of quantitative data.

Table 5-11: Summary of quantitative data

Colours with high whiteness	Emotional response	Heart Rate	Reading comprehension
Light orange	Exciting, pleasant, fresh, relaxed, light, warm and interesting.	Increases in HR	No impact
Light yellow	Exciting, pleasant, fresh, relaxed, light, warm and interesting.	Increases in HR	
Pale green-yellow	Exciting, pleasant, fresh, relaxed, light, cool and interesting.	Increases in HR	
Pale yellow	Dull, pleasant, fresh, relaxed, light, calm, warm and interesting.	Decreases in HR	
Pale purple	Calm, pleasant, fresh, relaxed, light, cool and interesting.	Decreases in HR	
Colours with high blackness	**Emotional response**	**Heart Rate**	**Reading comprehension**
Deep yellow	Dull, calm, unpleasant, heavy, stale, tense, dark, and warm.	Decreases in HR	No impact

The qualitative data agree with the quantitative data in regard to light yellow and light orange, because these colours were associated with positive feelings, as indicated in the quantitative results for emotional response, but there was disagreement in regard to the colour pale green-yellow. Pale green-yellow was related to positive feelings in the quantitative results for emotional response but not in the qualitative interview results. Table 5−12 shows the summary of the main findings of the interviews in Cycle 4 (Study C).

Table 5-12: Summary of interview results (qualitative data)

Colours	Summary
Light yellow and light orange	Perceived as happy, exciting, comfortable, vibrant and empowering, and as **suitable colours for study and focusing.**
Deep yellow	Associated with negative feelings (dark, depressing, boring, unappealing, annoying, disgusting and heavy). Feeling tired, sick, and sleepy. **Does not motivate to study.**
Pale yellow	Less emotional, very neutral, dull, boring and less stimulating. Calm and unpleasant. **It does not help to focus**. It is a good colour for a living room.
Pale purple	Calm, relaxing, unpleasant and inactive. Feeling sleepy and tired. **It does not encourage studying and focusing**. Good colour for child's bedroom.
Pale green-yellow	Very bright, strong and annoying. Causing eye fatigue, nervousness and distraction for the mind. **It is not a motivating colour for study.**

In addition, the qualitative results disagree with the quantitative results in terms of which colour supports learning. In regard to the quantitative results, no colour improved the reading comprehension scores. However, the qualitative results suggested that participants considered light orange and light yellow to be suitable colours for reading in the individual study room. The reason for the contradictory findings might be that the qualitative results are subjective responses, and the participants expressed their opinion when they were interviewed. Table 5-13 shows the main results per colour with different methods in regard to the reading task.

Table 5-13: The main results per colour with different methods in regard to the reading task

Colours	Quantitative Method (Reading task)	Qualitative Method (Reading task)
Light yellow	No effect	Good
Light orange	No effect	Good
Pale yellow	No effect	Bad
Pale purple	No effect	Bad
Deep yellow	No effect	Bad
Pale green-yellow	No effect	Bad
Conclusion	Reading scores did not vary across the different colours	Light yellow and light orange support reading task

The results of Cycle 4 (Study C) did not support the results of Cycle 3 (Study B) on some points. The six colours tested in Cycle 4 (Study C) were not all considered suitable for learning activities although they were in Cycle 3 (Study B). Only light yellow and light orange were considered good colours for studying in the individual study room. This may be due to the changes in the appearance of colours, because participants in Cycle 3 (Study B) evaluated small colour samples while the participants in Cycle 4 (Study C) evaluated the same colours chosen in Cycle 3 (Study B), but in large size. The effects of large size of some colours caused distractions for the participants. Figure 5–15 shows the main findings of Cycle 4 (Study C).

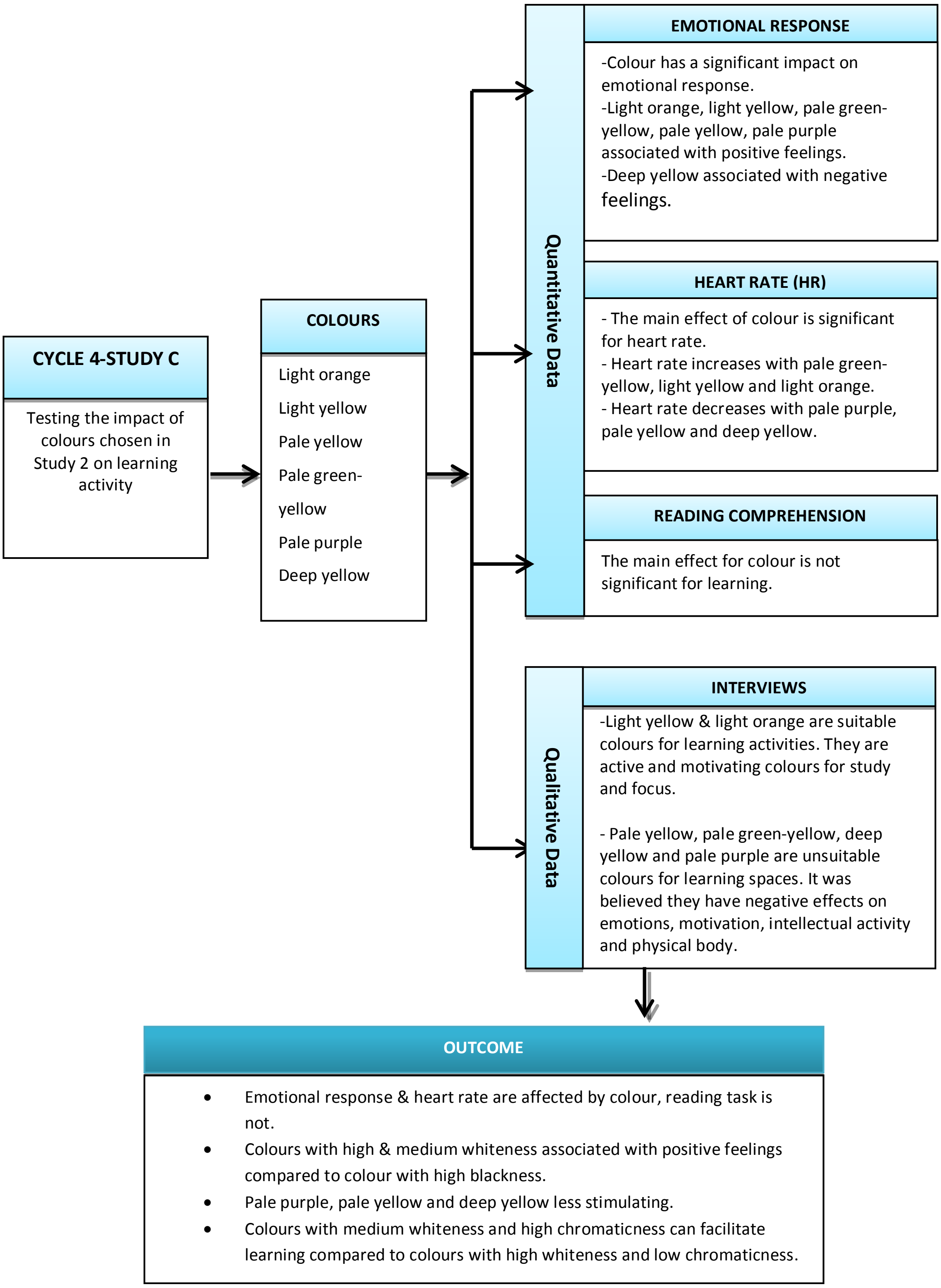


Figure 5-15: The Outcome of Cycle 4 (Study C)

6 CHAPTER 6: GENERAL CONCLUSION

The central focus of this research is the use and the role of colour in learning spaces within library spaces, with the aim of gaining a better understanding of how learners relate to learning spaces, and whether colour influences learning and encourages students to engage in studying. In contrast to previous colour studies, the enquiry investigates physiological (heart rate), psychological (emotional response) and subjective measures (preferences and association) to investigate the relationship between colour and learning performance.

This research will contribute to the knowledge base of architects and interior designers who wish to design effective colour systems for learning environments. Chapter 6 presents general conclusions derived from this thesis and synthesises the findings to convey the insights gained in response to the research questions posed. In addition, it outlines the limitations of this research and offers possible directions for future research.

6.1 The Study Conclusion

Each of the four action research cycles indicate significant key aspects to be investigated in the next cycle. Cycle 1 (literature review) established a starting point for Cycle 2 (Study A) by investigating previous finding on how learners might be influenced by colour in learning spaces. Cycle 1 (literature review) also established that the colours red, yellow and blue were believed to assist students' learning performance.

Building on this knowledge, Cycle 2 (Study A) examined the impact of six colours (including red, yellow, blue hue and nuance) on students' emotional responses, heart rate and reading comprehension. The results of this second cycle (Study A) showed that reading comprehension, emotional response, and heart rate were affected by colour conditions. As a result of Cycle 2 (Study A), it was then decided to identify other appropriate colours to examine their effects on university students' learning. The results of this work informed the design of the subsequent study held with focus groups who were invited to select suitable colours for an individual study room that would facilitate learning performance.

Cycle 3 (Study B) was conducted through focus groups comprising university students to gain rich information, including how colours can motivate students to study. The results of this cycle suggested six colours that would be suitable for an individual study room: light yellow, light orange, pale yellow, pale green-yellow, deep yellow and pale purple.

Cycle 4 (Study C) tested the impact of the six colours chosen in Cycle 3 (Study B) on emotional response, heart rates and reading comprehension. Cycle 4 used the same experimental procedure as Cycle 2 (Study A), thereby enabling comparison to be made between the 12 colours tested. There is considerable consistency of findings from the three studies (A, B, and C); however, there are also some inconsistencies. The three studies contributed valuable information on the effects of colour on emotional responses, heart rate and reading comprehension to the fields of colour studies and learning in university libraries.

This section will show how the following research questions were addressed and will summarise the findings.

1. To what extent do the hue and nuance dimensions of colour influence reading comprehension in the individual study room?

2. To what extent do hue and nuance dimensions of colour influence heart rate and emotional response to colour in the individual study room?

3. To what extent do emotional responses to colour and heart rate mediate the relationship between colour and reading comprehension in the individual study room?

6.1.1 The conclusions from emotional response evaluation and heart rate changes of Studies A and C

The results indicate that colour has a strong impact on emotional responses and heart rate in Studies A and C. regarding emotional responses, the results of Studies A and C consistently showed that light colour conditions with medium whiteness and medium chromaticness (light blue, light yellow, light red, light orange and pale-green-yellow) were associated with more positive effects on emotional responses. These colours were perceived as pleasant, relaxing, exciting, interesting, light and fresh. As for colours with high whiteness such as pale yellow and pale purple in Study C, the results showed that they had less positive effects on emotional responses as they were associated with negative effects.

On the other hand, colours with high chromaticness and low whiteness (vivid, red, vivid yellow and vivid blue) in Cycle 2 (Study A), and a colour with high blackness (deep yellow) in Cycle 4 (Study C) were associated with negative effects, as they were perceived as unpleasant, tense, dark, and heavy. Table 6-1 shows the main emotional response evaluation findings of Studies A and C.

Table 6-1: The main emotional response evaluation findings for Studies A and C

Studies	Colours	Emotional Response (quantitative data)
Study A	Vivid Red	Negative
	Light Red	Positive
	Vivid Yellow	Negative
	Light Yellow	Positive
	Vivid Blue	Negative
	Light Blue	Positive
Study C	Light orange	More positive effect
	Light Yellow	More positive effect
	Pale Yellow	Less positive effect
	Pale purple	Less positive effect
	Pale green-yellow	More positive effect
	Deep Yellow	Negative effect

Studies A and C consistently showed that increases in heart rates were found in association with the warm colours red and yellow in Cycle 2 (Study A), and with light yellow, light orange and pale green-yellow in Cycle 4 (Study C). These results support the notion that environmental stimuli can affect mood and emotions (Knez 2001) and that colour is an environmental stimuli that has a strong impact on humans' psychology and physiology (Abbas, Kumar and Mclachlan 2006; Küller, Mikellides and Janssens 2009). Table 6-2 shows the findings for main heart rate changes in Studies A and C.

Table 6-2: The main findings for heart rate changes in Studies A and C

Studies	Colours	Heart Rate (quantitative data)
Study A	Vivid Red	Increase in HR
	Light Red	Increase in HR
	Vivid Yellow	Increase in HR
	Light Yellow	Increase in HR
	Vivid Blue	Decrease in HR
	Light Blue	Decrease in HR
Study C	Light orange	Increase in HR
	Light Yellow	Increase in HR
	Pale Yellow	Decrease in HR
	Pale purple	Decrease in HR
	Pale green-yellow	Increase in HR
	Deep Yellow	Decrease in HR

6.1.2 The conclusions from reading comprehension assessment of Studies A and C

The results indicate that reading comprehension was affected by colour with improvement in vivid colour conditions such as vivid red, vivid yellow and vivid blue (colours with high chromaticness and low whiteness), while the scores of reading comprehension declined in light colour conditions (light red, light yellow and light blue) in Cycle 2 (Study A). However, reading comprehension was not affected by the colours light yellow, light orange, pale yellow, deep yellow, pale green-yellow and pale purple in Cycle 4 (Study C). The reason for these findings relates to the nuance rather than the hue, as all colours used in Study C were whitish, there were no vivid colours as in Study A. Table 6-3 shows the main findings of reading comprehension test in Studies A and C.

It is well documented in the literature described in Cycle 1 that the colours red and yellow are suitable colours for learning performance, particularly for cognitive tasks that need concentration, because these colours are arousing (Kaya and Crosby 2006). In addition, blue can be suitable for creative tasks because it encourages deep thought (Mehta and Zhu 2009; Pile 1997).

Table 6-3: The main findings of reading comprehension test in Studies A and C

Studies	Colours	Reading comprehension (quantitative data)
Study A	Vivid Red	Good
	Light Red	Bad
	Vivid Yellow	Good
	Light Yellow	Bad
	Vivid Blue	Good
	Light Blue	Bad
Study C	Light orange	No effect
	Light Yellow	No effect
	Pale Yellow	No effect
	Pale purple	No effect
	Pale green-yellow	No effect
	Deep Yellow	No effect

6.1.3 The conclusions from qualitative data of studies A, B, and C

The qualitative data confirmed many times (see interview results in Studies A and C, and focus groups results in Study B) that colours can indirectly affect learning performance by influencing emotions, the bodily response, motivation, intellectual activity, personal connections, associative properties and spatial perception. The premise of the three studies predicted that when colours put the students in a positive mood, they are more focused and more willing to study for a long time. This finding was supported by Elliot and Maier's study (2007) which revealed that colours which evoke positive feelings will stimulate an approach motivation, while colours evoking negative feelings will stimulate an avoidance motivation.

When the participants were interviewed in Studies A, B and C, they commented that colours that produce comfortable, calm and relaxed feelings and atmosphere would help them study and focus and improve learning performance. For this reason the participants considered light colours such as light blue, light yellow, light orange, pale green-yellow in Studies A, B and C suitable for learning environments, particularly for individual study spaces. However, feelings of relaxation and calmness could have a negative impact on learning performance in the individual study space, because students spend a considerable time in the study room and light colours would create a calm atmosphere which might make them less active and impair their performance.

The qualitative data provided insights into the effects of colour on learners in the university library, particularly in Cycle 3 (Study B) (focus group). The participants clarified how colour can facilitate learning and encourage students to study. The participants concurred that learners are affected by their surroundings in the library, especially colour. In the questionnaire, the participants indicated that the colours of the learning spaces in the Robertson Library have negative effects on learners because they are perceived as neutral, institutional and less stimulating colours. Therefore, the participants chose warm and stimulating colours such as yellows, orange and green-yellow as suitable colours for learning. Nature is another aspect that the participants talked about, suggesting that using natural colours in learning spaces can be empowering and stimulates them to study in the library for a long time.

For emotional responses, it can be seen that the qualitative data agree with the quantitative data in the three studies. The nuance and hue dimensions had a significant impact on emotions. In the quantitative data, the light colours were associated with positive feelings in Cycle 2 (Study A) and Cycle 4 (Study C); in the qualitative data (Studies A and C interviews and Study B focus groups), the participants asserted that light colours had positive effects on their psychological and physiological states.

6.1.4 Inconsistent results derived from all three studies

Across all three studies, there were some inconsistencies in the results. Firstly, the results of Cycle 2 (Study A), Cycle 3 (Study B) and Cycle 4 (Study C) showed that in regard to learning performance, the quantitative data disagreed with the qualitative data; the latter showed that light colours were considered suitable for learning environments, encouraging students to study and increase their focus in Studies A, B and C (qualitative data). However, light colours did not have a significant impact on the reading comprehension task in Studies A and C (quantitative data).

Secondly, results are inconsistent for Cycle 2 (Study A) and Cycle 3 (Study B); during the focus group sessions, it was found that colours with high chromaticness (vivid red, vivid yellow and vivid blue) were not selected by the participants as suitable colours for an individual study room in the university library, whereas colours with high chromaticness and low whiteness (vivid red, vivid yellow and vivid blue) enhanced reading activity in Cycle 2 (Study A).

Thirdly, the results of Cycle 3 (Study B) were dissimilar to findings in previous studies that suitable colours for university students' learning performance were the elementary colours red or blue. The participants in the focus group (Study B) did not select the elementary colours red or blue as suitable colours for learning; only yellow was perceived as an appropriate colour. Most of the colours selected (in Study B) had a roughly equal resemblance to two NCS Elementary colours, one of which was yellow or red. No colours that were mainly bluish, reddish or greenish were selected.

Finally, the quantitative data in Cycle 2 (Study A) show that the chromaticness, whiteness and blackness (NCS nuance) of colours play an important role in determining the effects on students' learning performance. For example, reading comprehension scores were affected by the nuance dimension (not hue); high performance in vivid colour conditions and low performance in light colour conditions were observed in Cycle 2 (Study A). However, the results of Cycle 4 (Study C) indicated that there was no effect of colour on reading performance. Hue and nuance dimensions had no significant impact on reading comprehension scores. This might have been due to the small differences in nuance between the colours used in Cycle 4 (Study C). Therefore, reading task needs warm or bright colours to stimulate the brain to focus and to help the students stay awake and active.

In contrast, the hue dimension (not nuance) had a significant effect on heart rates. It was found that when participants were exposed to different colours for periods of time their heart rates increased in response to arousing and warm colours. For example, the findings of Cycle 2 (Study A) indicated that red and yellow, whether in vivid conditions or in light conditions, increased heart rate, whereas blue decreased heart rate. The results of Cycle 4 (Study C) show that heart rate increased when the chromaticness increased in warm colours (such as light orange and light yellow), and decreased when the chromaticness decreased in warm colours (such as pale yellow, pale purple, and deep yellow). These findings are consistent with previous studies which found that heart rates increase in response to warm colours with high chromaticness and decrease in response to cool colours (Abbas, Kumar and Mclachlan 2006).

6.1.5 Conclusions derived from the relationship between emotional response, heart rate and reading comprehension

The quantitative data confirmed that emotional response and heart rate did not mediate the relationship between colour and reading comprehension (Studies A and C). The qualitative data indicated that positive emotions would encourage students to study and to increase their focus in the individual study room. The increases in heart rates in warm colour conditions made participants feel more active and alert, which helped them to focus on their reading tasks. The interviews, in which participants mentioned that warm colours were arousing and stimulating and increased their activation, confirmed these results. According to Kuschel, Förster and Denzler (2010), positive feelings tend to increase the ability to solve insight problems.

The reason for this finding is the participants were guided by limited emotional terms when they rated the emotional response in the questionnaire in the beginning of the experiment. On the other hand, in the interviews, the participants were thinking through their answers in more detail to clarify the effects of colour on their performance.

From this study it is concluded that warm colours with high chromaticness and medium whiteness would assist students to be alert and active and to focus on their task. As for hue, the results show that the colour blue is associated with positive emotional responses such as calm, light, pleasant, interesting, fresh, relaxing and cool; however, this colour cannot help participants to be active in studying and focusing because it calms them and decreases their heart rates. Figure 6-1 summarise the main findings of the four cycles.

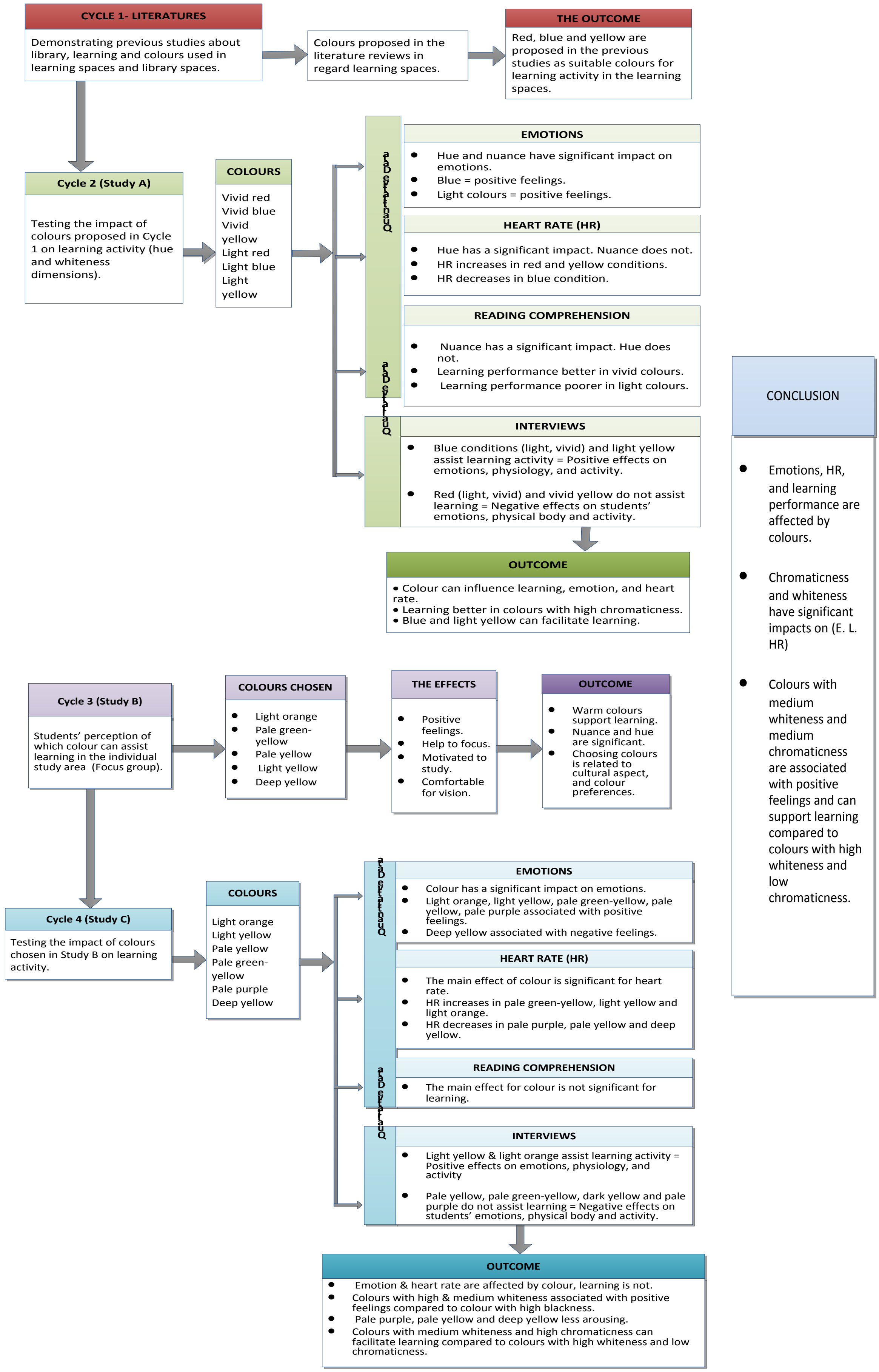


Figure 6-1: Main findings of the four Cycles summary

6.2 Main Conclusions

The following conclusions can be drawn from the study:

1. According to quantitative data, learning performance (reading comprehension) was influenced and improved by colour conditions, especially when the colours are more chromatic and arousing (vivid colours) as in Cycle 2 (Study A). The light colour conditions did not affect reading comprehension performance in Studies A and C.

2. Heart rate was significantly affected by hue (not nuance); it increased in the red and yellow conditions and decreased in the blue condition in Cycle 2 (Study A); and it increased in the light orange, light yellow and pale green-yellow conditions in Cycle 4 (Study C). This suggests that appropriate colours can evoke physiological and emotional responses in individuals that can focus attention and thereby facilitate learning. Overall, arousing colours can enhance students' learning performance and make them feel active, alert and willing to study and focus. In addition, they stimulate more positive emotions for the students.

3. Hue and nuance had a significant impact on students' emotional response in Studies A, B and C. The light colours were rated more positively in the three studies than the vivid colours because they were considered to be calming and relaxing and associated with feeling of happiness.

4. Although colours with high whiteness were associated with positive emotions in the three studies, learning performance was superior in colours with high and medium chromaticness.

5. Hue and nuance had a strong impact on learning performance. In regard to hue, blue and red were considered unsuitable colours for learning activities such as the reading comprehension task. It was found that the colour blue decreases heart rate and slows activity, and interferes with concentration due to its calming effect. As for the colour red, it is very arousing and

warm, which might help an individual to focus for a short time, but in the long-term it would be difficult to concentrate.

6. In regard to learning activity, light yellow and light orange were considered suitable colours for learning in the individual study room because they were related to happiness and natural aspects and they motivated students to study and increase their level of concentration.

6.2.1 Conclusion derived from the study regarding the appropriate colours for individual study room

The qualitative data of three studies consistently showed that light yellow is a suitable colour for the individual study room due to its positive effects on students' psychology and physiology state. As for light orange, Studies B and C showed that it is an appropriate colour for individual study room as it assists students to focus and study. The results for pale green-yellow show that this colour was strongly recommended for the individual study room in Cycle 3 (Study B), as it was perceived to be active and stimulating for study; while in Cycle 4 (Study C) it was moderately recommended for use in the individual study room, as it was perceived as a very arousing colour.

For the colours pale yellow, pale purple and deep yellow, the results from Studies B and C were inconsistent. In Study B it was found that these colours were considered as suitable colours for learning activity in the individual study room, but were not in Study C.

In regard to red and blue, the results of Cycle 3 (Study B) were inconsistent with Cycle 2 (Study A) and the literature review, because these colours were not selected and considered to be suitable colours for the individual learning room. Table 6-4 shows the main results of the three studies for the colours considered suitable for individual learning spaces.

Table 6-4: the main findings of three studies regarding the suitable colours for individual study room

Studies	Colours	Estimation of colour
Study A	Vivid Red	Bad
	Light Red	Bad
	Vivid Yellow	Bad
	Light Yellow	Good
	Vivid Blue	Good
	Light Blue	Medium
Study B	Light orange	Good
	Light Yellow	Good
	Pale Yellow	Good
	Pale purple	Medium
	Pale green-yellow	Good
	Deep Yellow	Good
Study C	Light orange	Good
	Light Yellow	Good
	Pale Yellow	Bad
	Pale purple	Bad
	Pale green-yellow	Medium
	Deep Yellow	Bad

It can be concluded that arousing and warm colours with medium chromaticness such as light yellow and light orange, as well as colours with high chromaticness regardless of hue, can enhance the focus and concentration of learners and increase their motivation to study in the individual study areas in the library building. It is concluded from these findings that colours with high chromaticness can increase feelings of happiness which will in turn increase the rate of achievement in interior spaces.

The small size of the individual study room may make the learner feel boxed in with little stimulation, and that can contribute to a monotonous study space. Therefore, the presence of active and stimulating colours would break this stereotypy of the learning spaces, and create dynamic interiors and assist learners to study without feeling bored. Figure 6–2 show the colours that have a high positive effect on learning performance.

This research recommends that architects and interior designers responsible for creating learning spaces in the library take into account the types of learning activities and the psychological and physiological states of the individuals when selecting colours. In addition, this research provides a good understanding of the importance of the use of colour in educational environments and explains the impact of colour on emotions and physiology of learners and their performance.

This work can help the designers of learning environments in their choice of effective colours for learning environments to facilitate learning and to encourage students to study in the physical libraries. Effective colours will enhance students' ability to concentrate effectively. This study can also inspire future research into the use of colour in the fields of education and library studies.

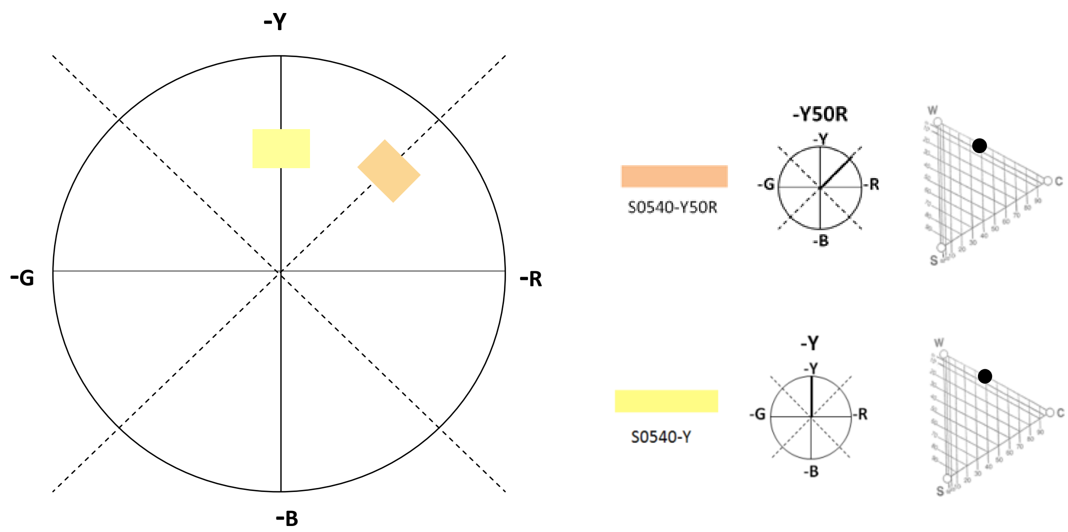


Figure 6-2: The most suitable colours for the tested individual study spaces and their locations within the NCS colour space

6.3 Method Evaluation

The methodology proved to be an appropriate choice for this study as it enabled the researcher to reliably evaluate the influence of colour in the indoor environment of the individual study room in the university library by using different colour dimensions. The methodology action research to achieve these research objectives has enriched this research. Action research incorporates a series of hypotheses that are sequentially explored and reflected upon, and the findings for each investigation are used to inform the next cycle. This method enabled the researcher to do a series of studies, with each study (cycle) based on the outcomes of the previous cycle. Action research in this thesis provides an in-depth, detailed understanding of colour's role in the individual study rooms in the learning environment.

The significance of the three studies (A, B, and C) conducted in this research was increased by using different methods in each cycle to investigate the impact of colour on learning performance in university libraries, and by addressing diverse students' responses. Cycle 1 (literature review) established that most previous studies had used a quantitative method to examine the impact of colour on learning, by measuring emotions, moods and performance using numbers and scales (Stone 2001; Stone and English 1998; Wang and Russ 2008). In contrast, this research integrated both qualitative and quantitative methods. A qualitative method acknowledges the complexities of individuals' relationships with and responsiveness to colour. It adds richness to data collection by demonstrating participants' perspectives and perceptions as learners in regard to colour in learning spaces.

Qualitative methods emphasise people's perceptions and perspectives that reveal surprises and new insights, while quantitative methods deal with numbers and scales (Brannen 2005). In order to illustrate the meaning that research participants attribute to their practice and actions, the qualitative data in this thesis provided narratives of events and experiences that offered a more holistic picture of their understandings than can be captured by the quantitative data.

In addition, the empirical method used to measure the impact of colour on emotional responses, heart rate and reading comprehension was effective, because it made the research more reliable and validated the results. According to Spencer, Zanna, and Fong (2005), experiments are an effective method for establishing cause and effect, as it is easy to control variables by removing unwanted variables, and easy to determine the cause and effect relationship. Further, the control set up by the experimenter and the strict conditions allow the experiments to be repeated, and results can be checked again; this gives the researcher greater confidence in the results.

It is important to be aware of the limitations of these studies when interpreting the results. First, the simulation of study spaces that are used in Studies A and C of this thesis cannot be translated into actual individual study room settings. This means the participants did not feel they were in an actual individual study room in the library. In addition, the comprehension test was a simulated learning task. Thus, the students may not have been motivated to study as much as they would be in real study situations. Also, the time spent studying and the time in various colour conditions was short. Thus, more research is needed to determine the underlying processes by which environmental colours might affect emotion and performance for various tasks.

6.4 Future Research

Based on the study results, further research is recommended. The results of this study contribute to understanding the influence of colour on adult students in the individual study rooms of university libraries. The study shows that hue and nuance of colour have specific effects on emotional responses, heart rate and reading task comprehension. Further studies are needed to investigate the effects of colour in other learning environments in university libraries such as group study rooms, training rooms, carrel study spaces and computer study areas.

As the time spent in the experimental studies (A and C) was short, more research is needed to conduct long-term field studies in real environments. In addition, research is needed to address not only the use of colour in the individual study rooms in the university library, but also lighting, noise, heat, furniture and other environmental factors, because there is reason to assume that colour interacts with other characteristics of the physical environment and influences a wide range of activities, including cultural differences and social life (see Chapter 2, Section 2.3.2).

Moreover, this study has focused on one kind of learning style (visual learning) in which reading comprehension is one possible task. Thus, further studies should assess other skills or learning styles, such as listening to lectures, creative work and problem solving.

Further research is also recommended to study the relationship between the colour preferences of individuals who use learning spaces and the effect of colour on their performance. Studying a larger more representative sample might help identify the more universal effects of colours on learning performance in the library building. In addition, an actual experiment could be recommended in which the individual study rooms are painted and observed for a designated time to detect which ones are preferred/utilised most.

This study and conclusions from both the qualitative and quantitative have provided a solid foundation for future research and to be tested in design practice.

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Appendix 1: Learning Channel questionnaire in Studies A and C

Learning Channel Preference

Dear participant

I would like to thank you for your cooperation in assisting with the proposed research. The following questions are very important to find out the preferred way in which you learn. All responses will be kept strictly confidential.

Procedure:

Read each sentence carefully and consider whether it applies to you. On the line, write:

3 often applies
2 sometimes applies
1 never or almost never applies

Preferred Channel: 1

____1. I enjoy doodling and even my notes have lots of pictures, arrows, etc. in them.

____2. I remember something better if I write it down.

____3. When trying to remember a telephone number or something new like that, it helps me to get a picture of it in my head.

____4. When taking a test, I can “see” the textbook page and the correct answer on it.

____5. Unless I write down directions, I am likely to get lost and arrive late.

____6. It helps me to LOOK at a person speaking. It keeps me focused.

____7. I can clearly picture things in my head.

____8. It’s hard for me to understand what a person is saying when there is background noise.

____9. It’s difficult for me to understand a joke when I hear it.

___10. It’s easier for me to get work done in a quiet place.

Total ______

Preferred Channel: 2

____1. When reading, I listen to the words in my head or read aloud.

____2. To memorize something it helps me to say it over and over to myself.

____3. I need to discuss things to understand them.

____4. I don’t need to take notes in class.

____5. I remember what people have said better than what they were wearing.

____6. I like to record things and listen to the tapes.

____7. I’d rather hear a lecture on something than have to read it in a textbook.

____8. I can easily follow a speaker even though my head is down on the desk or I’m staring out the window.

____9. I talk to myself when I'm problem solving or writing.

____10. I prefer to have someone tell me how to do something rather than have to read the directions myself.

Total_____

Preferred Channel: 3

____1. I don't like to read or listen to directions; I'd rather just start doing.

____2. I learn best when I am shown how to do something and then have the opportunity to do it.

____3. I can study better when music is playing.

____4. I solve problems more often with a trial and error, than a step-by-step approach.

____5. My desk and/or locker looks disorganized.

____6. I need frequent breaks while studying.

____7. I take notes but never go back and read them.

____8. I do not become easily lost, even in strange surroundings.

____9. I think better when I have the freedom to move around; studying at a desk is not for me.

____10. When I can't think of a specific word, I'll use my hands a lot and call something a "what-cha-ma-call-it" or a "thing-a-ma-jig".

Total _____

Thanks for your cooperation

Participant Name:_______________________________________

Date: _____________________________________

Appendix 2: Emotional Response Questionnaire in Studies A and C

The Influence of Colour on Learning in University Libraries

Emotional response

This section is concerned with your emotions. Please answer the following question **"What emotional response do you associate with this colour?"** by indicating the scale (1-7) that describe your feelings.

Emotions	Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely	**Emotions**
Dark								Light
Pleasant								Unpleasant
Fresh								Stale
Heavy								Light
Calm								Exciting
Dull								Sharp
Tense								Relaxed
Warm								Cool
Interesting								Boring

Thank you for your participation

Participant Code:_________________________________

Date/Time:_____________________________________

Colour:____

Appendix 3: Information Sheet for Studies A and C

INFORMATION SHEET

"The Influence of Colour on Learning in University Libraries"

Dear Participant

The aim of this research is to investigate the impact of colour on learning performance within academic libraries. This study is significant because it will provide a better understanding about the potential role of the use of colour in tertiary learning in the university libraries and it is considered an important study for interior designers and architects in the future.

You will be required to do The Colour Blindness Test and a questionnaire to determine your learning preference before the experiment period. Upon completing the questionnaires you will stay alone in a waiting room for five minutes. At the end of five minutes your heart rate will be taken twice, once before and then during the experimental session and you will be asked to rate your emotional state on a questionnaire. Participants will undertake a reading task while located in a room with different coloured walls. Your honest answers will help in accurate data analysis.

Your contribution in the study will be over **Six Days** and about **30 Minutes** each day. The total expected time for your participation is approximately **Two Hours** for six colour conditions. This experiment will be conducted in Curtin University at the School of Built Environment building.

Answers to the questions will be treated in the strictest confidence and your name will not be recorded in the transcribed data. The transcribed data will be safely stored for a period of five years in Curtin University. Your participation in this experiment is completely voluntary; you will be at liberty to withdraw at any time without giving a reason for withdrawal.

Thank you for your time. Your contribution is greatly appreciated

The contact details of my principal supervisor should participants require further information:

- Associate Professor Dianne Smith, School of Built Environment, Department of Architecture and Interior Architecture
- E-mail: dianne.smith@curtin.edu.au
- Tel: +61 8 9266 2716

The contact details of the researcher should participants require further information:

- Aseel Abdulsalam Al-Ayash, PhD candidate
- School of Built Environment, Department of Architecture and Interior Architecture
- E-mail: a.al-ayash@postgrad.curtin.edu.au / ssasal35@yahoo.com

The contact details of the Human Research Ethics Committee (Secretary) should participants wish to make a complaint on ethical grounds:

- Office of Research and Development
- Tel: +61 8 9266 9223
- E-mail: hrec@curtin.edu.au

Appendix 4: Consent Form in Studies A and C

CONSENT FORM

The Influence of Colour on Learning in University Libraries

Dear participant

Thank you for your cooperation in this study. Your signature will certify that you:

- Have been informed of and understand the purposes of the study.
- Have been given an opportunity to ask questions.
- Have received enough information about this study.
- Understand that you are free to withdraw from this study at any time without any prejudice.
- Are aware that any information, which might potentially identify you, will not be used in published material.
-

I agree to participate in the study as outlined to me.

Signature of participant: ____________________Date:_________________

Name (BLOCK LETTER):_______________________________________

Signature of investigator: ____________________ Date: _______________

Appendix 5: Explanation of the Statistic

The explanation of the *F*-value, dfs, and *p*-values

The *F*-value is the ratio of two variance estimates:

(*the variance attributable to the effect being tested*)/(*the error variance in the data*).

The *F*-value has two sets of degrees of freedom (*F*[df1, df2]). df1 is a function of the number of levels of the effect being tested; df2 is a function of the number of levels of the effects being tested and the number of participants in the study. For a particular combination of df1 & df2: The larger the *F*-value, the stronger the effect.

An *F*-value associated with a *p*-value of less than .05 has less than a 5% probability of being as large as it is simply by chance; we therefore conclude that such an *F*-value is statistically significant and reflects a real effect rather than a chance finding. *F*-values with *p*-values greater than or equal to .05 are considered (by convention) to be non-significant and merely generated by chance effects in the data.

In order to determine whether an *F*-value is statistically significant at a particular probability level, it needs to exceed its critical value for that probability level. The critical value associated with an *F*-value varies as a function of its degrees of freedom. The critical value for F (3, 140) at a *p*-value of .05 is approximately 2.67; the critical value for F (1, 200) at a *p*-value of .05 is approximately 3.90; the critical value for F (1, 200) at a *p*-value of .001 is approximately 11.16 (there are tables of critical values for the *F*-statistic, but current statistical packages have made these obsolete). If your *F*-value has exceeded its critical value at $p = .012$, then your *F*-value is statistically significant at $p = .012$ – which means that there's less than a 1.2% probability of your *F*-value being as large as it is simply by chance (Field 2013).

Appendix 6: Background questions in Study B

BACKGROUND QUESTIONS

The Influence of Colour on Learning in University Libraries

Dear participant

I would like to thank you for your cooperation in assisting with the proposed research. The following questions are very important for properly analysing the data. All responses will be kept strictly confidential.

Section 1: Demographic profile

1. Gender: Male ☐ Female ☐

2. Age: 18-22 ☐ 22 and above ☐

3. Study Level: Undergraduate ☐ Postgraduate ☐

4. Nationality: ………………………………..

Section 2: Studying in the Robertson Library building

5. On average, how much time do you visit the library building while you are on campus?

Never ☐ Some of the time ☐ Much of the time ☐ All of the time ☐

6. On an average day, how many hours of study in the library building do you do?

Please tick (×) one only

30 minutes- 1hr ☐ 1-2hrs ☐ 2-4hrs ☐ More than 4hrs ☐

7. a. Which study mode do you prefer when using the library building?

Studying alone ☐ Studying in group ☐ Both ☐

b. Which learning activity do you prefer while studying in the library building?

Please

tick (×) only one

Reading printed books ☐ Reading via computer ☐ Listening to lectures ☐

Other (please specify):____

8. In which study area in the library building do you prefer to study?

Private room ☐ Open area with carrels ☐

Give reason:_____________

____

____

____

Section 3: The Interior Design of the Library

9. Do you believe interior design can impact on learning activities in the library building?

Yes ☐ No ☐ Unsure ☐

Please explain how?________

____

____

____

10. Do you think the colour of the interior space has an important **<u>Impact On Your Learning Performance</u>** in the library building?

Yes ☐ No ☐ Unsure ☐

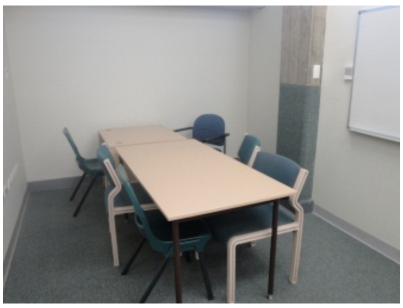
Please explain how?____

____

____

11. Are you satisfied with the **<u>Existing Colour Scheme</u>** in the following study areas of the library building?

a.



Group study room

Yes ☐ No ☐ Unsure ☐

Give reason and describe your emotions:____

____

b.

Individual study room

Yes ☐ No ☐ Not sure ☐

Give reason and describe your emotions:____

____

____

12. Do you think the existing colour schemes of the learning spaces in the individual study areas of the library building can **<u>Motivate You to Study</u>**?

Motivated ☐ Neutral ☐ Unmotivated ☐

Please explain how:____

____

____

13. Has <u>**Your Emotional State**</u> been affected by the colour scheme while studying in the learning spaces in the library building?

Yes ☐ No ☐ Unsure ☐

If (Yes) Please explain how:____

____

____

14. a. Which space in the <u>**Robertson Library Building**</u> do you feel has <u>A **Suitable Colour Scheme**</u> for study? Why do you feel this way?

____

____

____

b. Which space in the <u>**Robertson library building**</u> do you feel has <u>**An Unsuitable Colour Scheme**</u> for study? Why do you feel this way?

____

____

____

Participant Name:________________________________

Date: _______________________________

Appendix 7: Consent form in Study B

Consent to Participate in the Focus Group

You have been asked to participate in a focus group. The purpose of the focus group is to discuss and understand how colours can motivate students to study in the individual study space in the university libraries, and to get opinions about what are suitable colours for this activity.

You can choose whether or not to participate in the focus group and stop at any time. Although the focus group will be video and tape recorded, your responses will remain anonymous and no names will be mentioned in the report. There are no right or wrong answers to the focus group questions. We want to hear many different viewpoints and would like to hear from everyone. We hope you can be honest even when your responses may not be in agreement with the rest of the group. In respect for each other, we ask that only one individual speak at a time in the group and that responses made by all participants be kept confidential.

I understand this information and agree to participate fully under the conditions stated above:

Participant’s Name:____

Signed:____

Appendix 8: Survey of Stage 2 in Study B

Survey used in the Robertson Library:

The Influence of Colour on learning in University Libraries

1. **Gender:** Male ☐ Female ☐
2. **Study Level:** Undergraduate ☐ Postgraduate ☐
3. **Age:** 18-22 ☐ 22 and above ☐
4. **Nationality:………………**
5. Which colour scheme do you think is suitable for an individual study room in the library building and can help you to concentrate? **(select one)**

   1 ☐ 2 ☐ 3 ☐ 4 ☐

Give reason:

…………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

Participant Name……………………………………

Individual Study Room on Level 6

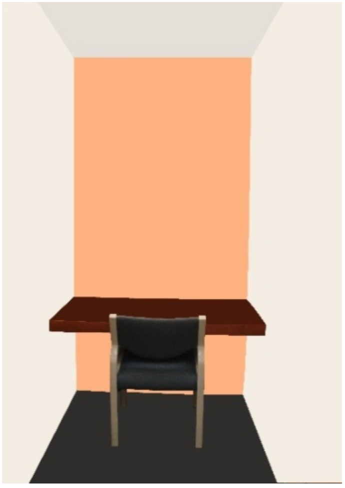


Image (1)

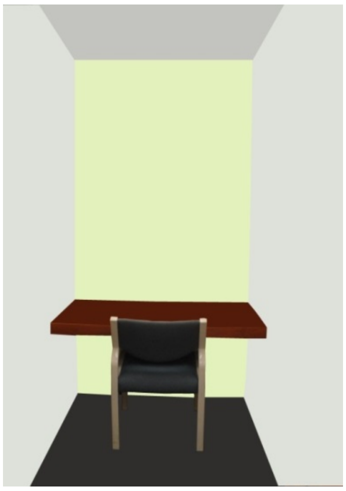


Image (2)

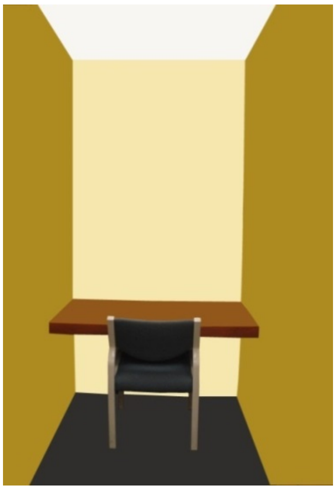


Image (3)

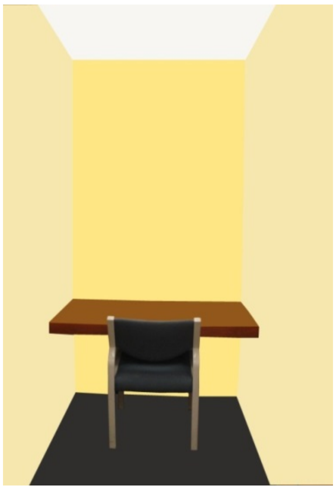


Image (4)