REPORT

STIMULATING DESIRED BEHAVIOR OF STUDENTS BY MEANS OF A CONTEXT AWARE DYNAMIC LIGHTING SYSTEM IN THE SMARTXP

Heleen M. Kok

EEMCS
CREATIVE TECHNOLOGY

EXAMINATION COMMITTEE
Ir. Ing. R.G.A. Bults
Dr. Ir. E.J. Faber

UNIVERSITY OF TWENTE.

Abstract

Smart lighting is an upcoming field of research. The effect of colored light on the body has already been researched in depth. From the effect of light on sleep to the effect on the heart rate. Additionally the preference lighting in offices, hospitals and homes has been studied. We now know, what colors of light people like, what effect it has on the body, but we do not know the effect it has on behavior. Or rather the way we can use light to stimulate behavior. The research question for this report is therefor: How to stimulate desired behavior of students by means of a context aware dynamic lighting system? The desired behavior was evaluated. A literary review describe the effect of light on the body. And the behavior change wheel was used to determine how to stimulate behavior, for this project the concept of nudge was chosen. Lastly the Unified Theory of Acceptance and Use of Technology (UTAUT) was used to evaluate the designed lighting system. The results of the study were that indicating lights alone are not enough to stimulate behavior. From the linear regression model we found that both performance expectancy (PE)(PE-BI, 0.721, 95 percent sig.) and effort expectancy(EE)(EE-BI, 0.592, 95 percent sig.) had significant influence on the behavioral intention (BI). And the correlation between the behavioral intention and the actual use had a standardized beta weight of 0.366 with a significance level of 0.008. After the user evaluation of the lighting system it was concluded that colored light alone is not sufficient to steer behavior. More behavior change techniques are needed than just nudging.

Acknowledgements

The first person I would like to thank and give credit is Jeroen Janssen van Roosendaal. He was working with me on this graduation project making the implementation of the system possible. I am really proud of the end result and what we accomplished in this time. Then I would like to express my gratitude to my advisor Richard Bults, for all the feedback, patience and understanding. Especially the brainstorms on how to improve the SmartXp and how to sculpture my graduation project so it would fit the requirements. I would also like to thank Alfred de Vries and Michel ten Bulte, for all the supplies, the help and advise. And Han and Frans from the vrijhof for their advise and assistance with the lights. Then I would like to give credit to the teachers who freed up their schedule for the interviews, this were Erik Faber, Edwin Dertien and Hans Scholten. Especially Erik Faber, because he also took the time to give a small lecture, so I could collect data. I could not have finished this project without the support of my family, they mean the world to me. Last but not least, I would like to thanks Alex, thanks for all the cooking, cleaning and love while I was too busy to help.

Contents

Chapter 1

Introduction

One of the most innovative and creative rooms of the University of Twente is the SmartXp. The theater of the SmartXp is a collaborative workspace. Due to its mobile furniture and three trusses, the theater can be transformed for several use cases. It is used for lectures, presentations, workspace, and for different types of research projects.

Ninety percent of the time, the study Creative Technology uses the theater for lectures and as a project related workspace. The other ten percent of the time the theater is reserved for the faculty of EEMCS[1] or for S.A. Proto[2], who use the workspace for research and gatherings and activities respectively.

The different users of the theater have different goals. While the users work in different sections of the theater, their goals often interfere (see fig. 1.1). For instance, their goals will interfere when one group would like to hold a lecture and another would like to have an active brainstorm session. Currently, the only option to dissolve this problem is to use the room dividers. Resulting in a situation where the users are not able to see each other. The dividers do absorb part of the noise, however, since the users do not see each other, they are less aware of each other and start to speak louder. Therefore the interference still remains.

The SmartXp has an advanced lighting system hanging in the trusses. This system is hardly ever used, usually the lights are set to one state and color. They remain on this state until one of the users requests a change. The amount of light and the color of the light has effect on the atmosphere of the room. ”In 2008, Vogels introduced the concept of atmosphere: the experience of ambient surroundings in relation to the observer.” [1]. At this moment the smart lighting industry is rising, making smart light bulbs and light scenes for consumers [2]. The lighting system in the SmartXp provides an opportunity to create a solution for the interference problem. With the light system we could create light scenes that indicate the desired

[1] Faculty of Electrical Engineering, Mathematics and Computer Science.
[2] The study association of Creative Technology.

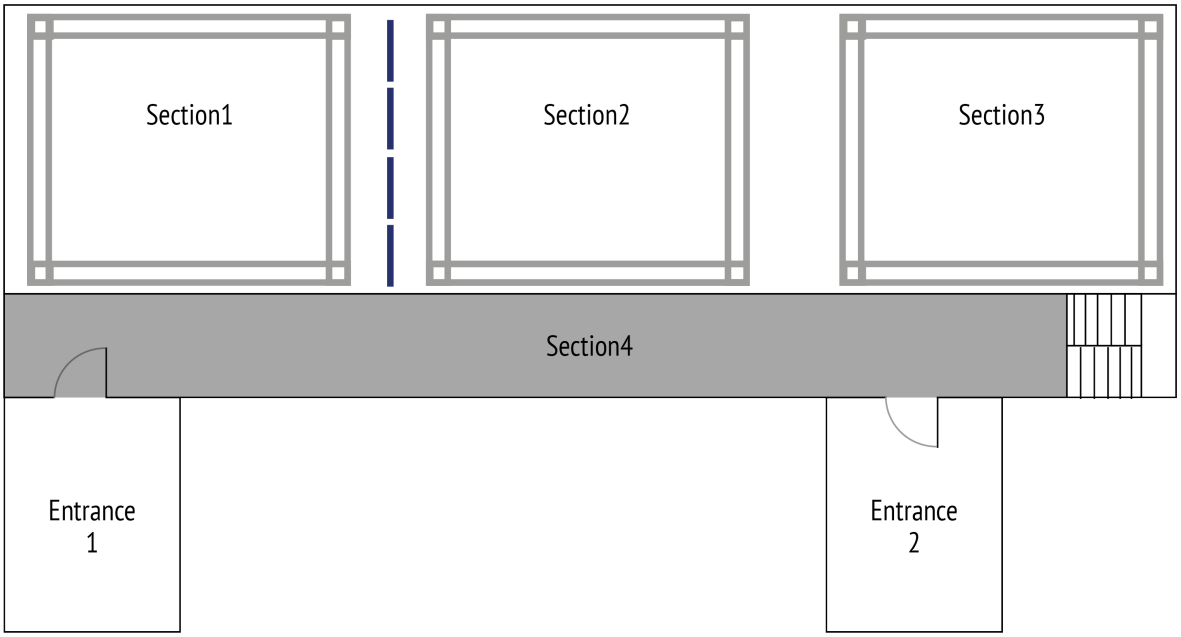

Figure 1.1: Floor map of the SmartXp, dividers between section 1 and 2

behavior of the students. This leads to the research question:

How to stimulate desired behavior of students by means of a context aware dynamic lighting system in the SmartXp?

In order to stimulate desired behavior we first need to know what the desired behavior in the SmartXp is. We then need to know what the effect of the color of light is, to be able to stimulate the desired behavior with that color. Consequently the following subquestions to the research question were formulated:

What is the desired behavior of the students for each use case of the SmartXp? And what light values for the hue, chroma and brightness match the desired behavior for the SmartXp use cases?

Chapter 2

State of the Art

2.1 Domain analysis

2.1.1 SmartXp

The theater of the SmartXp can be divided into four sections (See fig. 2.1). Section 1 to 3 are on the ground floor and section 4 is a mezzanine with the staircase in the theater. The office for the SmartXp technician is also located in the SmartXp area. Additionally, the hallways outside of the SmartXp are also equipped with lights.

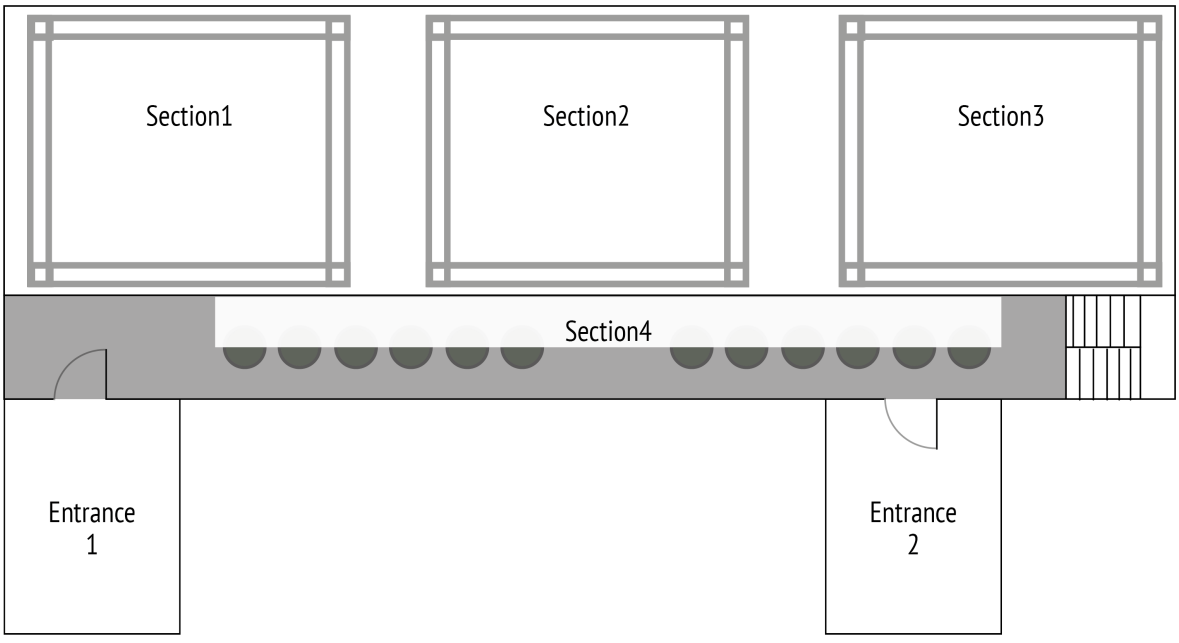

Figure 2.1: Floor map of the SmartXp

Section 1 to 3 of the theater are used for lectures, workspace and for research. Each section has its own truss, in fig. 2.1 the trusses are illustrated as gray squares. In the top of the trusses equipment can be placed to transform the section into a research area. LED lights are placed shining upward in the frame of the trusses,

giving the frame a certain color (see fig. 2.2). The SmartXp is equipped with the following lights;

- 12 RGB LED plateau spots that are placed in each corner of the truss frames,
- 17 RGB LED light spots,
- 2 moving head lights, and
- 2 white long range spots.

Figure 2.2: LED light shining upward in a truss frame

The SmartXp has fluorescent lights attached to the ceiling, these lights have to be turned on manually with switches that are located near entrance 1. The SmartXp has windows on both sides of the room, as is shown in fig. 2.3. The windows have blinders which can be lowered by using a manual switch near entrance 1. Behind the beamer screen in section 3 the windows are permanently blinded. The SmartXp has two skylights that cover the total width of the room. The first skylight is located between section 1 and 2 and the other between section 2 and 3. The skylights of

the room give a lot of daylight into the SmartXp. The skylights also have blinders that can be activated with a switch. Figure 2.3 also shows that the walls are white and that the floor is a dark gray color.

Figure 2.3: Picture of the SmartXp taken from section 2 facing section 3

2.1.2 User analysis

The SmartXp theater is mainly used for educational purposes for the study Creative Technology. This study occupies the theater 90 percent of the time. The other 10 percent of the time is reserved by the faculty EEMCS and by Study Association Proto. When the SmartXp is not reserved, it is used by students for unsupervised project time or self study.

Because of limited time this research will solely focus on the main occupant of the SmartXp. The study Creative Technology is the main occupant of the room as they spent most time inside the SmartXp.

2.2 Literature review

To be able to answer the research question knowledge is needed about color psychology and the effect of colored light on human behavior. The existing lighting systems and their implementation give insight in the way smart lighting systems are used.

2.2.1 Related work

The smart lighting industry is rapidly evolving. There are several manufactures of smart light systems. These smart light systems are mainly configured by a mobile application in which the user can set their preference. Examples of smart lighting systems are: Philips Hue [3], Belkin WeMo [4], and LightwaveRF [5]. These lighting systems mainly focus on home usage. The can all be used to create a pleasant ambiance. Each system can be adjusted by the user to their preference. Research regarding light systems in educational context is scarce. The main topic of that type of research was the effect of the color temperature of the white fluorescent lights that are often used in schools [6]. The results showing that a cooler color temperature gained more focus and better sleep quality.

2.2.2 Color categorization

Knowledge about color categorization is necessary ,to understand color psychology and the effect of colored light better [7]. A color can be divided into three values; hue, chroma and brightness [8–11]. Munsell categorized these values in three dimensions making a clear visualization of the categorization possible [12]. The brightness of a color is on the z-axis, the higher the value, the more white the color contains and the brighter the color appears. The hue is defined in a circle on the xz-axis, Munsell defined five primary hues on this circle, all other hue values are a combination of these five hues. The five primary hues are; red, yellow, green, blue and purple. Lastly, the chroma, this value indicates the saturation of a color. When the chroma is high, the saturation of the color is high and it gets close to its hue color (see fig. 2.4) [7, 12, 13].

The hue of a color has its own categorization besides its value. Namely, the hues can be categorized in warm and cool hues [1]. Every hue has its own wavelength. Depending on the wavelength, the hue is experienced as warm or cold. Cool hues have a short wavelength, the hues that are categorized as cool are green, blue and purple [6]. On the contrary, the warm hues have a long wave length. Red, orange, and yellow are categorized as warm hues [6]. The difference between warm and

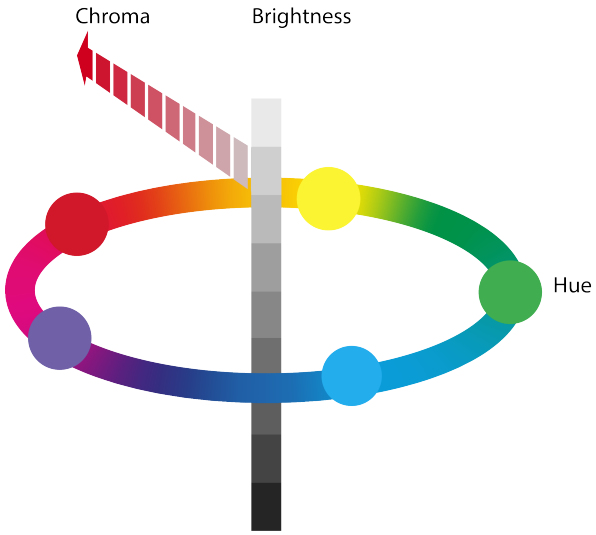

Figure 2.4: The Munsell color categorization, adapted from [7]

cool hues is important, since they have a different effect on the body. The effect will be explained in paragraph 2.2.4.

2.2.3 Color psychology

There has been a lot of research on the preference of colors and the color connotations [6, 7, 14–17]. Whether color has an effect on a psychological level or not is debatable [18]. However, the preference and the connotation of colors have been research in depth. Research showed that preference of colors was affected by the demographic characteristics of the user. The preference is strongly affected by the age, sex, and cultural background of the subject [7, 14, 19]. However, emotional color connotation was not influenced by demographics. Especially the descriptive dimensions of warm and cool colors showed significant results [20, 21]. Warm colors like red, orange and yellow were described as cute, sweet, joyful, and intimate [1, 6, 7, 19, 22, 23]. But these warm colors were also experienced as tensed, hot, and less pleasant [21]. The cool colors are blue, green and purple, these colors have a short wave length [24]. Cool colors were seen as bitter, cool, and sorrowful [1, 6, 19, 20, 22]. The table in appendix B gives an overview of the researched colors and there associations.

2.2.4 Effect of colored light

Colored light has shown several effects on the human body. It can affect the heart rate, the core body temperature and the brain activity. Especially the effect of light on the circadian rhythm has been researched in depth [14, 22, 23, 25–29]. Results

showed that blue light has a significant effect on the secretion of the hormone melatonin and thereby influencing the sleep-wake cycle. When people saw blue light during the day it improved their quality of sleep and decreased depression [29]. In addition to the effect on sleep the physiological effects of colored light have been studied. It was found that red light increases the heart rate, resulting in an elevated blood pressure and core body temperature [22, 26]. Another effect was that warm colored light increased brain activity [24]. The effects of cool colored light include faster cognitive processing [22], but not a faster reaction time. Cool light resulted in better concentration and had a sedative calming effect [29]. The overall effects that colored light had on the human body were on concentration, vitality, vigor, productivity, and learning ability [22,29,30]. There was one experiment that closely resembles my research question, namely the experiment of Jin [6]. This experiment changed two light factors that affected the atmosphere of a room. The light shining down was a white light of which the researchers changed the color temperature. The second light shined towards the ceiling in changing color. The experiment was executed to find out what color temperature and color combination was preferred in a living room during certain activities.

2.3 Interview

The structure of an interview can be divided in one of three categories.

Firstly, unstructured interviews; these interviews do not have restrictions, the interviewer can ask any question at any time. This leads to in depth qualitative research. However the downside of an unstructured interview is that it is hard to keep track of the progress of the interview and the outcome is hard to compare to other interviews.

Secondly, the structured interview; the questions of the interview are fixed. The interviewer is restricted to use only the planned questions. Structured interviews are often used to get data from a large group, and are distributed as surveys. Structured interview obtain quantitative data which is easy to analyze [31].

Lastly, the semi-structured interview; the interview gives enough structure to be able to compare the outcomes, but the interviewer is allowed to go into more detail and ask questions to get more in depth knowledge of the perspective of the interviewee. The semi-structured interview gives, according to Gill and Stewart, openness and allows the interviewer to go into more detail [31].

2.4 Behavior change

In order to stimulate behavior, information about behavior change is needed.

2.4.1 Behavior change wheel

A renowned behavior change tool is the Behavior Change Wheel(BCW), it was used to design this intervention. A behavior intervention is a strategy to change behavior. The BCW combines 19 frameworks of behavior change, and reduced them to nine intervention functions. The nine intervention functions are; education, persuasion, incentivisation, coercion, training, restriction, environmental restructuring, modeling, and enablement. The BCW can be categorized into sources of behavior, intervention functions, and policy categories [32]. In fig. 2.5 the sources of behavior are the core of the wheel and displayed in green. The intervention functions are shown in the middle ring in red and the outer ring of the wheel are the policy categories these are shown in gray. All in all, the BCW helps decide what intervention options to use and how to evaluate them.

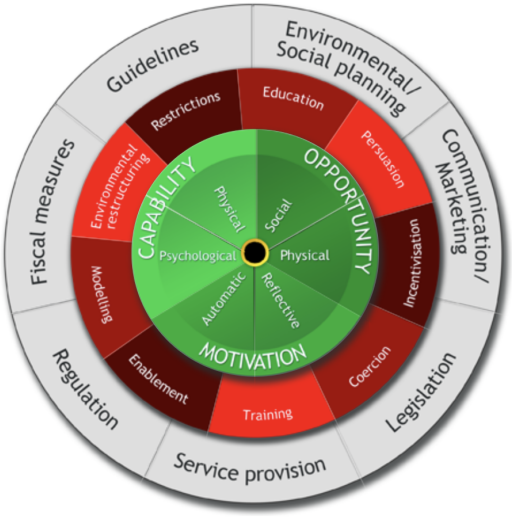

Figure 2.5: The behavior change wheel from [32]

At the core of the BCW is the COM-B model. COM-B stands for the components; capability, opportunity, motivation, and behavior (see fig. 2.6). The theory behind the COM-B model is that behavior change will involve changing one or more of the components [32].

The guide, uses eight steps to use the BCW [32];

1. define the problem in behavior terms,
2. select the target behavior,

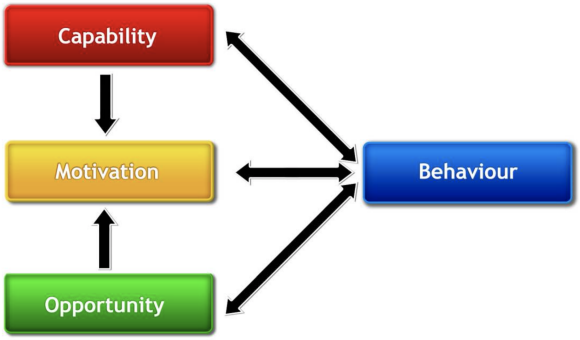

Figure 2.6: The COM-B model [32]

3. specify the target behavior,
4. identify what needs to change,
5. identify intervention functions,
6. identify policy categories,
7. identify behavior change techniques,
8. identify mode of delivery.

These eight steps will be used in the ideation paragraph 3.4 to define the problem behavior, the behavior change functions, and how to evaluate the intervention.

2.4.2 Nudge

The origin of many behavior change techniques is the concept of nudging. Richard Thaler wrote a book about nudging [33]. Thaler defined nudging as: ”A nudge, as we will use the term, is any aspect of the choice architecture that alters peoples behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates.” [33] Governments like the United States of America and the United Kingdom us the concept of nudging to create social impact [34]. Thaler explains in his book that people need a nudge for decisions that are difficult and rare, for which they do not get prompt feedback [33]. In the SmartXp the problem behavior is likely to be the result of the students not being aware of the situation and them behaving in a way that they learn from other students. Consequently, the nudge concept is applicable to this situation.

2.5 Technology acceptance models

There are many behavior theory models that predict the acceptance of a model. Three of the models will be described in this literature review. The models are based upon the Theory of Reasoned Action (TRA). This theory states that the intention of use indicates the actual usage of the intervention [35]. Additionally, Wixom states that the intention is influenced by the attitude towards the intervention and the social value it has [36].

2.5.1 TAM

The first model is developed by F.D. Davis [37]. It is the Technology Acceptance Model (TAM). Davis model uses the Perceived Usefulness (PU) and the Perceived Ease of Use (PEOU). The PU is the attitude of a person to what extend the technology will be useful to them. The PEOU is used to measure if a person expects the technology to be easy to use [37]. The PU and PEOU will predict the Intention (I) of use. The I can than predict the actual Usage (U) of the technology (see fig. 2.7). TAM is the best known acceptance model [39]. The TAM is widely used because the

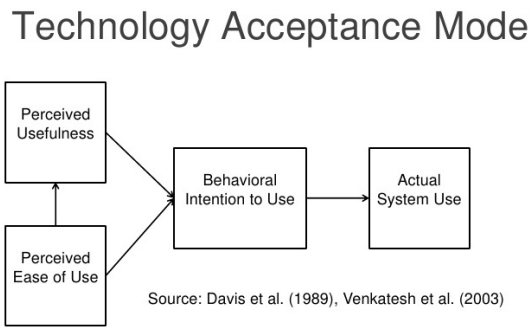

Figure 2.7: Schematic view of the TAM [38]

model is simple, specific [35] and the because of the strong theoretical background of the model [40]. The downside on the TAM is that it assumes that people plan their behavior and that they behave rationally. Another downside is that the model only predicts the usage of the technology, it does not indicate what needs improvement.

2.5.2 TPB

The authors of the TRA model expanded the model to predict what determinant drives people to accept a technology. The new model is the Theory of Planned Behavior (TPB). The TPB model has three determinants that influence the Usage Intention (I):

1. Attitude (A)
2. Subjective Norms (SN)
3. Perceived Behavioral Control (PBC)

The A is the same factor as the TAM uses. The SN is a new determinant, it measures the social influence the usage of the technology has on a person. The PCB is an extended version of the PEOU, it also measures if the user feel that he or she has enough knowledge to operate the technology and if they feel the facilitating conditions are sufficient [35] . Unlike the TAM the TPB does not believe that its model can be used in every situation, this model has no standard questions, because the questions are context specific [41]. TPB is often used to determine which variable influence the actual usage [35].

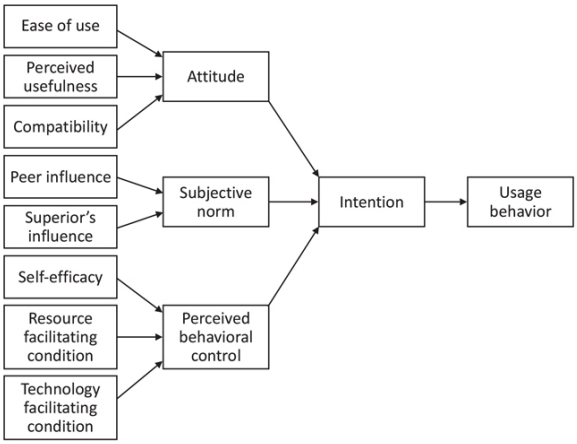

Figure 2.8: Schematic view of the TPB model [35]

2.5.3 UTAUT

The last model is the Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT combines the theory of TAM, TPB and six other models [42]. As can be seen in the model, the behavioral intention is influenced by four core constructs that have a direct influence and four indirect variables (see fig. 2.9). Venkatesh showed that the UTAUT explains 70 percent of the variation in the use behavior of technology [38]. The validation of the UTAUT model was greater than the eight previous models [42]. Carlsson state in his study; ”The model has been empirically examined and found to outperform the eight individual models, including the TAM model.” [43]. Fatema Akbar used UTAUT to research the student acceptance of technology, she reported that the UTAUT model is applicable to some extent in the educational setting, however some modifications need to be made to improve the model for educational use [42].

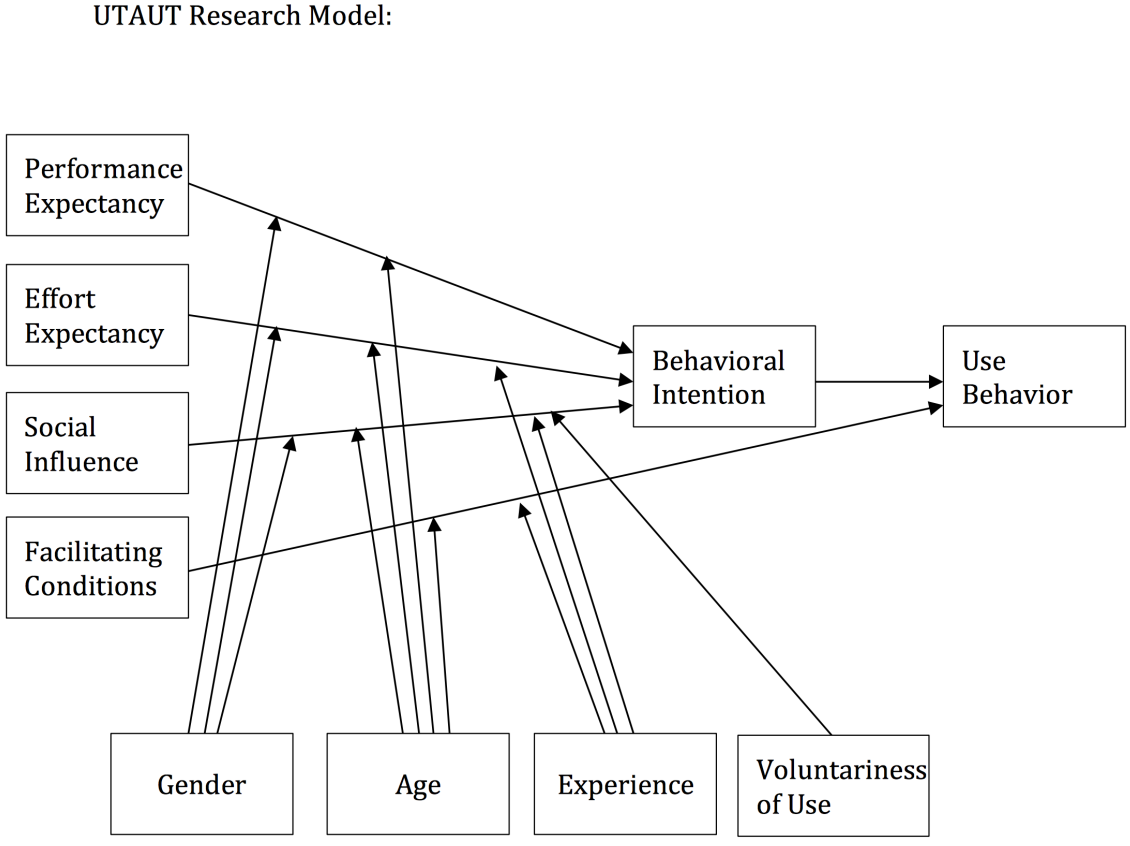

Figure 2.9: UTAUT model from [42]

Table 2.1 shows the definitions of the constructs of the UTAUT model as reported in the originating UTAUT study [38].

Table 2.1: Definitions of the UTAUT constructs

Construct	**Definition**
Performance Expectancy (PE)	The degree to which an individual believes that using the system will help him or her to attain gains in job performance.
Effort Expectancy (EE)	The degree of ease associated with the use of the system.
Social Influence (SI)	The degree to which an individual perceives that important others believe he or she should use the new system.
Self Efficacy (SE)	Judgment of ones ability to use a technology to accomplish a particular job or task. (Adapted from the Social Cognitive Theory)
Anxiety (ANX)	Evoking anxious or emotional reactions when it comes to performing a behavior (i.e. using the technology) (Adapted from the Social Cognitive Theory)
Attitude (ATUT)	An individual's overall affective reaction to using a system.

2.6 Research hypotheses

In the study "Adoption of mobile devices/services searching for answers with the UTAUT" [43] Carlsson modified the the impact hypotheses of Venkatesch study [38] to fit the context of mobile devices/services. The hypotheses that Carlsson used have been adopted in this study, H5 and H6 have been modified to fit the context of the light system. Expected relationships for direct effects are:

H1: Performance expectancy has an influence on behavioral intention.

H2: Effort expectancy has an influence on behavioral intention.

H3: Social influence has an influence on behavioral intention.

H4a: Facilitating conditions will not have an influence on behavioral intention.

H4b: Facilitating conditions has an influence on usage.

H5: Anxiety toward the the effect of the light system will not have an influence on behavioral intention.

H6: Attitudes towards the light system will not have an influence on behavioral intention.

H7: Behavioral intention will have a positive influence on usage.

2.7 Analysis of the literature

There have been several studies to find out what the effects of light are on the human body [14, 22, 23, 25–29]. Also the preference of colored light has been researched in depth [1, 6, 7, 13, 21, 44]. However, to the best of our knowledge, no research has been published on stimulating behavior using colored light. Therefore, it is presumed that the research question is novel and significant. The effect of light on the human body can be used in the installation to stimulate or sedate the body. Stimulating colors are colors with a warm hue like red, orange, and yellow. A sedative effect is accomplished with cool hues like blue, green, or purple. Blue light has a high effect on the quality of sleep of the subject. Furthermore, the preference of a color is determined by demographic characteristics, while the emotional connotation of the colors where culture and gender independent. As can be seen in table B.1 some colors have been researched more than others. A critical review on color psychology pointed out that many of the articles about color psychology lack in empirical evidence, because there sample groups are to small [18]. It is therefore important to evaluate the color connotations for the target group and compare the results with the results that were found in the literature.

The BCW will be used to decide what intervention options are necessary and how to evaluate them. To evaluate if the intervention th UTAUT model will be used. The validation of this model was greater than the models it consists of [42].

Chapter 3

Ideation

The ideation phase normally consists of three stages, the user identification, the technology, and the creative idea stage. However, since the focus of this graduation project lies in defining a user experience, not designing a prototype, a slightly different approach is taken. First, the users will be identified, then the use cases will be defined. Results of user interviews will be discussed next, and finally the light scenes per use case will be discussed.

3.1 Target group

The target group can be categorized in the following groups:

- Students
- Teachers
- Student assistants

To get an idea of the goals of the target group personas were made. The personas can be found in appendix A. A stakeholder analysis was conducted to find how the users influence the dynamic lighting system and what their interest in the system is. Sharp wrote an article about stakeholder identification [45]. He stated in his article: ”Stakeholders are related to each other and interact with each other [22,11,17]. Interactions between them include: exchanging information, products, or instructions, or providing supporting tasks.” [45]. In the table table 3.1 the interaction between stakeholders can be found.

In table table 3.2 the stakeholders and their role of influence is defined. The level of importance is based on the dimensions of importance as reported in the originating study of Sharp [45]: ”Dimensions of importance are: relationships between stakeholders, the relationship of each stakeholder to the system, and the priority to be given to each stakeholders’ view.”.

Table 3.1: Stakeholders interaction

Stakeholder	**Interaction with**	**Interaction**
Teacher	Student	Provide information and instructions
Student	Teacher or Student Assistant	Ask questions
Student	Technical consultant of the SmartXp	Ideate and creation of compartments for projects
Technical consultant	Student and Teachers	Facilitate technology
Cleaners	All	Providing supporting tasks
Students of other studies	Creative Technology students	Collaborate
Management SmartXp	All	Improve the SmartXp and facilitate

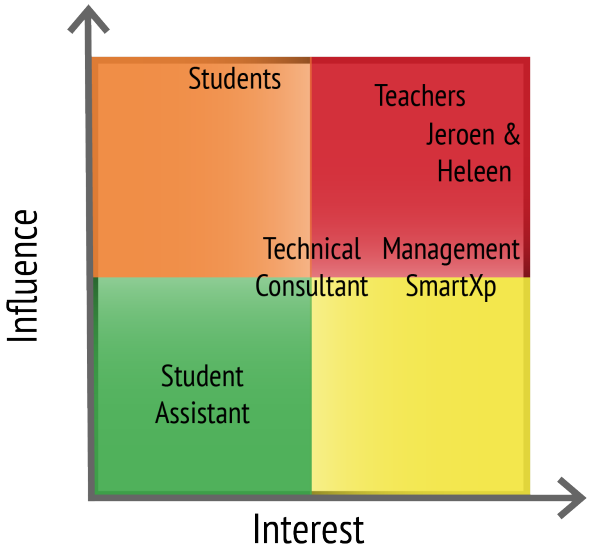

Figure 3.1: Interest Influence Matrix

Table 3.2: Stakeholders and their role and Influence

Stakeholder	**Role**	**Key interest**	**Topic**	**Level**
Students	End users	Usability	Interaction	Medium
Student assistants	End users	Usability	Interaction	Low
Teachers	Legislator	Improvement	Interaction	High
Technical advisor	Developer	Development	R and D	Medium
Management SmartXp	Decision-maker	Implementation	R and D	High
Heleen and Jeroen	Researcher	Development	Everything	High

3.2 Use cases

The SmartXp has many use cases. Their are educational and social use cases. Jeroen Jansen van Roosendaal placed a survey on facebook asking the students for which use cases they used the SmartXp. Next to that source, the schedule of the SmartXp was used to define the educational use cases. The use cases regarding the target group are; lectures, tutorials, presentations, project time, meetings, consulting the technical adviser, workshops, eating lunch and self study. Each will be further discussed in their own section.

3.2.1 Educational use cases

- Lecture: A plenary way of teaching. Often involves a powerpoint with additional information. When the SmartXp is reserved for a lecture, the sections 2 and 3 are used for this activity. Students attending the lecture sit in rows facing the lecturer.
- Tutorials, practicals, and colstructions: These use cases are supervised educational activities. The teacher and student assistants help the attending student to solve the questions or to build the tasks. Sometimes extra explanation is needed and the teacher then switches to a plenary teaching situation. During these use cases it is important that the student assistant walks around to help.
- Presentations: Presentations take place in section 3, the tables in this section are then removed and the chairs are placed in half circles.
- Supervised project time: When project time is supervised, this often includes meetings between the project group and the supervisor. These meetings take place in section 3. The project groups that are not in a meeting, are spread in the SmartXp, working with their group on their project. The groups often rearrange tables in a way that the members face each other, and they are able to work together.
- Unsupervised project time: During unsupervised project time, the SmartXp is reserved for students, so they are able to do project related work.

3.2.2 Miscellaneous use cases

The following use cases are categorized as miscellaneous, since they are not educational but they do involve the target group and the SmartXp.

- Meetings: During the lunch break the SmartXp is often used for committee meetings. The students sit in section 1 to discuss what needs to be done.
- Consulting the technical adviser of the SmartXp: many students use the facilities of the SmartXp to build project work or personal projects. The technical adviser of the SmartXp help the students ideate and create the components that the students need in order to finish their project. The room of the technical adviser is in the back of the SmartXp next to section 1.
- Meet friends: the SmartXp is the home of the study Creative Technology. For which the theater has become a meeting space.
- Workshops: the study association initiates a workshop in which students can learn to build something new. During the workshops the tables are filled with electronics and equipment. Workshops are usually planned at night.
- Eating lunch: students responded that they use the SmartXp theater to eat lunch.
- Self study: students who use the SmartXp for self study seek a workspace. Often students sit together with friends to work on assignments or to study for a test. Students who use section 4, work by themselves and sit next to their friends. Students who use section 1 for self study, group around a table and often make use of an extra screen to work together.

3.3 Interviews

For the qualitative analysis of the wanted behavior, semi-structured interviews with three teachers that have overseen educational use cases in the SmartXp have taken place. The full results of the interviews can be found in appendix chapters K to M. In the interview, the educational use cases that the teachers oversee where discussed. For each use case, the wanted behavior of the attending and surrounding students was assigned. The usage of the entrances and the staircase was discussed too. The notion of surrounding students will be used to describe the group of students that use the SmartXp during an educational use case, but who do not attend the educational use case.

3.3.1 Result of the interview

The following table gives the results of the interviews. For each use case the desired behavior of the attending students and the surrounding students are described. Additionally, the usage of the entrances and stairs is evaluated with the scale of open, semi open, and closed. When an entrance is set to semi open, it is allowed to use this entrance but only in a quiet manner.

Table 3.3: Results of the expert interviews per use case

Use case	**Attending students**	**Surrounding students**	**Entrance Usage**
Lecture	Focused, awake, feeling free to ask questions	Quiet	1: Semi open, 2: Closed, Stairs: Closed
Lectorials	Can sit where they want, go to section 3 for questions	Do not disturb	All: Semi open
Assisted self study	Collaborate and self sufficient working attitude, student assistants need to walk around	Do not disturb	All: semi open
Supervised project	Discuss and collaborate, meetings with the teacher in section 3	Does not matter	1: Open 2 and Stairs: Semi Open
Demo market	Walk around, try out projects	Try out projects	All: Open

3.4 Behavior intervention

In this section the eight steps that were discussed in paragraph 2.4 are used to define the behavior that needs to be changed and how to change that behavior.

3.4.1 The behavior

First an understanding of the current behavior, and the target behavior is needed. The interviews, observations, and personal experience let to the answers of step 1 to 4.

Define the problem

The CBW guide states that to be able to define the problem in behavior terms, a knowledge about the location, the behavior and the individual or group that displays the behavior are necessary [32]. The knowledge about the location can be found in the domain analysis of paragraph 2.1. The groups that are involved are described in paragraph 3.1.

The problem behavior can be defined in one sentence as: **Disturbing educational use cases in the SmartXp by talking, using the entrances, using the stairs and or making noise.** The surrounding students show most of the problem behavior. The surrounding students are in the SmartXp for the miscellaneous use cases that are described in paragraph 3.2.2.

Select the target behavior

In table 3.3, the desired behavior of the students that are in the SmartXp during an educational use case is described.

After discussing the problem with students of Creative Technology, the reason why they showed the problem behavior became more clear. Students mentioned that they often did not know when there was a lecture present in the SmartXp. By the time the students arrived at entrance 2 and they could see that there was a lecture they would decide to sneak into the room quickly. Another reason to make noise was that they did not know that when they talked in section 1 this would be disturbing for the lecture. A couple of students mentioned that they learned from older students that their was one teacher who they should not walk in on and that the other teachers did not care if you used the entrances or the stairs.

The behavior that needs to be addressed is the awareness of the content of the SmartXp. Students need to know what the use case is in order to show the desired

behavior. Furthermore, the entrances need to show if they can be used and how they should be used.

Specify the target behavior

- Who need to change their behavior?
  - Surrounding students
- What behavior needs changing?
  - Usage of entrances
  - The behavior displayed when entering the room
  - Distracting behavior like:
    - Talking
    - Walking around
    - Laughing
    - Building/making noise
- Where does the behavior take place?
  - In the SmartXp
- When does the behavior take place?
  - During educational use cases
- Why does the behavior take place?
  - Student do not know that there is a use case active in the SmartXp
  - Students learned to ignore the active use case
  - Students do not know that their behavior is disturbing
- With whom do the surrounding students display the unwanted behavior?
  - With other surrounding students

In example, during the lecture use case, entrance 2 and the staircase should not be used. When people want to enter the SmartXp they should do so by entering through entrance 1 and enter quietly. The surrounding students are allowed to be in the SmartXp, but they should be quiet. The attending students should be focused, awake, and feel free to ask questions.

What needs to change?

The surrounding students need to know where they are allowed to sit and what behavior is expected of them during the active use case. The problem behavior is distracting the educational use case, by using the entrances, the stairs or by making noise. People should learn when they are allowed to use the entrances and the staircase, and they should learn when they should be quiet. The awareness of the surrounding students of the SmartXp needs to change.

3.4.2 Intervention options

Now that the target behavior and what needs to change is defined the intervention options can be chosen.

APEASE criteria

The APEASE criteria are used to identify the appropriate behavior change technique. Michie describes the APEASE criteria in her book as [32]:

- Affordability: how much the delivery mode will cost, in terms of design and delivery.
- Practicability: the mode of delivery should allow the intervention to be delivered as designed.
- Effectiveness: also revered to as cost-effectiveness, especially the delivery mode has influence on the effectiveness.
- Acceptability: how acceptable the stakeholders find the intervention.
- Safety: unintended side effects of interventions should be explored.
- Equity: will the delivery mode result in the intervention reaching the intended recipients or will some targets not have access because of health, wellbeing, or standard of living?

An intervention function is suitable for the behavioral change when the APEASE criteria are met [32]. See table 3.4 for the intervention functions of this system.

Intervention functions

The following intervention functions listed in table 3.4 meet the APEASE criteria; education, persuasion, training, restriction, environmental restructuring and modeling. These intervention functions can be used to change the behavior toward the target behavior.

Table 3.4: Identification of the behavior change techniques by using the APESE criteria

Intervention function	**Definition**	**BCTs for this system**	**APEASE?**
Education	Increasing knowledge or understanding	Providing information how to use the lighting system	Yes
Persuasion	Using communication to induce positive or negative feelings or stimulate action	By changing the atmosphere, stimulating the behavior	Yes
Incentivisation	Creating an expectation of reward	-	Not practicable
Coercion	Creating an expectation of punishment or cost	-	Not practicable
Training	Imparting skills	Teachers and older students explaining the system to new users of the SmartXp, an explanation lecture at the start of the college year	Yes
Restriction	Using rules to reduce the opportunity to engage competing behavior	Rules for the usage of the doors on a poster near the entrances	Unlikely to be acceptable
Environmental restructuring	Changing the physical or social context	Using a dynamic light system to indicate desired behavior	Yes
Modeling	Providing an example for people to aspire to or imitate	Students and teachers showing how the system should be used	Yes
Enablement	Increasing means, reducing barriers to increase capability or opportunity	No further than environmental restructuring or training	No

Policy categories

The policy categories are displayed in the outer ring of the behavior change wheel (see fig. 2.5). The policies are also put in a table and evaluated using the APESE criteria (see table 3.5). There are many policies than can be chosen to implement the intervention. However, the time for the graduation project is limited and therefore the following policies were chosen;

- Environmental planning,
- Communication, and
- Regulation.

Regulation scores as unlikely acceptable in the APEASE criteria, because it is unlikely that the current students that use the SmartXp are going to accept the rules and principles of behavior in the SmartXp. The current students already have a mindset and their own rules regarding the SmartXp. However, the new students of the SmartXp that start in September do not have this mindset and for them the regulation policy could be acceptable, when it is clear and logical. Therefore the regulations will be designed and evaluated.

Table 3.5: Identification of the policies using the APESE criteria

Policy	**Definition**	**Option for this system**	**APEASE?**
Environmental or social planning	Designing and or controlling the physical or social environment	Changing the environment by changing the lights	Yes
Communication and marketing	Using print, electronic, telephonic or broadcast media	Using posters to explain the color codes and the rules	Yes
Legislation	Making or changing the laws	Does not apply	No
Service provision	Delivering a service	Does not apply	No
Regulation	Establishing rules or principles of behavior	Establishing rules for the usage of the doors and describe principles for each color code	Unlikely acceptable
Fiscal measures	Taxes and financial costs	Not possible	No
Guidelines	Documents that recommend or mandate practice	Documents or a workshop how to use the system	Yes

3.4.3 Implementation

Now that the behavior wheel steps have been completed, the techniques to use can be chosen. The University College London has categorized the 93 evidence based behavior techniques (BCTs) into 16 categories [46]. The BCTs were then placed in a mobile application, giving the categories the BCTs and examples of the BCT

implementations. The application was used in this project to see what BCTs were applicable for the lighting system.

Behavior change techniques

BCT 4.1 Instruct on how to perform the behavior "Advise or agree on how to perform the behavior (includes 'Skills training')" [46]

By instructing the student what the colored light means, they are able to interpret the lighting system and act upon the instructions.

BCT 7.1 Prompt or cues "Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behavior. The prompt or cue would normally occur at the time or place of performance." [46]

The color of the light is the cue. The color shows what the context of the section is. Whether a student is allowed to sit there and what behavior is expected of the student.

BCT 8.2 Behavior substitution "Prompt substitution of the unwanted behavior with a wanted or neutral behavior." [46]

This BCT is applicable in case of the entrance usage. When the students are allowed to use the entrance but should use it quietly, the color of the light is blue. The blue light prompt the students to stop talking, but they are still allowed to use the entrance.

BCT 12.1 Restructuring the physical environment "Change, or advise to change the physical environment in order to facilitate performance of the wanted behavior or create barriers to the unwanted behavior." [46]

The first restructuring of the SmartXp is the removal of the room dividers between section 1 and 2. The room dividers do not solve the problem and in order to test if the light system works it is advisable to have the same setup in each section.

BCT 12.5 Adding objects to the environment "Add objects to the environment in order to facilitate performance of the behavior." [46]

To get the same amount of light in each section, more lights are needed. Each section needs the same amount of color adjustable lights. The teacher needs to have the focus during a lecture, therefore spotlights need to be taken into account in the system. To be able to show students whether the entrances may be used, the entrances need color adjustable lights. Additionally, section 4 needs colored light to indicate what the desired behavior is for that section. It was decided to use an RGB

LED strip to illuminate this section. After the interviews, one of the teachers mentioned that the usage of the staircase was distracting. The other teachers confirmed that the stairs were as much a distraction as entrance 2. This insight led to another RGB LED strip to indicate the usage of the staircase.

3.5 Mode of delivery

For the design of the intervention the chosen BCTs of the previous sections were used. BCT 12.1 and 12.5 were used to design the light plan. To indicate what behavior was desired the colors of the sections and entrances was designed in color codes and the light scenes, there BCT 7.1 and 8.2 were used. The last part of this section is instructions, here BCT 4.1 was used to design posters to give instructions of the use of the light system.

3.5.1 Light plan

Together with Jeroen, the light plan was designed. Each section should have the same amount of colored lights, to be able to create the same effect in each section. The design of the light plan is depicted in fig. 3.2. The lights that had the same address, were lamps of the same manufacturer and type. When a hue, chroma and brightness is set for this address the lights will all show the same value. These addresses are shown next to the light indicators.

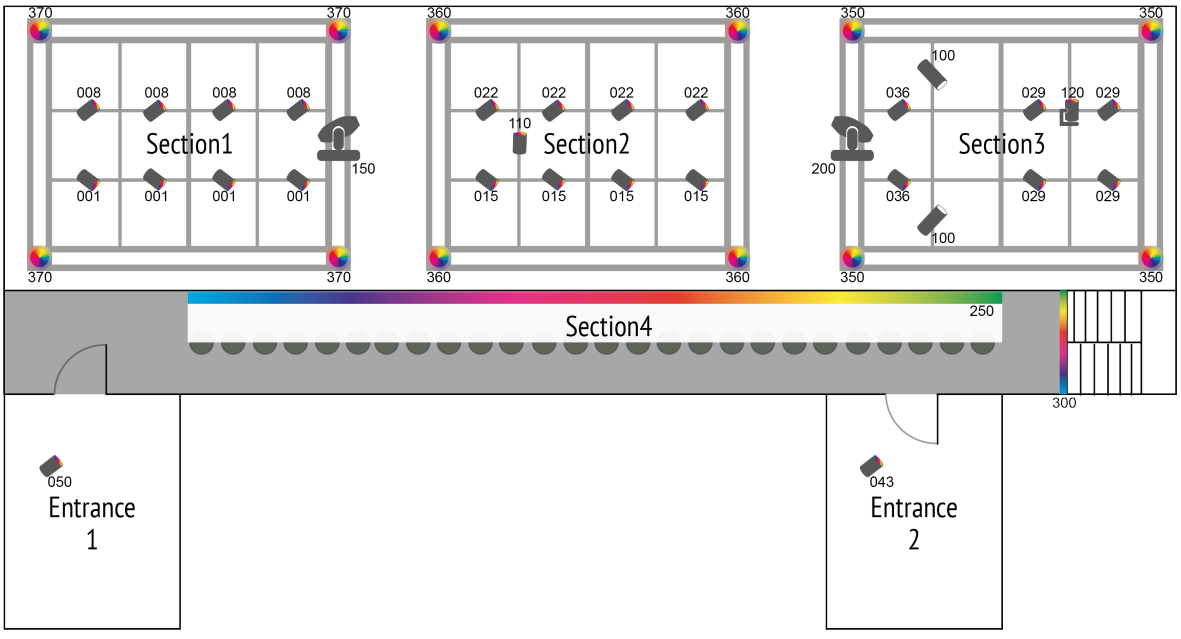

Figure 3.2: The light plan designed by Heleen and Jeroen, the numbers indicate the addresses through which the lights can be accessed

3.5.2 Color coding

For the scope of the graduation project, it was decide to give the same color for all the lights in one section. After the color connotation survey described in paragraph 4.2, the colors to prompt the behavior with could be chosen. The colors and the behavior that they indicate are illustrated in fig. 3.3, on the left are the colors that indicate the behavior for each section, and on the right the colors that were used at the entrances and for the staircase. Each of the colors will be described next, what behavior the color indicates, and what the connotation of the color was.

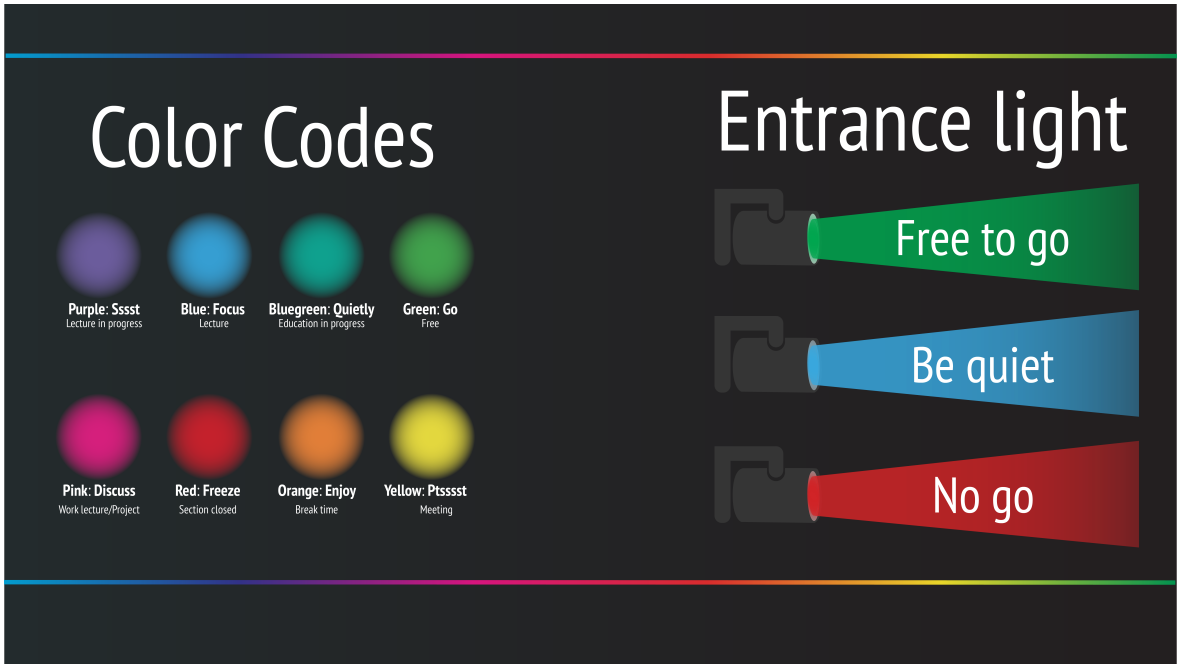

Figure 3.3: Chosen colors and their behavior indication

Purple: Ssst This color was chosen for sections were student were allowed to sit, but only in silence. The purple color is of the cool hue range and has a calming effect on the body. Furthermore, purple was seen as a closed, serious and balanced color. These are connotations that fit working in silence.

Blue: Focus A blue section indicates that students in that section attend a lecture. The results of the literature study showed that blue light had the highest effect on the circadian rhythm, resulting in the subjects staying alert in blue light. From the connotation results the students also evaluated blue as an awake color. Moreover, the color blue was cool, active but relaxed, interesting and balanced. The connotation suited the desired behavior of students that attend a lecture, namely students to be awake and focused, but also to ask questions and be actively involved.

Bluegreen: Quietly For most of the educational use cases the teachers mentioned that the behavior of the surrounding students did not matter as long as they did not distract the attending students too much. In order to inform the surrounding students that an educational use case is active the color bluegreen appears in the sections which are available for the surrounding students. This color like the colors purple,blue and green is from the cool hue range and has a calming effect. The color connotation showed that this color is relaxed, happy, open and balanced.

Green: Go The SmartXp is not always reserved, to indicate that the room is free to use the color green was chosen. Firstly, because green has the traffic light connotation of go. Secondly, the color was seen as happy, relaxed, interesting and balanced. Lastly, green was chosen because the SmartXp is the home of the study Creative Technology and green is the color of the study association.

Pink: Discuss During work lectures and projects the teachers would like to see the students collaborate as much as possible. However, the SmartXp gets noisy we people talk too loud. Pink is mix of the warm and stimulating hue red, and the calming serious hue purple. Because of the mix of a warm and cool hue, the color pink should stimulate while also staying awake and active. However, pink evoked strong distinctions in the color connotation, the chaotic and tensed feeling it evoked could have a negative effect on the work lecture or project time.

Red: Freeze Red got the highest ratings for the connotations closed, tensed and serious. This color has alike green the association with traffic lights and was chosen to indicate that a section or an entrance is closed.

Orange: Enjoy During lunch time the SmartXp should be open and happy. Research has shown that warm hues increase appetite [47]. Also walking around and a change of atmosphere are necessary to be able to focus later on. The playful and active connotation of orange could help achieve a better break.

Yellow:Psst When a section is set to yellow a group is having a meeting in that section. Yellow was seen as the happiest color. Furthermore, the connotation showed that the color is active and exiting. For a meeting these are not necessarily the best features. However, when the meeting needs to brainstorm or think out of the box the features are necessary.

3.5.3 Light scenes

In this section the light scenes for the most occurring use cases are explained. In the illustrations the corners of the sections 1-3 show colored circles, these circles are representative for the color of all the RGB LED lights in that section. The brightness of the lights was set to full, because the distance between the light and the subject was very far. Excluding the LED strips, the brightness for the LED strips was set lower to approximately a value of 40 on a scale from 0 to 255. For the hue and the chroma the colors of fig. 3.3 were tried to reach.

Lecture

During a lecture sections 2 and 3 are used. To indicate where the attending students may sit in these sections are set to blue. The color blue was chosen, because this is a cool color and therefore a calming color. The color blue has the highest effect on the circadian rhythm, keeping the attending students focused and awake. The focus of the attending students should be on the lecturer and the presentation. A way to get more focus on the lecturer is by illuminating the lecturer and dimming the surroundings. To achieve this effect the spotlights in section 3 (see fig. 3.2 the lights with address 100) are turned on and set upon the lecturer. In addition, the fluorescent lights that illuminate the hallway beneath section 4 should be turned off. For the surrounding students, the sections 1 and 4 are free to use as a workspace. The lights in these sections are set to purple, indicating that a lecture is in progress and they should be quiet (see fig. 3.3 and fig. 3.4). Entrance 2 and the staircase should not be used during this use case and are set to red. However entrance 1 may be used, but only if the user is quiet.

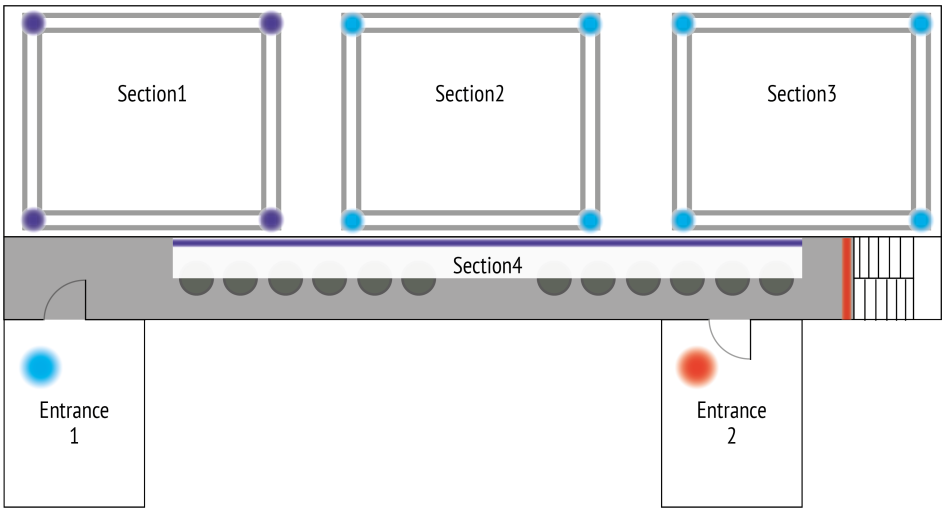

Figure 3.4: Light scene for the lecture use case

Work lecture

A work lecture can differ from a practicum, supervised self study, or a colstructure. All these use cases include a teacher, student assistants, and attending students. These use cases are similarly to a lecture arranged in section 2 and 3. Because the teachers want the student and student assistants to collaborate, the color pink was chosen. Pink is a color that consists of a mixture between the warm hue red and the cool hue purple, resulting in the fact that the color is both exiting and awake. In the results of the color connotation it can be seen that pink is also seen as an interesting and open color. However, pink was also seen as tensed and chaotic. That is why this color is not suitable for a work lecture were the students need all their attention like a mathematical work lecture. In case of a serious work lecture, where silence is preferred, the light scene of the lecture use case is more suitable. As can be seen in the illustration for the work lecture (fig. 3.5), the surrounding students are allowed to sit in section 1 and 4. The surrounding students are allowed to use both entrances and the stairs. However, in order not to distract the the explanation sessions that the teachers often give in section 3, the staircase and entrance 2 should be used quietly. The color of section 1 and 4 is bluegreen, and indicates that the students may talk, but not disturb the attending students.

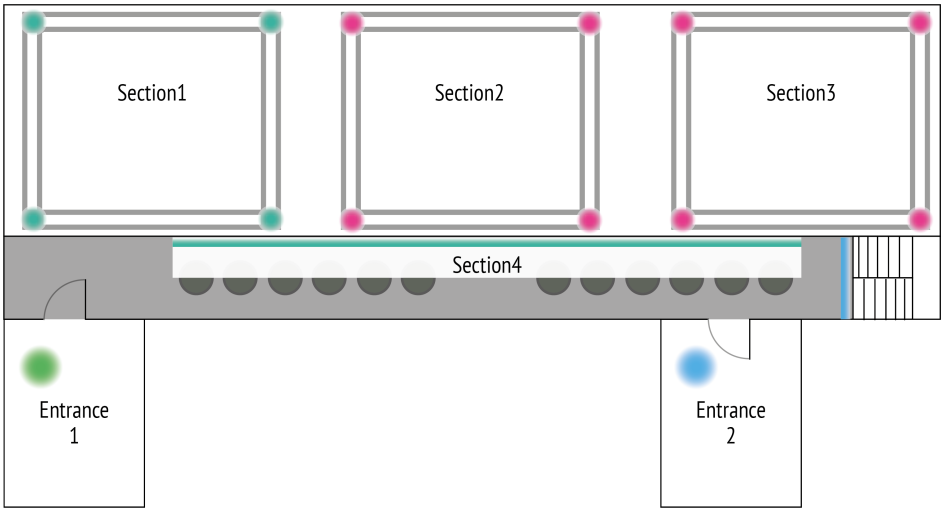

Figure 3.5: Light scene for the work lecture use case

Supervised Project

The light scene for supervised project is almost the same as the light scene for the work lecture use case. The difference is that section 1 is also reserved for supervised project time, while during supervised project time all the attending students work in the SmartXp in groups and they need all the space they can get. Not all supervised projects need entrance 2 and the staircase to be set to blue. Only the supervised projects that have project meetings with the supervisors in section 3 need this light setting. However, it was decided to set the stairs and entrance 2 to blue for all the supervised project, because it should reduce the amount of walking and talking in the hallways and that will reduce the total produced volume.

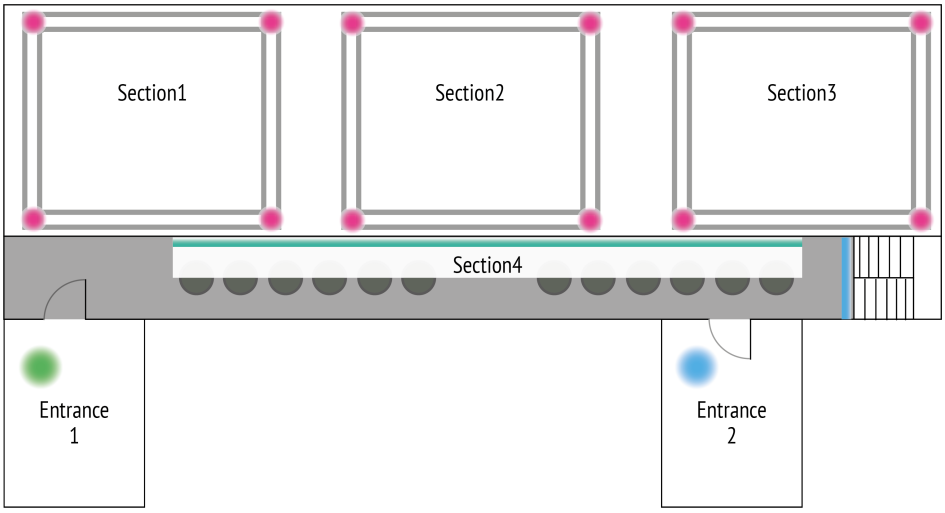

Figure 3.6: Light scene for the supervised project use case

Unsupervised Project

The only difference between the unsupervised project and the work lecture light scenes are at entrance 2 and the staircase. These are set to green because it does not matter how they are used. The reason that section 1 is not pink as can be seen in the light scene for the supervised project, is because it is optional to sit in the SmartXp. The SmartXp is reserved for the attending students as to facilitate their project. Not all the project groups use this time slot or the SmartXp for their project, that is why not all the sections are needed.

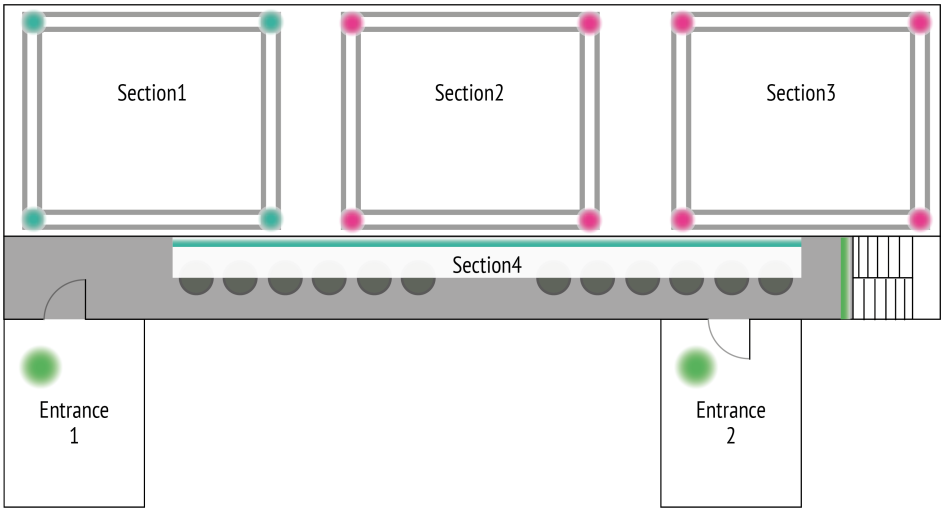

Figure 3.7: Light scene for the unsupervised project use case

Break

Because the students stated that they used the SmartXp during the lunch as a place to meet friends and to eat lunch an appropriate light scene for the lunch time was designed. Every work day at 12:30 the light switch to the light scene that is illustrated in fig. 3.8. The connotation results for orange were; awake, warm, happy, playful, interesting, and open. Because of this connotation, the color orange seemed like a good color for break time.

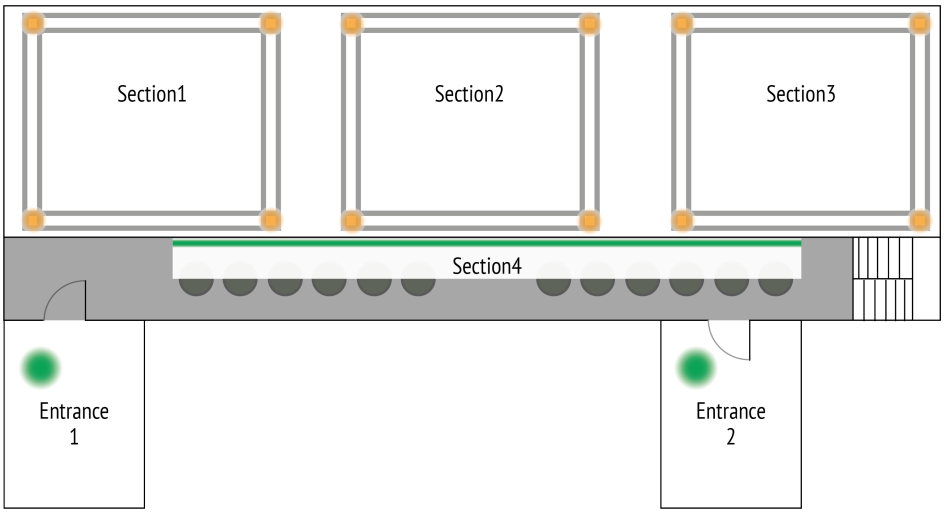

Figure 3.8: Light scene for the use case break time

Meeting

The other use case for the SmartXp is for meetings. During this use case the students gather to have a meeting for committees and projects. As was described in paragraph 3.2.2, the students often sit in section 1. However, after rearranging the SmartXp, the more logical section for a meeting became section 3. Section 3 is more suitable for a meeting, because the this section is almost empty during lunch time. Furthermore, this section is darker because of the permanent blinders, a darker area gives less focus on the surroundings and more focus on the meeting. Especially when the moving head (see **??**) is set as a spot on the meeting students. Another reason why meeting should move from section 1 to section 3, is because the office of the technical consultant is near section 1. During the day many students walk in section 1 to get help from the technical consultant. Especially during the lunch break, the section gets crowded with students who have questions. Consequently the section is crowded, it gets noisy, and a noisy environment is not ideal for a meeting.

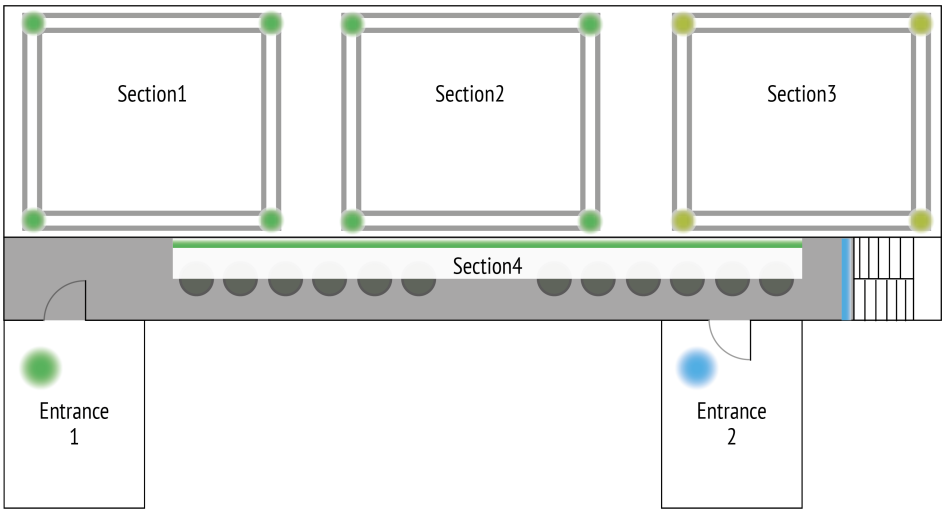

Figure 3.9: Light scene for the meeting use case

Free

If there are no activities scheduled in the SmartXp the light scene will set all the light to green. Green indicates that the students may sit where they want and do what the want. Green is a cool color giving a calming effect. Additionally, the connotation showed that the students found green a happy color, relaxing and balanced as well. Green was associated as an open color. Using this color to indicate that the students are free to do what they want seemed obvious.

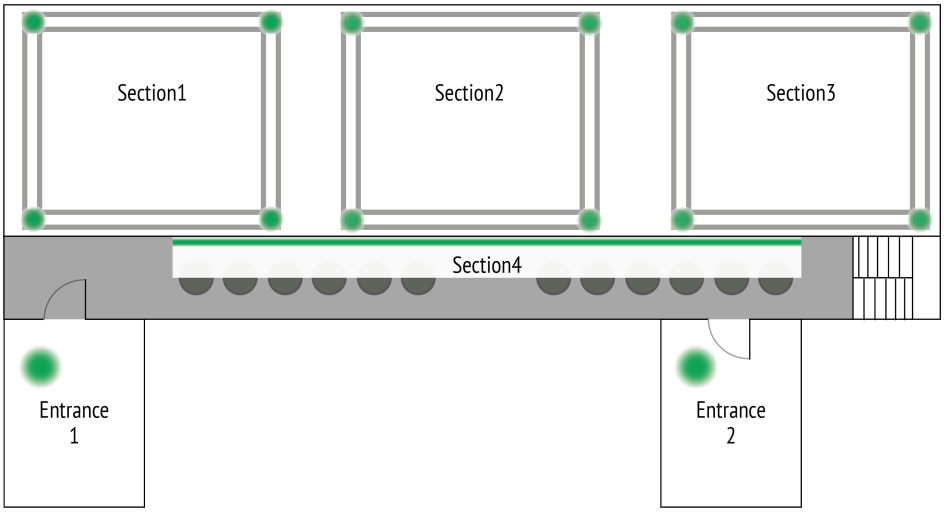

Figure 3.10: Light scene for the free use case

Closed

When other users than the study of Creative Technology want to use the SmartXp, the room should indicate that the sections are closed for students. By setting the sections to red, the students can see that they should not be using the setting. Red was chosen, because this color got the most votes for the connotations tensed and closed.

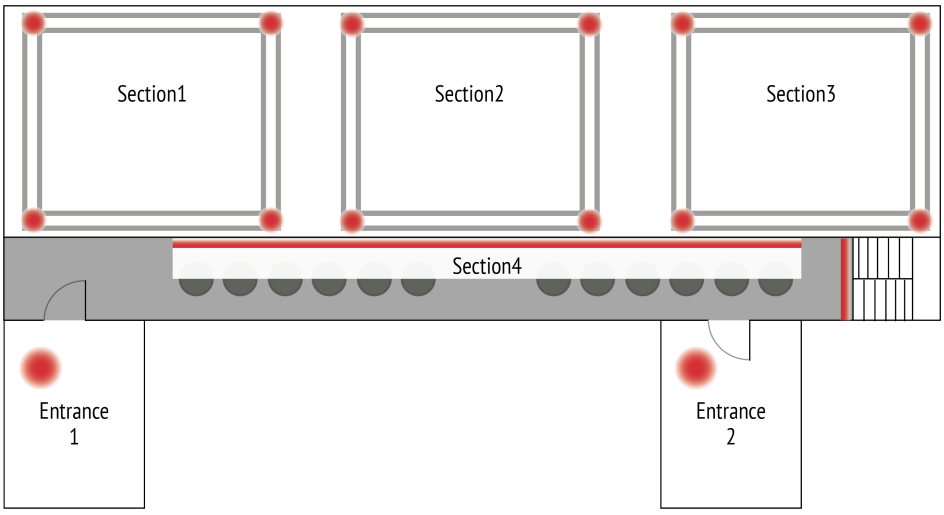

Figure 3.11: Light scene for the closed use case

3.5.4 Instructions

The the light scenes and colors all indicate what behavior is wanted from the students. However, the students need a tool to be able to interpret the lights. On several places in the SmartXp posters where hung to give the instructions. The

posters used minimal information to get more attention. Further the design of the posters was high in contrast and suited the interior design of the SmartXp.

Figure 3.12: Instruction poster at the top of the stairs

Figure 3.13: Instruction poster at entrance 2

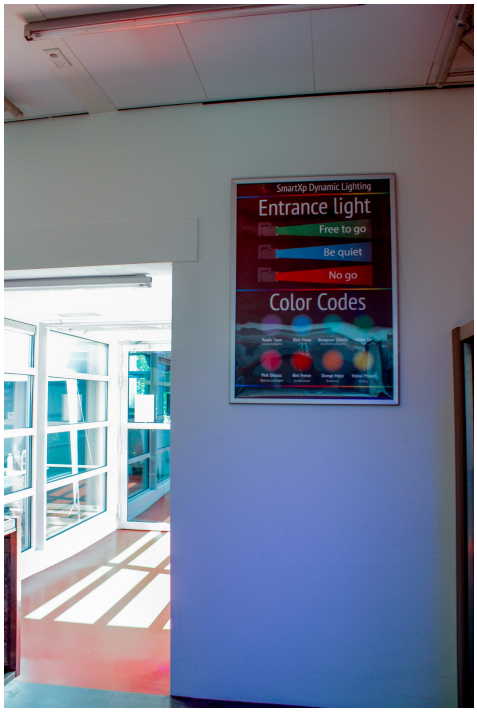

Figure 3.14: Instruction poster with all the instructions in the hallway before entering the SmartXp

Figure 3.15: Instruction poster at entrance 1

Chapter 4

Method

4.1 Preparation of the interviews

The Guide to Semi Structured Interviews [48] emphasizes on a good preparation. While preparing for an interview the interviewer needs to have a goal for the interview, make an appointment, prepare how to record the interview and confirm the data and location with the interviewee [48]. For the semi-structured interviews with the teachers an interview plan was made, consisting of topic, main questions and follow-up questions. While preparing the questions, closed questions were avoided as much as possible. The interview plan can be found in appendix J and the results of the interviews can be found in chapters K to M. After the second interview the interview plan was adjusted, because the interviewee noted that the usage of the staircase was as distracting as the usage of the entrances. Consequently the outcomes of the second and third interview could be compared considering the usage of the staircase.

4.2 Color connotation

The first part of the experiment was to evaluate what color connotations the target group has for several colors. This is necessary because the literature research showed varying results and especially red, green and blue were evaluated. Also several of the studies had a small sample size and therefor their research can not be taken for granted. In order to evaluate the color connotation for several hues by the target group a survey was conducted.

The survey used the hue colors of the Munsell color system. This system consists of five primary hue colors and five secondary hue colors (see fig. 4.1. The primary hue colors are red, yellow, green, blue and purple. These primary colors have a brightness half way the brightness scale and a full chroma. This means that

these colors are fully saturated and show the primary hue. The primary colors of the Munsell system were chosen to use for this connotation survey, because most of the studies used color chips from the Munsell color system.

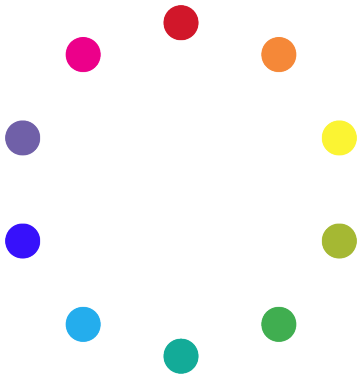

Figure 4.1: The Munsell hue colors

Each color was evaluated separately. The subject sees the color in a square and is asked to choose between descriptive words, see fig. 4.2.

Figure 4.2: Example question of the color connotation survey

The descriptive words have their origin in the articles of the color connotation table. The articles were compared and the most commonly used descriptive pairs were chosen for this survey. After each color evaluation question a blank page with a demographic question was placed. This is important because the previous color

can influence the results of the following color. The total color connotation survey can be found in chapter C.

The color connotation survey was distributed via; social media, whatsapp, email and by addressing people in person. The survey had 74 responses, of which 53 completed the survey. Of the respondents 54.72 percent was male and 45.28 female. The age range was between 18 and 25 years. The respondents were mostly Dutch. One of the participants is colorblind. The results of the color connotation can be found in chapter D and will be further discussed in paragraph 5.1.

4.3 Light scene effect

When the values for the hue, chroma, and brightness have been determined to match the desired behavior, the proposed scenes needed to be tested and evaluated. Therefor the SmartXp was converted into an experiment stage. The furniture in each section needed to be identical, the only variable being the color of the light.

4.3.1 Test setup

In order to get good results a good preparation is needed. First data needs to be collected when the light system is off. That data will then function as the normal situation of the SmartXp. During the experiment the only variable that changes needs to be the light scene.

Informed consent

The test subjects need to sign an informed consent in order for me to be able to observe and collect data about them. To inform the students of the SmartXp that the whole room is used as an experimental setup, information posters need to be placed at the entrances. Informing that everyone who enters the room will be part of the experiment, where the information can be found, and who to contact for feedback and questions.

Entrance usage

The doors of the SmartXp will be monitored with cameras, recording how many people use the entrances, during different light scenes.

Effect of the colored sections

To test if the color of light has effect on the focus of the students the produced volume will be measured. In each section the volume will be measure using an decibel measure application on a mobile phone. Each section will be measured for at least 40 seconds walking through the whole section to measure, an average decibel and the maximum volume that was produced in that section. The decibel measurements will be done at intervals of 2 hours, starting at 9:45 and ending at 17:45.

Environmental factors

The light coming in trough the windows changes during the day and can influence the atmosphere. In the critical examination of Veitch [49] the results show that the setting in which the experiment is performed have great influence on the results. Especially, when light is the object of study. Presence of windows, furniture, and color of wall all are variables that influence the intensity of the light and the study [49]. Knowing this it would be a logical step to examine the light system in a controlled environment. However, the study of Fabio states that an application that is tested in a controlled environment could result less effective when implemented in the real environment [**?**]. The acceptability and usability of the lighting system is important, consequently the system will be examined in the real environment. The results of the experiment can then help improve the system and increase the behavioral intention.

Although, the experiment is in the real environment, this does not mean that we can not control this environment. As mentioned in paragraph 2.1, the blinders of the windows can be manually lowered. During the extend of the experiment the following blinders will be closed; skylights 1 and 2, and the windows on the entrance side of the SmartXp. All the sections need the same setup to be able to compare the volume measurements, therefore the furniture in section 1 to 3 needs to be identical. Lastly the fluorescent lights in all the sections need to be turned on, because that is similar to the real environment of the SmartXp. When the fluorescents lights are on, the influence of the windows that are not blinded will be smaller.

Test week

During week 25 and 26 of 2017 the SmartXp was reserved for Supervised Project. We got permission to test the light scenes in that week. The experiment could only continue if all the attending students of the supervised project agreed with the terms on the informed consent. The attending students of the use case were second year Creative Technology students. The attending students were divided into five

large groups, with an average group size of 13 students. The room was divided into project areas to facilitate the project groups. Every group had its own project area that contained of a large table setting, a toolkit, and tape on the ground to define the area. Because the SmartXp was reserved for this supervised project for the duration of two weeks, the project groups were able to leave materials in their project area.

20-06 This was the first test day, and the normal state of the SmartXP was evaluated. The blinders were closed on one side and the blinders of the skylights were closed. The lighting system was off and the fluorescent lights were on. During the day the produced volume of each section was measured and cameras that faced the doors recorded the flow through the doors. This was one of the first days of the supervised project and most groups were complete. The surrounding students sat in section 4, went to the study association, or consulted the technical consultant.

21-06 First day with the lighting system on. The light scene was set to the supervised project use case, with an adjustment to the entrance and stairs settings. During this day the entrances and staircase were set to the color green.

22-06 The light system was set to supervised project again. Entrance 1 was set to green, entrance 2 and the staircase were set to blue.

23-06 This day the lighting system was yet again set to supervised project. Entrance 2 and the staircase were set to red and entrance 1 was set to blue.

4.4 UTAUT survey and analysis method

4.4.1 Survey questions

The UTAUT survey was based upon the survey that was used in the study ”What affects students’ acceptance and use of technology?” [42] page 29. The survey questions can be found in chapter E. All the constructs of the UTAUT model were measured using a 5-point scale, instead of the 7-scale that is used in the original UTAUT study. The 5-point scale is used every module in the Student Experience Questionnaire (SEQ) [50]. The students are familiar with the 5-point scale, since they use it every module. Therefor the 5-point scale proved more suitable for the target group. The positive end of the scale (strongly agree) equaled the value 1 and the negative end (strongly disagree) equaled 5.

4.4.2 Survey participants

The survey was distributed via the social media, email and by asking in person to respond to the survey. The distribution was amongst students and teacher of Creative Technology. However, only three teachers replied to the survey. Resulting that the age distribution was mainly between below 20 till 25 (see fig. 4.3. The survey got 74 responses of which 52 completed the survey. As shown in fig. 4.3, 58,46 percent of the participants was male, 36,92 percent female, and 4.62 percent did not want to share their gender.

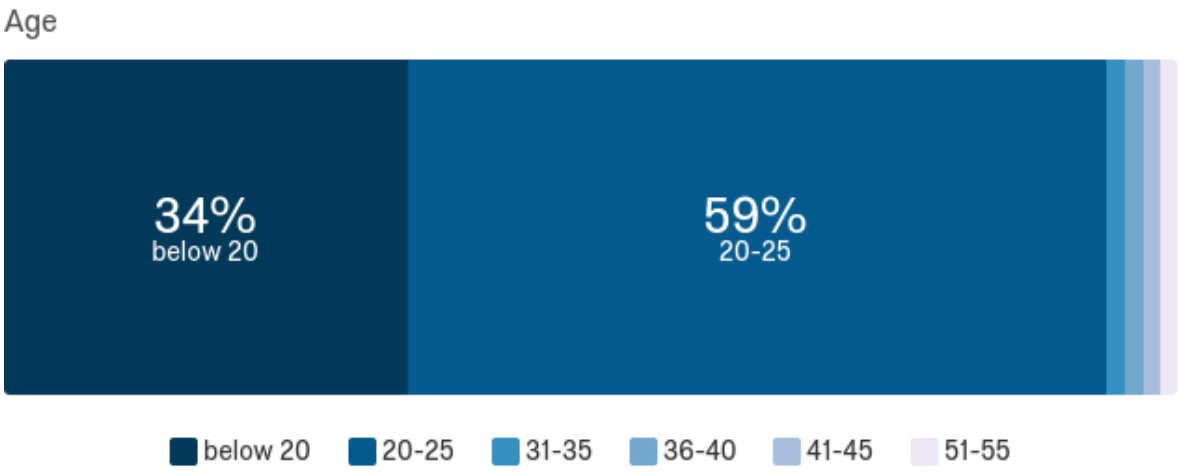

Figure 4.3: Participants' age distribution

4.4.3 Data analysis

In order for the results to be statistically significant a certain threshold for the sample size needs to be met. The sample size requires at least ten times the number of items that the most complex construct contains [51]. The construct with the most items is called the most complex construct [52]. The most complex constructs of this survey are PE, EE, and FC they all have 5 items. Consequently, the sample size needs a minimum of 50 responses.

The analysis method will consist of a linear regression analysis in SPSS, the first regression analysis will use BI as the dependent variable, the second regression analysis uses USE as the dependent variable. Additionally, a path analysis will be performed with AMOS to verify if the results are consistent across different statistical methods. In **??** the analyses will be used to test the hypotheses of paragraph 2.6.

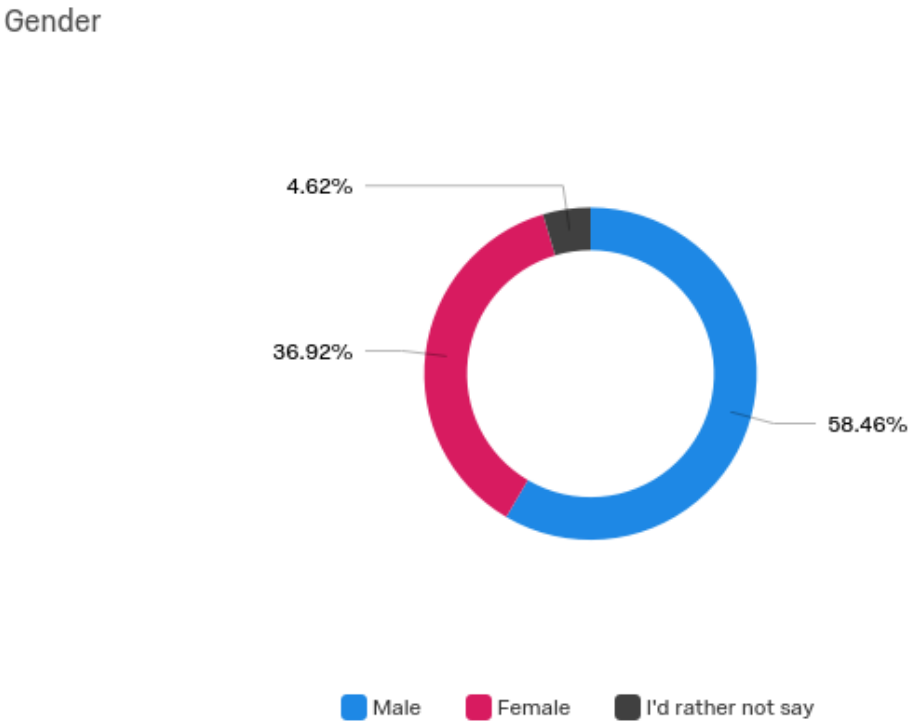

Figure 4.4: Participants' gender distribution

Chapter 5

Results

5.1 Color connotation results

The results statistical and percentages of the color connotation for each color can be found in chapter D. The data from the survey was used as input for a data visualization program (Quadrigram)[1] to make the data interactive and to be able to compare the results. In fig. 5.1 the data visualization of the connotation of red is visible. Each bar shows the amount of vote that connotation got. The first two bars are the first connotation couple, awake and tired, the graph clearly shows that red was connotated as awake. In the following paragraphs the colors from the literature review (see appendix chapter B) will be compared with the results of the survey (see appendixchapter D), the visualization graphs are included as visual aid.

5.1.1 Red results analysis

According to the literature review red was seen as demanding, intense, strong, exciting, warm, and distracting. The results of the survey in fig. 5.1 confirm the connotations; warm, exciting, and tensed. The color was further seen as active, interesting, closed and chaotic.

5.1.2 Orange results analysis

Orange was described as warmest color with the positive reactions in the literature. The connotation survey confirms these statements, the color orange was definitely seen as a warm color. The color scored high for the connotations awake, happy, playful, active interesting, open and balanced (see fig. 5.2).

[1] The data visualization can be found at [53] and is interactive

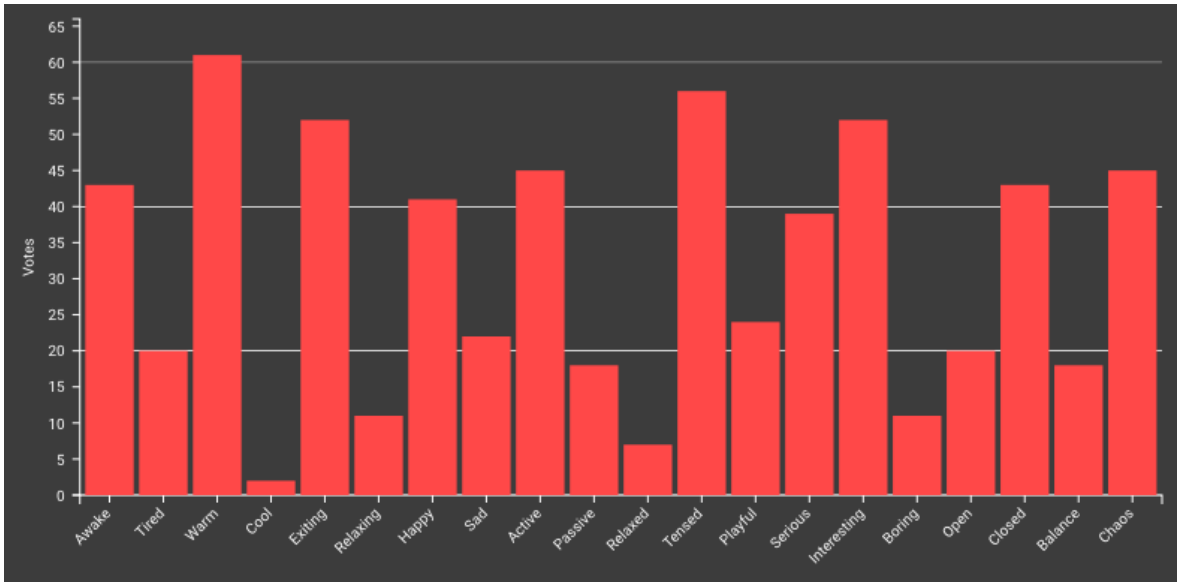

Figure 5.1: Results of the color connotation for the red color [53]

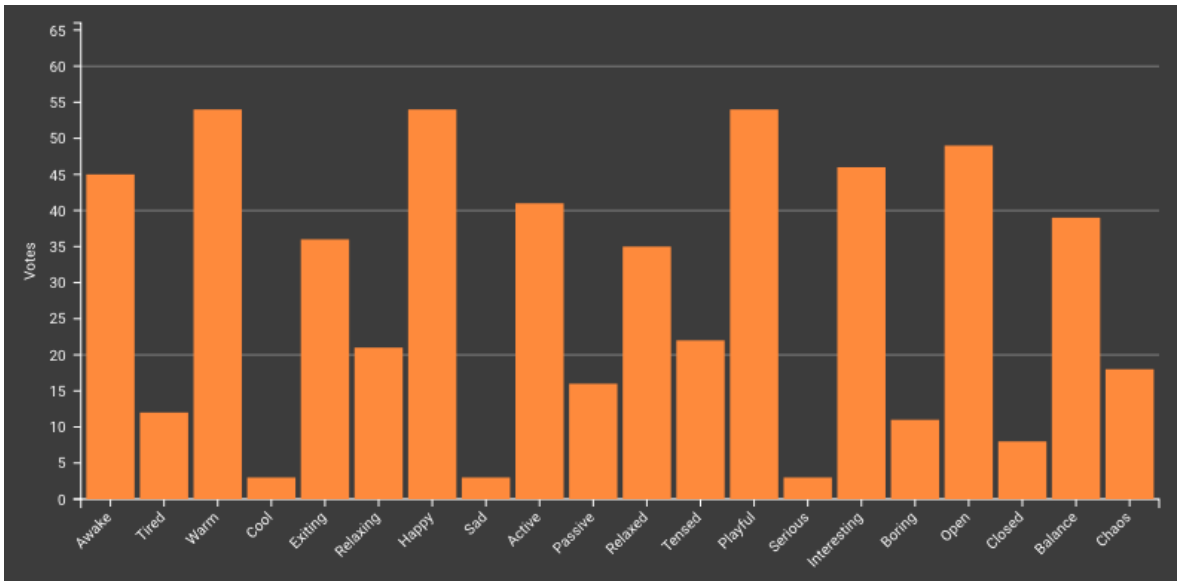

Figure 5.2: Results of the color connotation for the orange color [53]

5.1.3 Yellow results analysis

Remarkable about the yellow connotation is that all the students reviewed this color as happy (see fig. 5.3). The literature confirms this positive connotation of yellow. Also the stimulating connotations like; exciting, awake, active, playful, and interesting correspond with the literature.

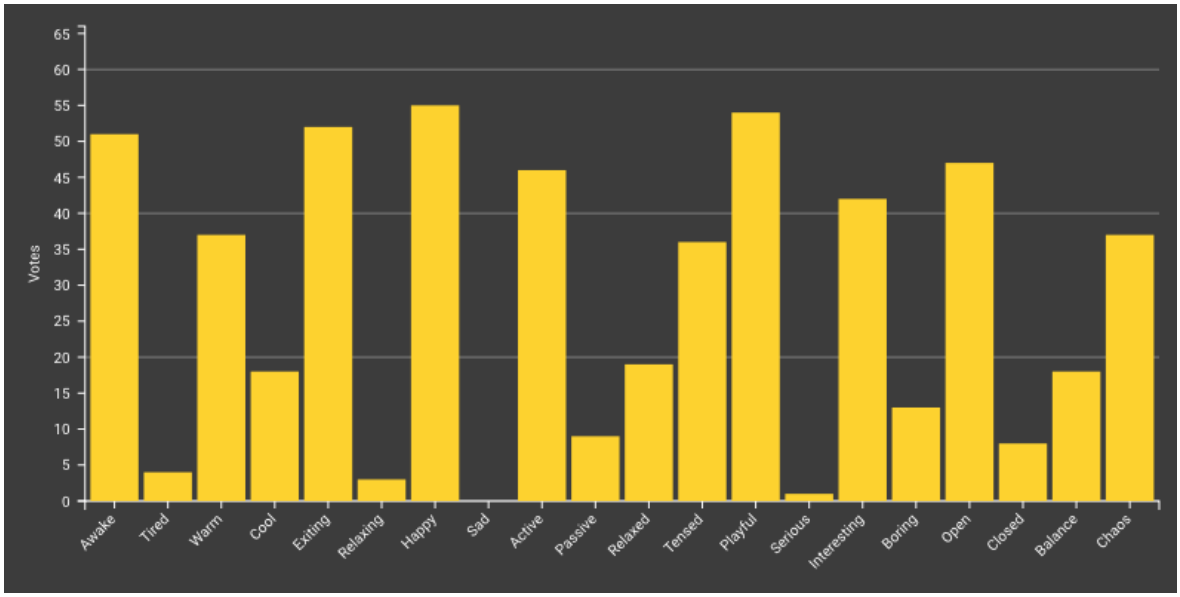

Figure 5.3: Results of the color connotation for the yellow color [53]

5.1.4 Yellow-green results analysis

The hue between yellow and green has not been researched before, thus can not be compared to literature. The connotations for yellow-green from this survey were; relaxed, happy, passive, serious, open, and balanced.

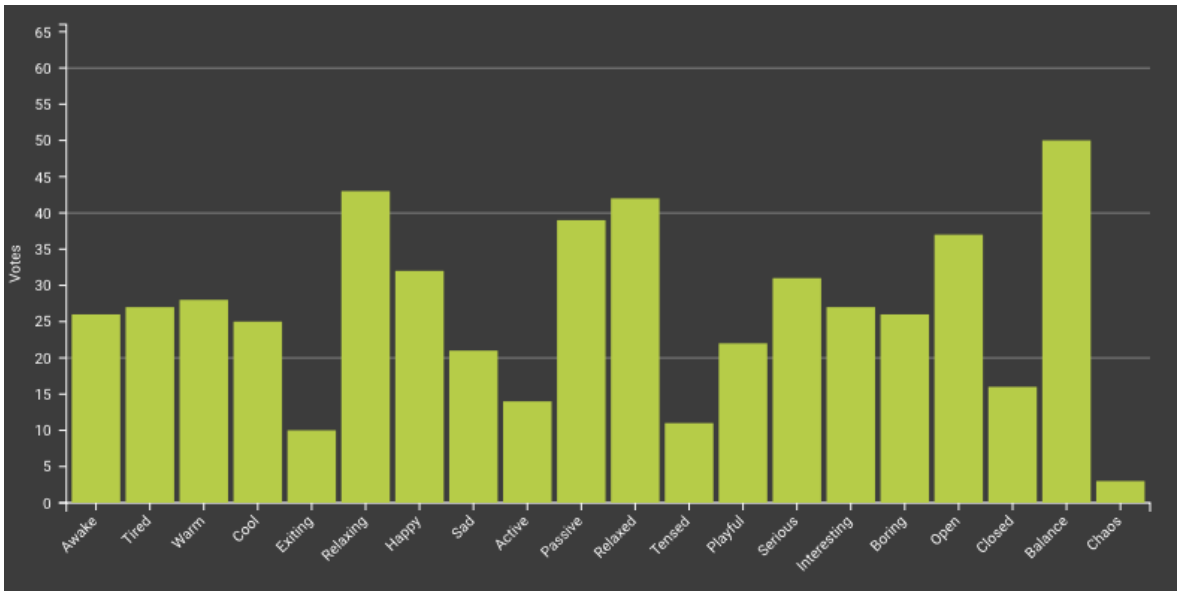

Figure 5.4: Results of the color connotation for the yellow-green color [53]

5.1.5 Green results compared

Green got the connotation awake, cool, happy, relaxed, interesting, open, and balanced. The literature equally uses the connotations balance, happiness, and relaxing. However, the literature connotated green as boring, and the survey indicates the opposed connotation.

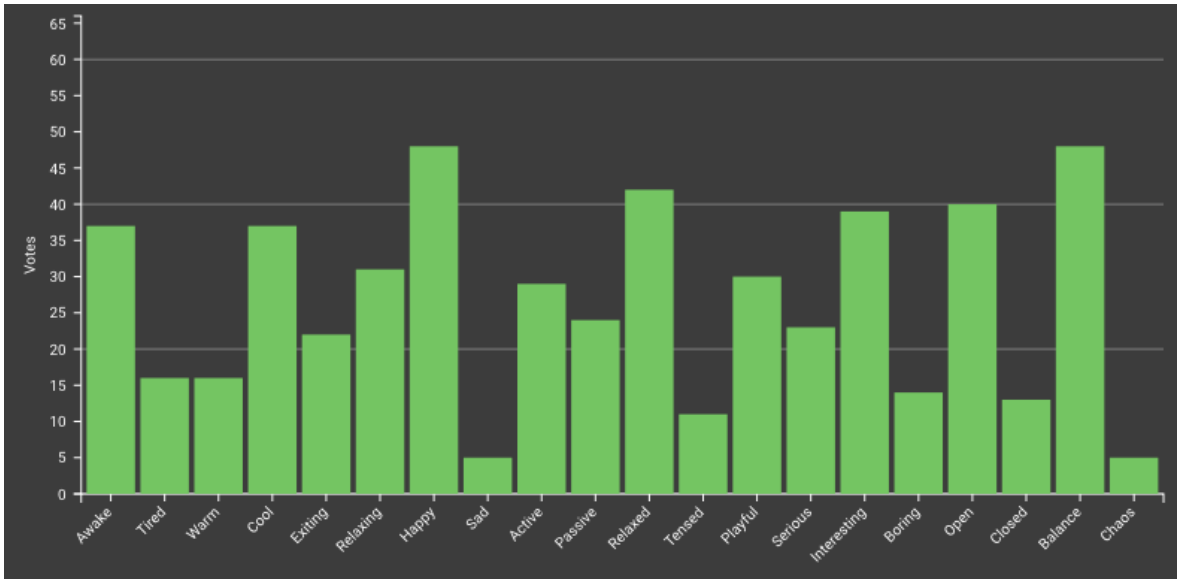

Figure 5.5: Results of the color connotation for the green color [53]

5.1.6 Blue results analysis

When the survey results for the color blue are compared with the results found in the literature the connotations calm, relaxed and cold are similar. Remarkable is, that the blue connotation did not score high for both the relaxed statements. The exciting versus relaxing connotation got a mean of 1.45, in this scale exciting got the value 1 and relaxing 2.

5.1.7 Purple-blue results analysis

Like yellow-green, the color purple-blue has not been described in research. The connotations that this color gets, are awake, cool, exciting, sad, active, tensed, serious, interesting, and closed.

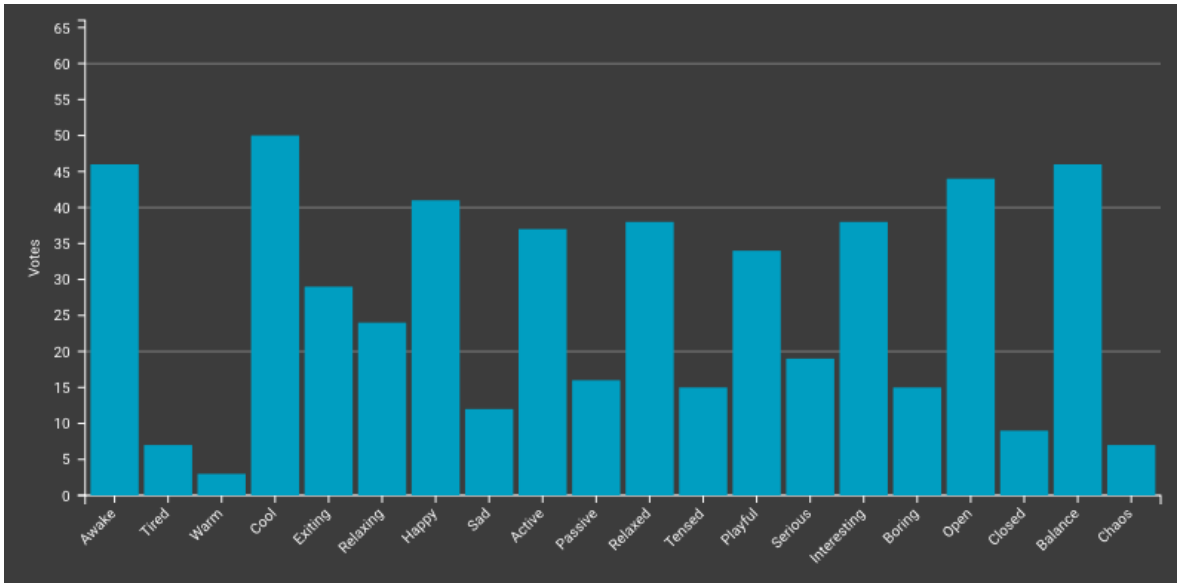

Figure 5.6: Results of the color connotation for the blue color [53]

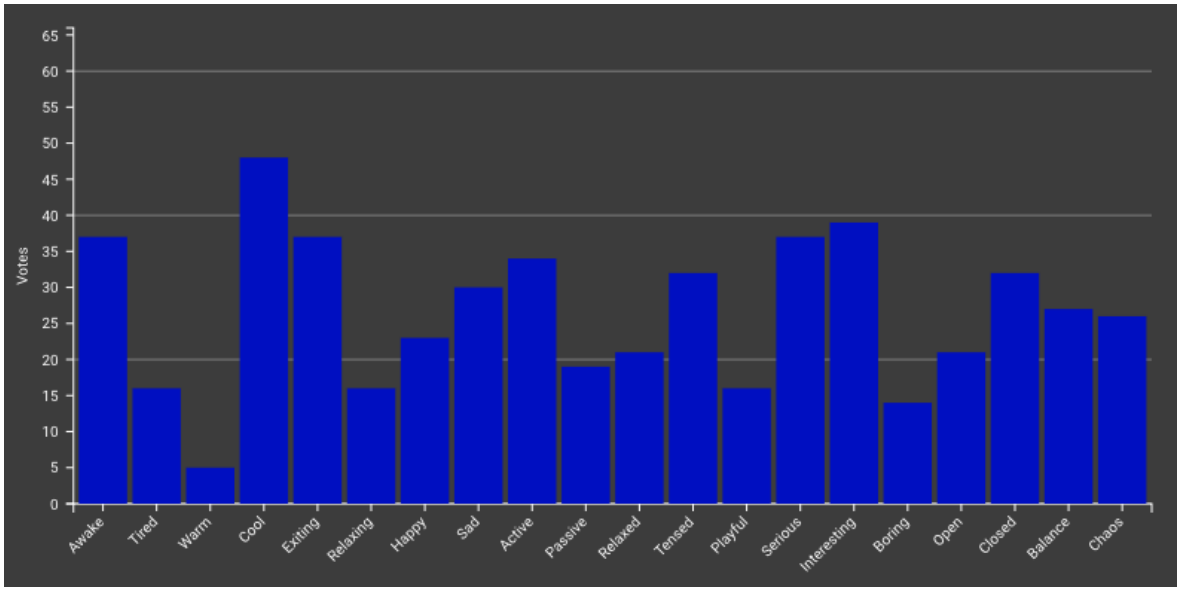

Figure 5.7: Results of the color connotation for the purple-blue color [53]

5.1.8 Purple results analysis

In the literature review only two articles examined the color purple. The resulting connotation was cool, striking and rich. Of those descriptives only cool was examined in this survey. With a mean of 1.58 it can be said that the color purple was evaluated here as cool as well. With a mean of 1.72 on the scale playful (1) versus serious (2), the color purple is seen as a serious color. The other connotations of purple were; tired, relaxing, sad, passive, boring, closed, and balanced (see fig. 5.8).

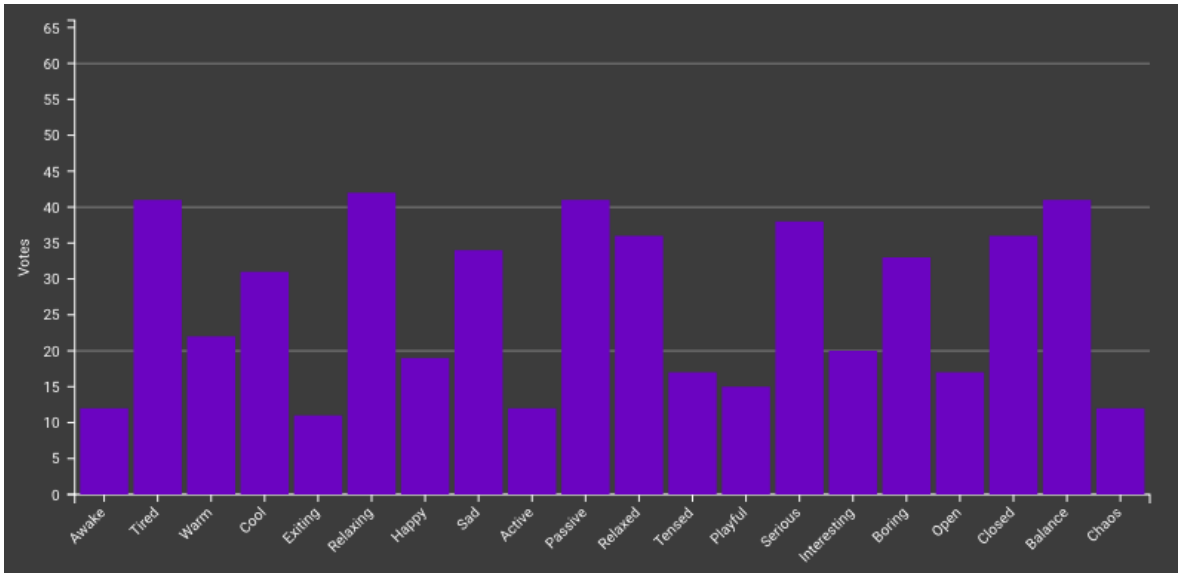

Figure 5.8: Results of the color connotation for the purple color [53]

5.1.9 Pink results analysis

Lastly the color pink can be compared with the results from the literature review. The literature stated that pink evoked strong feelings in the participants. The strong feelings can be seen in fig. 5.9. Pink got low variance scores for the connotation couples. Pink was seen as; awake, warm, exciting, happy, active, tensed, playful, interesting, open, and chaotic.

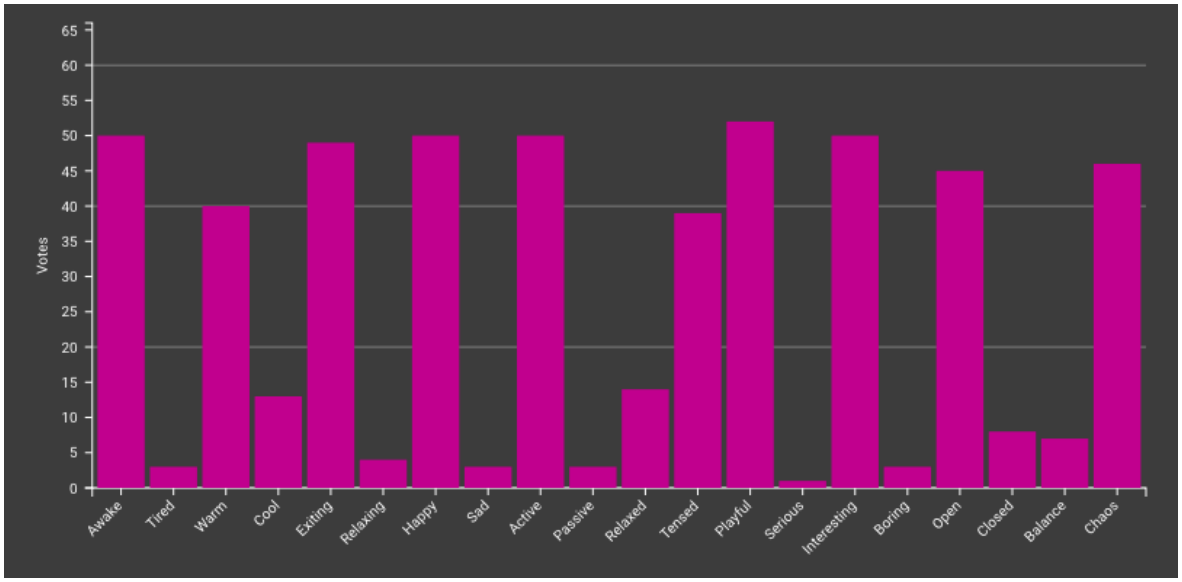

Figure 5.9: Results of the color connotation for the pink color [53]

5.2 Light scene effect results

5.2.1 Volume

The data of the dB measurements during week 25 can be found in chapter I. The average and maximum volumes are listed there per section per day. In fig. 5.10 the average volume of the first day, when the light system was off, is visible. The figures 5.11, fig. 5.12, and fig. 5.13 show the average measurements of each section during the days that the lighting system is active. All the measurements are within the dB range of a normal conversation. On 20-06 there was a peak at 11:45 in section 2 (see fig. 5.10).

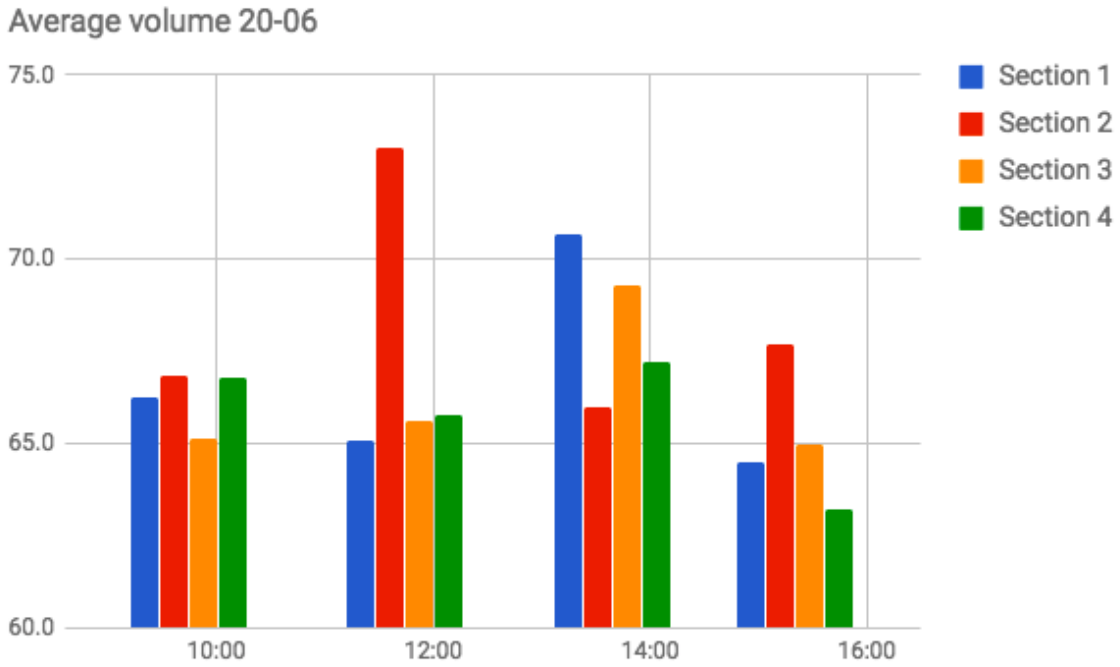

Figure 5.10: Average volume on 20-06 day 1 of the experiment week, normal situation

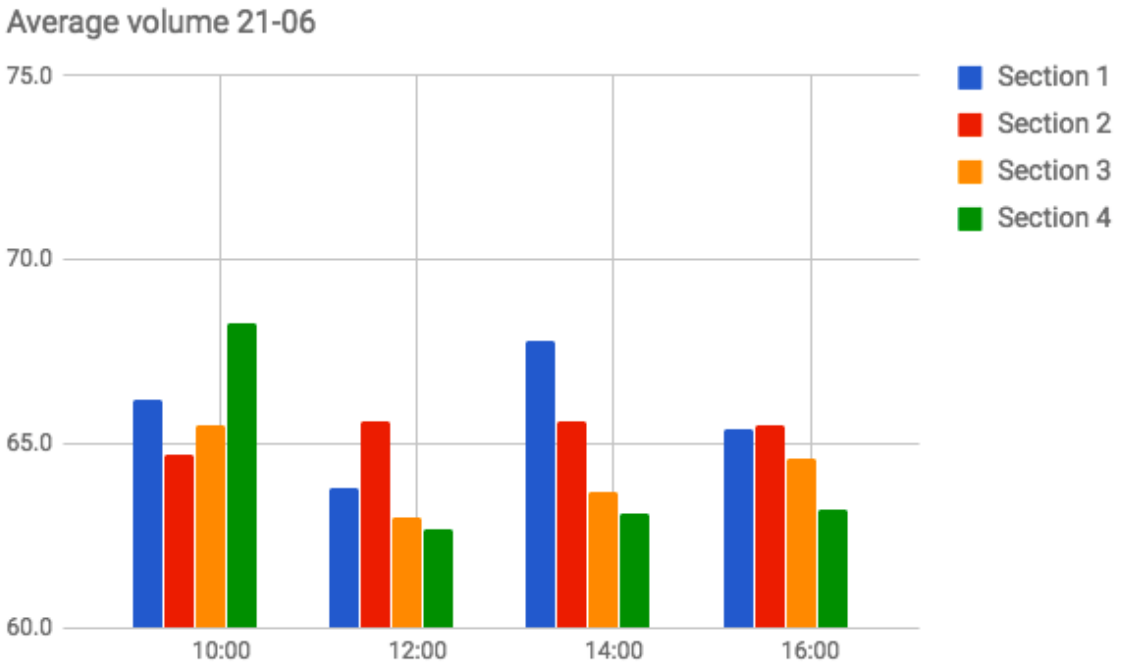

Figure 5.11: Average volume on 21-06 day 2 of the experiment week, light scene: Supervised project, Entrance 1: Green, Entrance 2: Green, and Stairs: Green

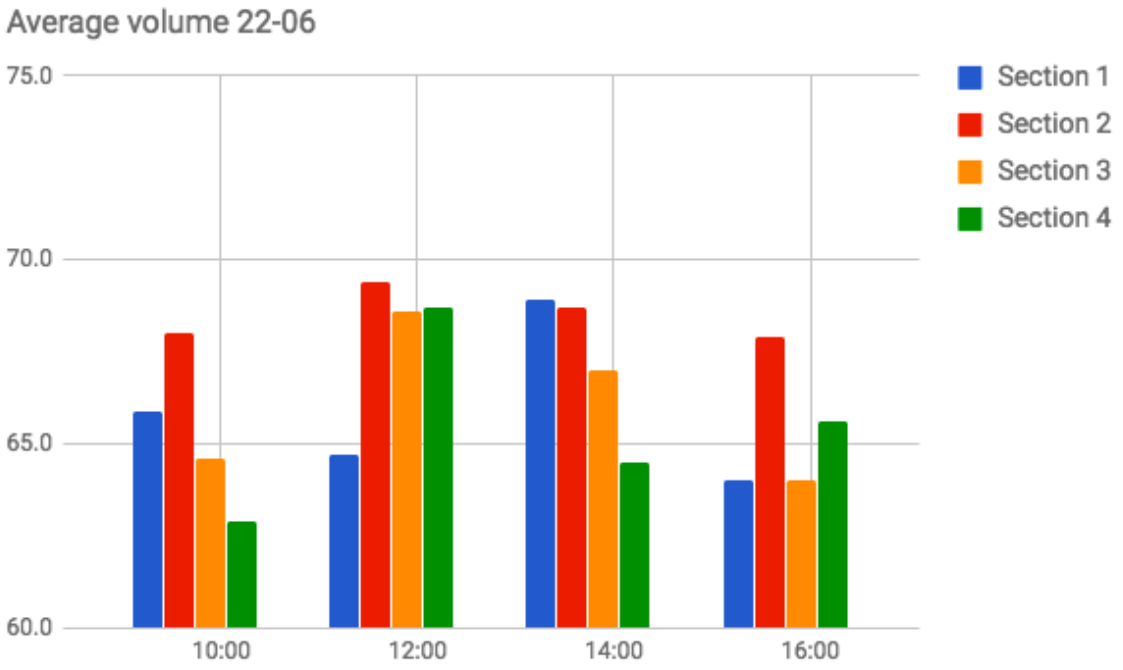

Figure 5.12: Average volume on 22-06 day 3 of the experiment week, light scene: Supervised project, Entrance 1: Green, Entrance 2: Blue, and Stairs: Blue

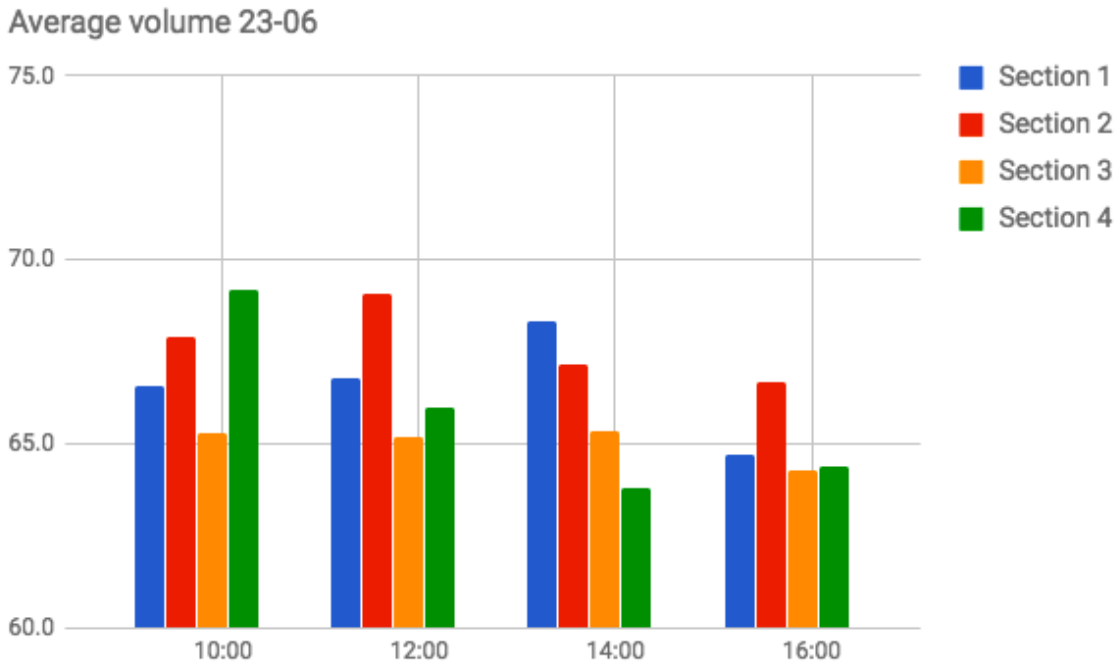

Figure 5.13: Average volume on 23-06 day 4 of the experiment week, light scene: Supervised project, Entrance 1: Blue, Entrance 2: Red, and Stairs: Red

5.2.2 Entrance usage

The data for the entrance usage have been excluded from this report due to malfunctioning equipment. However, the observations will be discussed in this section.

20-06 In the normal situation the entrances and the stairs were used regularly.

21-06 This was the first day the lights were officially on and the entrances were set to green. To test if the posters were clear a user evaluation took place. Most of participants did not notice the instruction poster. The participants who did notice the poster, did not take the time to read it. Different positions for the poster were tested, but the position did not effect the notability of the poster. Both entrances and the stairs were used regularly.

22-06 During this day the lights on the entrance 2 and the stairs were set to blue. The blue color indicated that the entrance or stairs may be used but only quietly. However, the students did talk while walking in.

23-06 This day the entrance 1 was set to blue, and entrance 2 and the stairs to red. Some students noticed the red light, but chose to ignore it and go through the

entrance or up the stairs.

5.3 UTAUT analysis linear regression

The complete linear analysis outputs can be found in chapters F to H. The tables that are used for the UTAUT analysis are also displayed in the next paragraphs.

5.3.1 Significance

For the linear regression analysis, the stepwise method was chosen to filter the significant constructs from the insignificant constructs. In fig. 5.15 the ANOVA method is used to test the statistical significance of each step from the stepwise model. The significance for all the steps is below .0005, the steps are therefor accepted as significant. Below the table the constructs of the steps can be seen. For the dependent variable BI the constructs PE, and EE have significant effect. In fig. 5.14 the R value (which is the linear correlation coefficient) goes up with each step, showing that the each independent variable that is added as a predictor variable strengthens the correlation for predicting the independent variable. A correlation of +1 indicates a perfect fit [54]. In the correlation table fig. 5.18 only the constructs themselves have a perfect correlation fit. The stepwise method for choosing the constructs can be seen in fig. 5.16 and fig. 5.17. For the linear regression with BI as dependent variable, the significant constructs were PE, EE, and USE. For the linear regression of dependent variable USE only BI was a significant construct.

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.721[a]	.520	.510	.72289	.520	54.134	1	50	.000	
2	.786[b]	.618	.602	.65154	.098	12.550	1	49	.001	
3	.815[c]	.665	.644	.61641	.047	6.745	1	48	.012	2.268

a. Predictors: (Constant), PE

b. Predictors: (Constant), PE, EE

c. Predictors: (Constant), PE, EE, USE

d. Dependent Variable: BI

Figure 5.14: ANOVA

5.3.2 Linear regression model dependent variable BI

To measure the effect of the behavioral intention (BI) on the actual usage (USE), behavior intention was regressed over the variables of the UTAUT model (see fig. 5.18). In the figure the standardized correlation coefficients between the constructs and BI

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	28.288	1	28.288	54.134	.000[b]
	Residual	26.128	50	.523		
	Total	54.417	51			
2	Regression	33.616	2	16.808	39.595	.000[c]
	Residual	20.801	49	.425		
	Total	54.417	51			
3	Regression	36.179	3	12.060	31.739	.000[d]
	Residual	18.238	48	.380		
	Total	54.417	51			

a. Dependent Variable: BI

b. Predictors: (Constant), PE

c. Predictors: (Constant), PE, EE

d. Predictors: (Constant), PE, EE, USE

Figure 5.15: Model summary

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	PE	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	EE	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	USE	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: BI

Figure 5.16: Stepwise analysis of the significant regression variables with the dependent variable BI

can be found. From the stepwise method we know that PE and EE are significant. The correlation coefficients between PE and BI is 0.721. The correlation coefficient

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	BI	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: USE

Figure 5.17: Stepwise analysis of the significant regression variables with the dependent variable USE

between EE and BI is 0.592. Looking at the coefficients table (see fig. 5.20) the standardized beta weights helps predict which predictor variable is best, both PE and EE have a positive standardized beta weight. Therefore, a positive value for PE or EE will give a positive value for BI. The beta weight of PE is higher than the beta weight of EE, consequently PE is better at predicting BI than EE. However, the R value for step 2is higher than for step 1(see 5.14), resulting in the constructs together being better at predicting the behavioral intention than by themselves. This is corresponding to the original UTAUT model [38].

5.3.3 Linear regression model dependent variable USE

The only construct that had significant correlation with the actual usage of the system was BI. In fig. 5.20 the standardized beta weight for BI with dependent variable USE is 0.366 with a significance level of 0.008.

Correlations

		USE	PE	EE	ATUT	SI	FC	ANX	SE	Gender	Age	BI
Pearson Correlation	USE	1.000	.098	.297	.150	.244	.361	-.052	.212	-.029	.057	.366
	PE	.098	1.000	.429	.844	.742	.224	-.190	-.117	.040	-.134	.721
	EE	.297	.429	1.000	.414	.487	.709	-.314	.375	.077	.062	.592
	ATUT	.150	.844	.414	1.000	.740	.375	-.270	-.113	.170	-.200	.628
	SI	.244	.742	.487	.740	1.000	.322	-.263	.052	.055	-.089	.671
	FC	.361	.224	.709	.375	.322	1.000	-.319	.334	.152	.057	.467
	ANX	-.052	-.190	-.314	-.270	-.263	-.319	1.000	.048	.023	.041	-.133
	SE	.212	-.117	.375	-.113	.052	.334	.048	1.000	.015	.023	.055
	Gender	-.029	.040	.077	.170	.055	.152	.023	.015	1.000	-.314	.122
	Age	.057	-.134	.062	-.200	-.089	.057	.041	.023	-.314	1.000	-.066
	BI	.366	.721	.592	.628	.671	.467	-.133	.055	.122	-.066	1.000
Sig. (1-tailed)	USE	.	.245	.016	.144	.041	.004	.356	.066	.418	.344	.004
	PE	.245	.	.001	.000	.000	.055	.089	.204	.390	.172	.000
	EE	.016	.001	.	.001	.000	.000	.012	.003	.295	.330	.000
	ATUT	.144	.000	.001	.	.000	.003	.027	.213	.114	.078	.000
	SI	.041	.000	.000	.000	.	.010	.030	.356	.348	.264	.000
	FC	.004	.055	.000	.003	.010	.	.011	.008	.142	.343	.000
	ANX	.356	.089	.012	.027	.030	.011	.	.369	.437	.386	.173
	SE	.066	.204	.003	.213	.356	.008	.369	.	.459	.436	.349
	Gender	.418	.390	.295	.114	.348	.142	.437	.459	.	.012	.195
	Age	.344	.172	.330	.078	.264	.343	.386	.436	.012	.	.320
	BI	.004	.000	.000	.000	.000	.000	.173	.349	.195	.320	.

Figure 5.18: Correlation table for the complete UTAUT model compiled with the linear regression model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.683	.320		2.135	.038	.040	1.325					
	PE	.780	.106	.721	7.358	.000	.567	.992	.721	.721	.721	1.000	1.000
2	(Constant)	.065	.337		.192	.849	-.612	.742					
	PE	.619	.106	.572	5.851	.000	.406	.831	.721	.641	.517	.816	1.226
	EE	.437	.123	.346	3.543	.001	.189	.686	.592	.452	.313	.816	1.226
3	(Constant)	-.343	.355		-.966	.339	-1.058	.371					
	PE	.628	.100	.581	6.270	.000	.426	.829	.721	.671	.524	.815	1.228
	EE	.348	.122	.275	2.852	.006	.103	.593	.592	.381	.238	.750	1.334
	USE	.338	.130	.227	2.597	.012	.076	.599	.366	.351	.217	.910	1.098

a. Dependent Variable: BI

Figure 5.19: Linear regression estimates for the dependent variable BI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	1.069	.274		3.904	.000	.519	1.619					
	BI	.247	.089	.366	2.782	.008	.069	.425	.366	.366	.366	1.000	1.000

a. Dependent Variable: USE

Figure 5.20: Linear regression estimates for the dependent variable USE

5.4 UTAUT analysis Path analysis

In addition to the linear regression analysis the path analysis was executed. In fig. 5.21 the model that was made in AMOS can be seen. Each construct is an collection of items, each item being a question of about the topic of the construct. The regression weights table the regression weights, the standard error and the probability values are shown (see fig. 5.22). The probabilities of the regression weights between the constructs and the dependent variable BI are to high to be of significant value. The last column in the assessment of normality (see fig. 5.23 confirms that the significance is too low because the critical values are negative.PEP

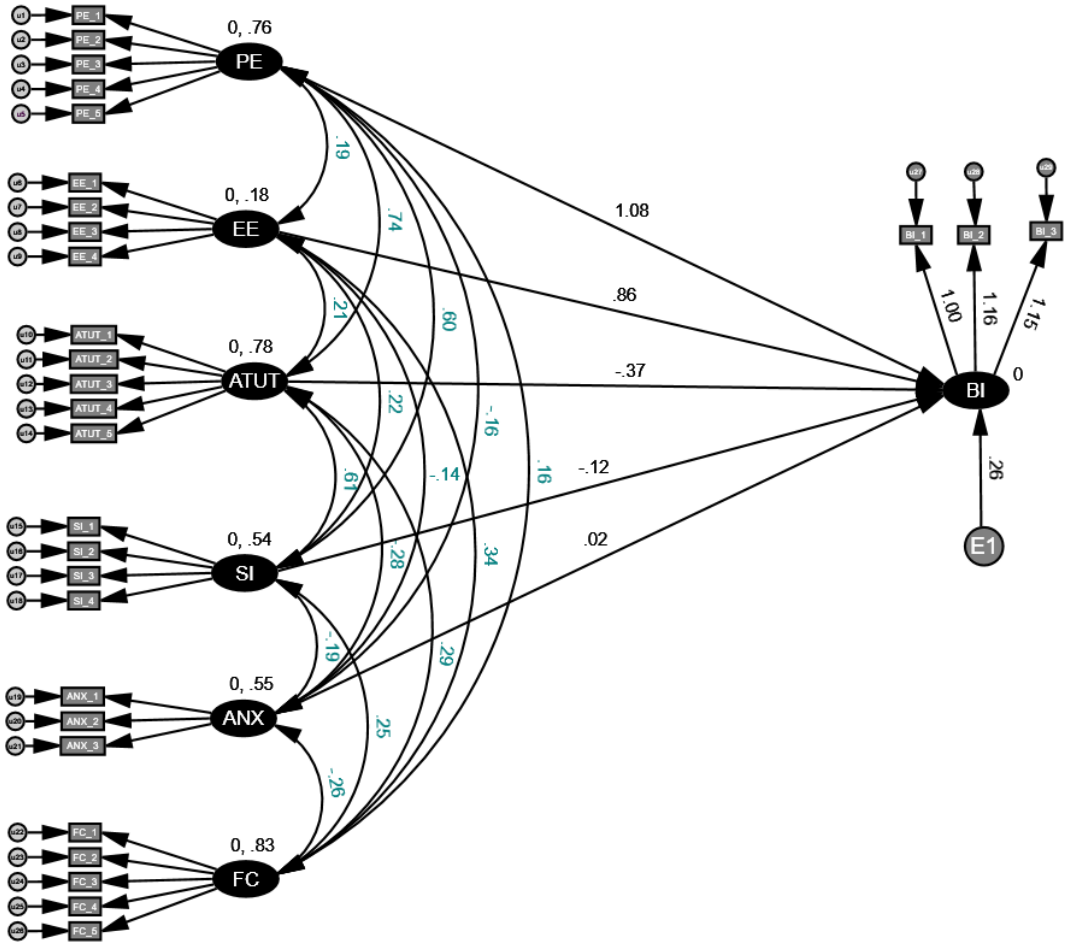

Figure 5.21: The UTAUT model in AMOS with the dependent variable BI

5.5 UTAUT results per construct

The following figures show the results per construct. The results give the percentage and the amount of votes for each item of a construct. In the performance expectancy construct item 4 and 1 evaluate the different components of the lighting system. Remarkable is, that performance expectancy of the lights at the entrances is much higher than the expectancy of the lights in the sections (see fig. 5.24). The results for item 5 from the attitude towards the system confirm the preference for the entrance lighting system(see fig. 5.29). The results for item 4 of the Social influence construct show that the respondents intend to act ask the lighting system indicates during a lecturefig. 5.26. The mean for that item was 2.32, indicating that the intention lies between somewhat agree and neither agree nor disagree. Another remarkable result is the outcome that from the facilitating conditions item 3, which states that the user has the knowledge necessary to use the lighting system, compared to the outcome of the social-efficacy construct(see fig. 5.27 and fig. 5.28). Namely, item 3 from FC shows that most of the respondents agree to have enough knowledge to use the lighting system, but they also want a help tool with instructions (SE item 2). There is little anxiety towards the lighting system, because the answers to those questions were skewed toward the negative side of the scale(see fig. 5.30). In the actual usage of the construct it can be seen that the group that had already interacted with the lighting system was less than half of the total responses. Lastly the behavioral intention toward the system, the intentions of the users for item 2 and 3 is skewed toward the positive side of the scale. However, the first item is skewed toward the negative side of the scale.

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
BI	<---	PE	1.076	1.374	.783	.433	par_35
BI	<---	EE	.865	.713	1.214	.225	par_36
BI	<---	ATUT	-.369	.722	-.510	.610	par_37
BI	<---	ANX	.020	.225	.088	.930	par_38
BI	<---	SI	-.124	1.449	-.085	.932	par_39
BI	<---	E1	.264	.151	1.747	.081	par_42
EE_4	<---	EE	1.000				
EE_3	<---	EE	1.744	.565	3.086	.002	par_1
EE_2	<---	EE	1.662	.551	3.014	.003	par_2
EE_1	<---	EE	2.026	.657	3.082	.002	par_3
ATUT_5	<---	ATUT	1.000				
ATUT_4	<---	ATUT	.980	.179	5.477	***	par_4
ATUT_3	<---	ATUT	.900	.185	4.864	***	par_5
ATUT_2	<---	ATUT	1.062	.197	5.391	***	par_6
ATUT_1	<---	ATUT	1.147	.171	6.725	***	par_7
SI_4	<---	SI	1.000				
SI_3	<---	SI	.630	.185	3.400	***	par_8
SI_2	<---	SI	.705	.171	4.120	***	par_9
SI_1	<---	SI	1.000				
ANX_3	<---	ANX	1.000				
ANX_2	<---	ANX	1.366	.259	5.276	***	par_10
ANX_1	<---	ANX	1.352	.258	5.242	***	par_11
FC_5	<---	FC	1.000				
FC_4	<---	FC	.355	.147	2.420	.016	par_12
FC_3	<---	FC	.988	.149	6.640	***	par_13
FC_2	<---	FC	.588	.148	3.972	***	par_14
FC_1	<---	FC	1.106	.148	7.474	***	par_15
PE_5	<---	PE	1.000				
PE_4	<---	PE	.983	.209	4.712	***	par_16
PE_3	<---	PE	1.017	.162	6.277	***	par_17
PE_2	<---	PE	1.081	.173	6.260	***	par_18
PE_1	<---	PE	1.031	.166	6.197	***	par_19
BI_1	<---	BI	1.000				
BI_2	<---	BI	1.164	.271	4.300	***	par_40
BI_3	<---	BI	1.146	.258	4.434	***	par_41

Figure 5.22: Regression weights of the path analysis with dependent variable BI

Assessment of normality (Group number 1)

Variable	min	max	skew	c.r.	kurtosis	c.r.
BI_3	1.000	5.000	.019	.055	-.851	-1.253
BI_2	1.000	5.000	.454	1.337	-.790	-1.163
BI_1	1.000	5.000	-.171	-.504	-1.407	-2.072
PE_1	1.000	5.000	.458	1.348	-.826	-1.216
PE_2	1.000	5.000	.199	.585	-.893	-1.314
PE_3	1.000	5.000	-.059	-.175	-.562	-.827
PE_4	1.000	5.000	.780	2.297	-.615	-.905
PE_5	1.000	5.000	-.037	-.109	-.801	-1.179
FC_1	1.000	5.000	.857	2.524	.288	.423
FC_2	1.000	5.000	.166	.489	-.532	-.783
FC_3	1.000	5.000	.588	1.732	-.215	-.317
FC_4	1.000	5.000	-.422	-1.241	.435	.641
FC_5	1.000	5.000	.408	1.200	-.693	-1.021
ANX_1	1.000	5.000	-.391	-1.150	-.940	-1.384
ANX_2	1.000	5.000	-.956	-2.815	-.109	-.161
ANX_3	1.000	5.000	-.837	-2.465	-.450	-.662
SI_1	1.000	5.000	.001	.004	-.822	-1.210
SI_2	1.000	5.000	.523	1.539	.077	.113
SI_3	1.000	5.000	.433	1.274	.111	.163
SI_4	1.000	5.000	.925	2.722	.582	.856
ATUT_1	1.000	5.000	.600	1.767	-.690	-1.016
ATUT_2	1.000	5.000	.579	1.704	-.605	-.891
ATUT_3	1.000	5.000	-.065	-.190	-.736	-1.083
ATUT_4	1.000	5.000	.188	.552	-.469	-.690
ATUT_5	1.000	5.000	1.298	3.820	.820	1.206
EE_1	1.000	5.000	.015	.043	-1.239	-1.824
EE_2	1.000	5.000	.496	1.460	-.696	-1.024
EE_3	1.000	5.000	.053	.155	-.870	-1.280
EE_4	1.000	4.000	.577	1.700	-.491	-.723
Multivariate					24.213	2.059

Figure 5.23: Assessment of normality for the path analysis model in AMOS

PE - Do you agree or disagree with the following statements?

#	Field	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
3	Using the lighting system will increase my productivity	6.35% 4	23.81% 15	33.33% 21	26.98% 17	9.52% 6
2	Using the lighting system will enable me to accomplish tasks more quickly	3.17% 2	23.81% 15	34.92% 22	19.05% 12	19.05% 12
5	I find the lights in the room useful	7.94% 5	30.16% 19	30.16% 19	20.63% 13	11.11% 7
4	I find the lights at the entrances useful	33.33% 21	36.51% 23	9.52% 6	9.52% 6	11.11% 7
1	I find the lighting system useful	12.70% 8	49.21% 31	12.70% 8	20.63% 13	4.76% 3

Figure 5.24: Results of the UTAUT survey regarding the Performance Expectancy construct

EE - Do you agree or disagree with the following statements?

#	Field	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1	My interaction with the lighting system is clear and understandable	15.25% 9	33.90% 20	13.56% 8	28.81% 17	8.47% 5
2	It will be easy for me to become skilful at using the lighting system	23.73% 14	32.20% 19	25.42% 15	16.95% 10	1.69% 1
3	I find the lighting system easy to use	28.81% 17	18.64% 11	37.29% 22	11.86% 7	3.39% 2
4	Learning to interpret the lighting system is easy for me	25.42% 15	42.37% 25	18.64% 11	13.56% 8	0.00% 0

Figure 5.25: Results of the UTAUT survey regarding the Effort Expectancy construct

SI - Do you agree or disagree with the following statements?

#	Field	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1	People who are important to me think that I should act as the lighting system suggests	1.75% 1	19.30% 11	38.60% 22	24.56% 14	15.79% 9
2	The instructor of this course has been helpful in the use of the system	1.75% 1	14.04% 8	61.40% 35	8.77% 5	14.04% 8
3	In general, the study of CreaTe has supported the use of the lighting system	7.02% 4	29.82% 17	43.86% 25	10.53% 6	8.77% 5
4	When there is a lecture in the room I would act as the lighting system suggests	21.05% 12	42.11% 24	26.32% 15	5.26% 3	5.26% 3

Figure 5.26: Results of the UTAUT survey regarding the Social Influence construct

FC - Do you agree or disagree with the following statements?

#	Field	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1	I have the resources necessary to use the lighting system	25.93% 14	35.19% 19	27.78% 15	3.70% 2	7.41% 4
2	The lighting system is compatible with other systems I use	20.37% 11	29.63% 16	37.04% 20	11.11% 6	1.85% 1
3	I have the knowledge necessary to use the lighting system	20.37% 11	37.04% 20	27.78% 15	9.26% 5	5.56% 3
4	A specific person is available for assistance with the lighting system difficulties	12.96% 7	9.26% 5	61.11% 33	12.96% 7	3.70% 2
5	The instructions for the use of the lighting system are clear	24.07% 13	29.63% 16	29.63% 16	12.96% 7	3.70% 2

Figure 5.27: Results of the UTAUT survey regarding the Facilitating Conditions construct

SE - I would know how to interact with this system...

#	Field	Choice Count
3	If there was someone around to instruct me	9.62% 5
1	If there was no one around to tell me how to act	23.08% 12
2	If there was a help tool with the instructions	67.31% 35

Figure 5.28: Results of the UTAUT survey regarding the Self-efficacy construct

ATUT - Do you agree or disagree with the following statements?

#	Field	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1	Using the lighting system is a good idea	26.67% 16	36.67% 22	18.33% 11	16.67% 10	1.67% 1
2	The system will make working in the SmartXp more interesting	16.67% 10	31.67% 19	28.33% 17	10.00% 6	13.33% 8
3	Working with the lighting system is fun	13.33% 8	16.67% 10	38.33% 23	23.33% 14	8.33% 5
4	I like working with the lighting system on	11.67% 7	20.00% 12	48.33% 29	10.00% 6	10.00% 6
5	I like that the lighting system shows me that if I can use the entrances	36.67% 22	40.00% 24	11.67% 7	3.33% 2	8.33% 5

Figure 5.29: Results of the UTAUT survey regarding the Attitude towards the lighting system system construct

ANX - Do you agree or disagree with the following statements?

#	Field	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1	I feel apprehensive (anxious) about the lighting system	2.00% 1	10.00% 5	28.00% 14	24.00% 12	36.00% 18
2	The lighting system is intimidating to me	2.00% 1	8.00% 4	14.00% 7	26.00% 13	50.00% 25
3	I feel anxious that the lighting system will influence my work	2.00% 1	12.00% 6	10.00% 5	34.00% 17	42.00% 21

Figure 5.30: Results of the UTAUT survey regarding the Anxiety construct

BI - Do you agree or disagree with the following statements?

#	Field	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1	I plan to interact with the system the next 2 months	8.00% 4	26.00% 13	16.00% 8	14.00% 7	36.00% 18
2	I predict I would act as the lighting system indicates the next (college) year	16.00% 8	40.00% 20	18.00% 9	18.00% 9	8.00% 4
3	I intend to act as the lighting system indicates during the remaining years of my bachelor CreaTe	15.69% 8	27.45% 14	29.41% 15	21.57% 11	5.88% 3

Figure 5.31: Results of the UTAUT survey regarding the Behavioral intention construct

USE - Have you interacted with the system?

#	Field	Choice Count
1	Yes	36.00% 18
2	No, not yet	48.00% 24
3	No, I don't intend to	16.00% 8

Figure 5.32: Results of the UTAUT survey regarding the Use behavior construct

Chapter 6

Discussion and Conclusion

6.1 Discussion

The results from the UTAUT statistical analysis showed little significance for many of the constructs. Especially for the path analysis method. The sample size was to small to make any assumptions based on the path analysis. However, the results from the linear regression do accept the first two hypotheses with a significance level of 95 percent:

H1: Performance expectancy has an influence on behavioral intention.

H2: Effort expectancy has an influence on behavioral intention.

The original UTAUT model and the analysis of Akbar, both used three time points to collect their data [38, 42]. In order to improve the significance and the validity of the UTAUT analysis, the analysis has to be done at least three times, with a larger sample size.

Concerning the color connotation results, there were similarities with the literature. Nevertheless, this color connotation survey used 10 sample colors, all fully saturated, and only a sample size of 74. More empirical research needs to be done in this field of study.

The target group for the experiment was suboptimal. The students of the supervised project hardly noticed to the entrance lights, when they noticed the entrance lights they decided to ignore the light and still use the entrance. The students mentioned that they knew they had to be in the room, consequently the light did not apply for them. This is a logical train of thought. The students of the second year have already certain feeling and expectations towards the SmartXp. With this in mind it is logical that they have a hard time adjusting to the lighting system.

It would be better to test the light system during a lecture, since light system then gives a logical indication. Another reason for testing the light system during a lecture, is to test if the lights work as dividers of the sections, to see if users understand the color and behave as the system indicates. The lights did not effect the produced

volume, therefore a different way of evaluating the effect of the light scene should be considered.

6.2 Conclusions

The behavioral intention towards the lighting system, especially the entrance indication component, shows promise. Moreover, the students intention to act as the system indicates during a lecture is a good reason to further improve the lighting system and to test that intention. The research question for this graduation report was:

How to stimulate desired behavior of students in the SmartXp by means of a context aware dynamic lighting system?

Several behavior techniques can be used to stimulate behavior. However, using light merely as an indicator of the desired behavior is not sufficient. In order for the lighting system to stimulate desired behavior, first awareness of the necessity of the behavior change needs to be created. Then feedback on the display behavior is needed. Additionally training in how to interpret the lighting system could help implementing the lighting system. Lastly information about the social consequences and social comparison needs to be distributed.

Chapter 7

Recommendations

7.1 Behavior change techniques

In paragraph 3.4 the behavior change techniques (BCTs); 4.1, 7.1, 8.1, 12.1, and 12.5 were chosen to stimulate the desired behavior. These constructs were chosen because they were feasible in the time span of the graduation project. In addition to the used BCTs I recommend that the following BCTs are added to the lighting system;

1.9 Commitment By stating their intention to use the lighting system the students already made a commitment to the intervention.

5.3 Information about social and environmental consequences Inform the students that the majority of the teacher finds the problem behavior disturbing and that attending students disapprove of the problem behavior.

5.6 Information about emotional consequences Explain that the students benefit from the light system and can now see from a distance if the entrance may be used. This will result in them not having to peer through the door to see if a lecture is active, and to be so close to the SmartXp, but yet having to veer around.

6.1 Demonstration of the behavior Demonstrate via film or pictures an example of the performance of the behavior.

6.2 Social comparison Draw the attention to the performance of other students in order for the student to compare its own behavior.

6.3 Information about others approval Tell the students of the new college year the the other students behave as the lighting system indicates.

9.2 Credible source Present a speech given by a professional to persuade the students to behave as the lighting system indicates.

9.3 Comparative imagining of future outcomes Let the students imagine that lectures become more efficient, or that they will be more focused because of the light scenes.

13.1 Identification of self as role model In form the students that already know the SmartXp that they will become a role model to the new students and that they have to set a good example.

13.2 Framing/reframing Give a new perspective to the veering around to the other door. Like exercise is good for the brain, if you veer around you help your brain and you do not disturb the lecture.

15.1 Verbal persuasion about capability Tell the students that it was logical that they used to disturb the lectures, because they did not know the what use case was active. Now the have the ability to perform the wanted behavior.

7.2 Design changes

The LED strips in section 4 and at the stairs should be made diffuse by covering, because the lights are now a bit to bright and it is hard to distinguish the color. Additionally, the lights at the stairs should be more present, for instance on every step a LED strip.

There should be feedback to show if the user is performing correctly. This could be screens that show you if you did right or not.

One of the changes made during the installation was that the lights should not shine in people their faces, and the lights should hang either high or in such a way that people cannot move them.

The color for Pink was evaluated as not suitable for project time, the students wanted more focus therefore the pink sections for project time should change to blue or blue-green. This should also be evaluated for the work lecture use case, as this light scene is quite similar to the project light scene.

7.3 Evaluation

All the use cases should be evaluated during active use cases to see what the effect is and to get more feedback from the students and the teachers about what the wanted behavior is for that use case.

Appendices

Appendix A

Personas

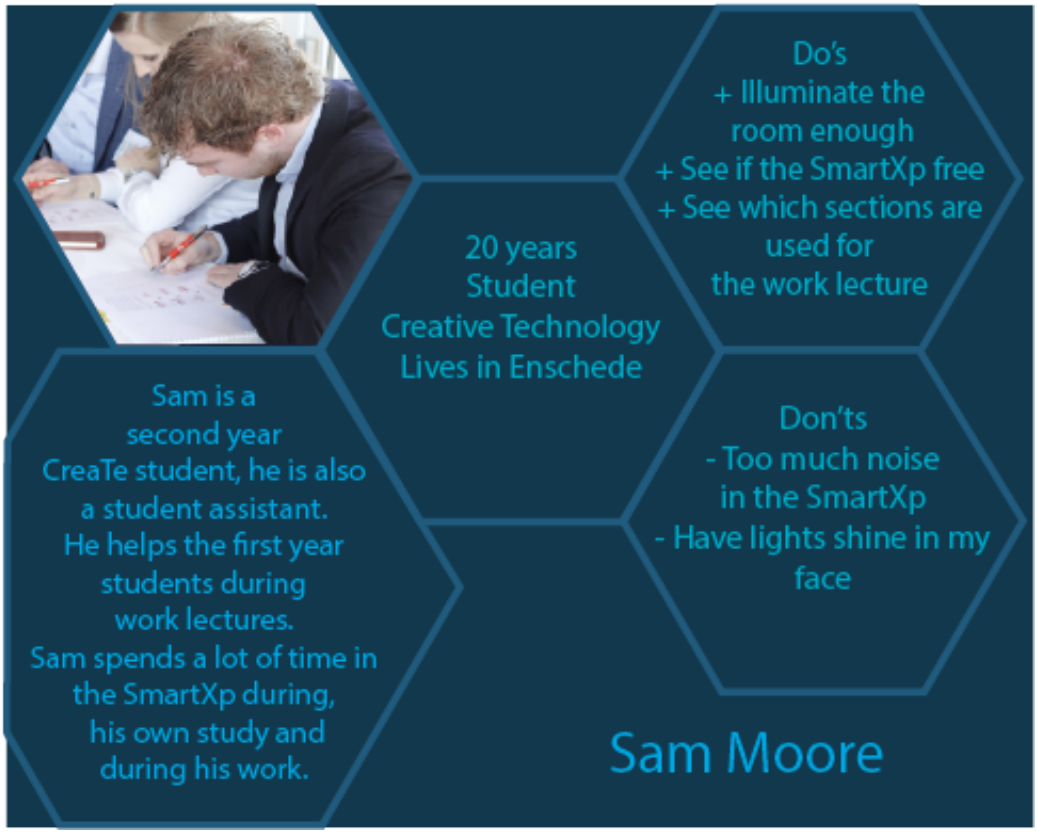

Figure A.1: Persona of a student assistant of Creative Technology

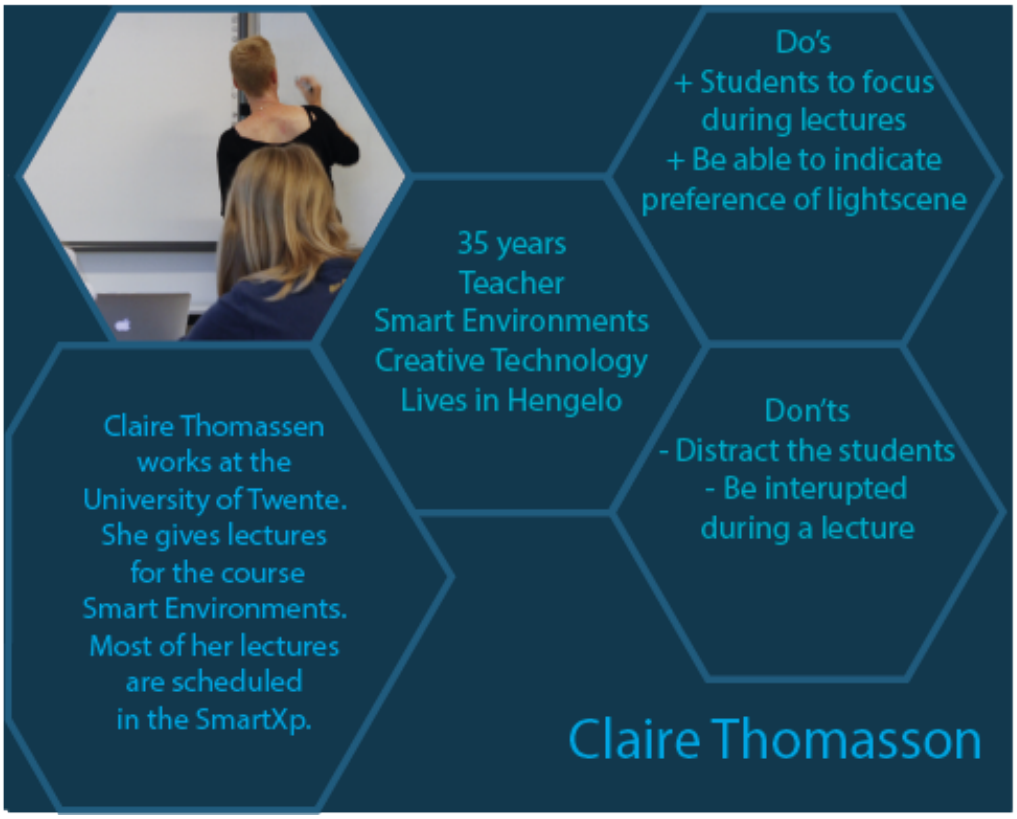

Figure A.2: Persona of a teacher of the study Creative Technology

Appendix B

Color connotation literature review

Table B.1: Literature research results of color connotation

Color	Results	References
Red	This color was experienced as; demanding, intense, strong, exciting, warm, and distracting. Results also showed that this color excited the body, and increased the appetite	[6, 7, 14–16, 55]
Orange	Orange was evaluated as the warmest color, and the subjects had a strong positive reaction to this color.	[6, 20]
Yellow	Yellow scored high in preference. However, the results showed that the chroma was determining for the preference of the color. Yellow was experienced as ugly, positive and stimulating.	[6, 7, 14, 19, 55, 56]
Green	The most positive color was green. The color was associated with; balance, harmony, and happiness. But also with; boring, calming, and stress reducing.	[6, 7, 14–16, 55, 56]
Blue	Blue was considered; calm, relaxed, cold, focused, and attention enhancing. This color was favored in most of the studies.	[6, 7, 15, 16, 19, 22, 29, 55, 56]
Purple	The color purple was seen as; cool striking and rich. Similarly to the yellow color, the chroma of the purple color had impact on how it was interpreted.	[7, 55, 56]
Pink	Pink got strong reactions especially in experiments performed in Asia. It was determined to be a stimulating color. The subjects either loved or hated the color.	[6, 7, 19, 20, 56]

Appendix C

Color connotation survey

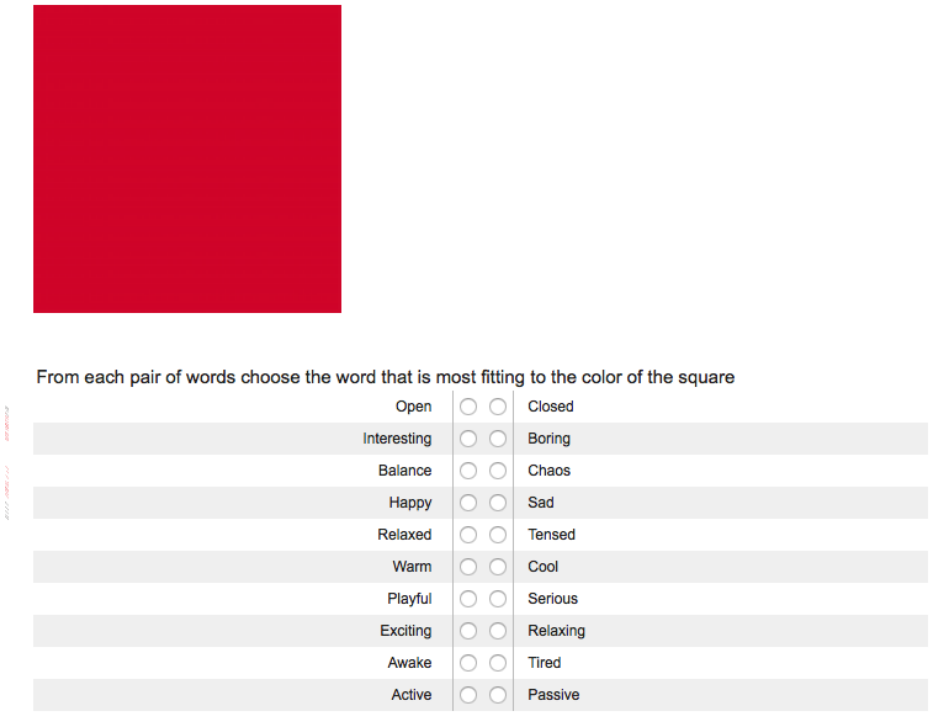

Figure C.1: Example question of the color connotation survey

For each of the ten munsell hue colors the **Color chip questions** will be asked, after the connotation question a question on a different subject will be asked.

Color chip question From each pair of words choose the word that is most fitting to the color of the square

- Awake vs Tired
- Warm vs Cool
- Exciting vs Relaxing

- Happy vs Sad
- Active vs Passive
- Relaxed vs Tensed
- Playful vs Serious
- Interesting vs Boring
- Open vs Closed
- Balance vs Chaos

1. Are you a student?
    - If yes let them continue the survey
    - I no, skip to end of the survey
2. **Color chip question**: Red
3. What is your current education level?
    - Attending higher education (Dutch: HBO)
    - Completed higher education
    - Attending bachelor student
    - Completed bachelor's degree
    - Attending a pre-master student
    - Attending master student
4. **Color chip question**: Orange
5. What study are you attending?
6. **Color chip question**: Yellow
7. How old are you?
8. **Color chip question**: Green-yellow
9. What is your gender?
    - Male
    - Female
    - I'd rather not say

10. **Color chip question**: Green
11. What was the primary culture in which you grew up? (For example: Thai, South Korean, Mexican, Anglo-American, Swedish, African-American, Russian, Dutch, German, etc. This is likely to be the same as your country of origin unless your childhood household embraced a culture different from the predominant one in your country of origin.)
12. **Color chip question**: Blue-green
13. Did you know that apples float? They float because they consist of 25 percent air
    - Yes
    - No
14. **Color chip question**: Blue
15. Would you like another fun fact?
    - 5-point scale only skip the last fun fact if the answer is definitely not
16. **Color chip question**: Purple-blue
17. Did you know that a strawberry is not an actual berry?
    - Yes
    - No
18. **Color chip question**: Purple
19. A banana on the other hand is a berry!
20. **Color chip question**: Pink

Appendix D

Color connotation survey results

Red connotation statistics

Field	Mean	Std Deviation	Variance
Awake:Tired	1.32	0.47	0.22
Warm:Cool	1.03	0.18	0.03
Exciting:Relaxing	1.17	0.38	0.14
Happy:Sad	1.35	0.48	0.23
Active:Passive	1.29	0.45	0.20
Relaxed:Tensed	1.89	0.31	0.10
Playful:Serious	1.62	0.49	0.24
Interesting:Boring	1.17	0.38	0.14
Open:Closed	1.68	0.47	0.22
Balance:Chaos	1.71	0.45	0.20

Figure D.1: Statistical results of the color connotation survey for the color Red

Orange connotation statistics

Field	Mean	Std Deviation	Variance
Awake:Tired	1.21	0.41	0.17
Warm:Cool	1.05	0.22	0.05
Exciting:Relaxing	1.37	0.48	0.23
Happy:Sad	1.05	0.22	0.05
Active:Passive	1.28	0.45	0.20
Relaxed:Tensed	1.39	0.49	0.24
Playful:Serious	1.05	0.22	0.05
Interesting:Boring	1.19	0.39	0.16
Open:Closed	1.14	0.35	0.12
Balance:Chaos	1.32	0.46	0.22

Figure D.2: Statistical results of the color connotation survey for the color Orange

Yellow connotation statistics

Field	Mean	Std Deviation	Variance
Awake:Tired	1.07	0.26	0.07
Warm:Cool	1.33	0.47	0.22
Exciting:Relaxing	1.05	0.23	0.05
Happy:Sad	1.00	0.00	0.00
Active:Passive	1.16	0.37	0.14
Relaxed:Tensed	1.65	0.48	0.23
Playful:Serious	1.02	0.13	0.02
Interesting:Boring	1.24	0.42	0.18
Open:Closed	1.15	0.35	0.12
Balance:Chaos	1.67	0.47	0.22

Figure D.3: Statistical results of the color connotation survey for the color Yellow

Green-yellow connotation statistics

Field	Mean	Std Deviation	Variance
Awake:Tired	1.51	0.50	0.25
Warm:Cool	1.47	0.50	0.25
Exciting:Relaxing	1.81	0.39	0.15
Happy:Sad	1.40	0.49	0.24
Active:Passive	1.74	0.44	0.19
Relaxed:Tensed	1.21	0.41	0.16
Playful:Serious	1.58	0.49	0.24
Interesting:Boring	1.49	0.50	0.25
Open:Closed	1.30	0.46	0.21
Balance:Chaos	1.06	0.23	0.05

Figure D.4: Statistical results of the color connotation survey for the color Green-yellow

Green connotation statistics

Field	Mean	Std Deviation	Variance
Awake:Tired	1.30	0.46	0.21
Warm:Cool	1.70	0.46	0.21
Exciting:Relaxing	1.58	0.49	0.24
Happy:Sad	1.09	0.29	0.09
Active:Passive	1.45	0.50	0.25
Relaxed:Tensed	1.21	0.41	0.16
Playful:Serious	1.43	0.50	0.25
Interesting:Boring	1.26	0.44	0.19
Open:Closed	1.25	0.43	0.19
Balance:Chaos	1.09	0.29	0.09

Figure D.5: Statistical results of the color connotation survey for the color Green

Blue-green connotation statistics

Field	Mean	Std Deviation	Variance
Awake:Tired	1.34	0.47	0.22
Warm:Cool	1.94	0.23	0.05
Exciting:Relaxing	1.68	0.47	0.22
Happy:Sad	1.23	0.42	0.18
Active:Passive	1.55	0.50	0.25
Relaxed:Tensed	1.17	0.38	0.14
Playful:Serious	1.40	0.49	0.24
Interesting:Boring	1.23	0.42	0.18
Open:Closed	1.17	0.38	0.14
Balance:Chaos	1.13	0.34	0.11

Figure D.6: Statistical results of the color connotation survey for the color Blue-green

Blue connotation statistics

Field	Mean	Std Deviation	Variance
Awake:Tired	1.13	0.34	0.11
Warm:Cool	1.94	0.23	0.05
Exciting:Relaxing	1.45	0.50	0.25
Happy:Sad	1.23	0.42	0.18
Active:Passive	1.30	0.46	0.21
Relaxed:Tensed	1.28	0.45	0.20
Playful:Serious	1.36	0.48	0.23
Interesting:Boring	1.28	0.45	0.20
Open:Closed	1.17	0.38	0.14
Balance:Chaos	1.13	0.34	0.11

Figure D.7: Statistical results of the color connotation survey for the color Blue

Purple-blue connotation statistics

Field	Mean	Std Deviation	Variance
Awake:Tired	1.30	0.46	0.21
Warm:Cool	1.91	0.29	0.09
Exciting:Relaxing	1.30	0.46	0.21
Happy:Sad	1.57	0.50	0.25
Active:Passive	1.36	0.48	0.23
Relaxed:Tensed	1.60	0.49	0.24
Playful:Serious	1.70	0.46	0.21
Interesting:Boring	1.26	0.44	0.19
Open:Closed	1.60	0.49	0.24
Balance:Chaos	1.49	0.50	0.25

Figure D.8: Statistical results of the color connotation survey for the color Purple-blue

Purple connotation statistics

Field	Mean	Std Deviation	Variance
Awake:Tired	1.77	0.42	0.18
Warm:Cool	1.58	0.49	0.24
Exciting:Relaxing	1.79	0.41	0.16
Happy:Sad	1.64	0.48	0.23
Active:Passive	1.77	0.42	0.18
Relaxed:Tensed	1.32	0.47	0.22
Playful:Serious	1.72	0.45	0.20
Interesting:Boring	1.62	0.48	0.23
Open:Closed	1.68	0.47	0.22
Balance:Chaos	1.23	0.42	0.18

Figure D.9: Statistical results of the color connotation survey for the color Purple

Pink connotation statistics

Field	Mean	Std Deviation	Variance
Awake:Tired	1.06	0.23	0.05
Warm:Cool	1.25	0.43	0.19
Exciting:Relaxing	1.08	0.26	0.07
Happy:Sad	1.06	0.23	0.05
Active:Passive	1.06	0.23	0.05
Relaxed:Tensed	1.74	0.44	0.19
Playful:Serious	1.02	0.14	0.02
Interesting:Boring	1.06	0.23	0.05
Open:Closed	1.15	0.36	0.13
Balance:Chaos	1.87	0.34	0.11

Figure D.10: Statistical results of the color connotation survey for the color Pink

Appendix E

UTAUT survey

- What is your gender?
- What is your age?
- Performance Expectancy (PE):
    1. I find the lighting system useful
    2. Using the lighting system will enable me to accomplish tasks more quickly
    3. Using the lighting system will increase my productivity
    4. I find the lights at the entrances useful
    5. I finds the lights in the room useful
- Effort Expectancy (EE):
    1. My interaction with the lighting system is clear and understandable
    2. It will be easy for me to become skillful at using the lighting system
    3. I find the lighting system easy to use
    4. Learning to interpret the lighting system is easy for me
- Attitude towards the light system (ATUT):
    1. Using the lighting system is a good idea
    2. The lighting system will make working in the SmartXp more interesting
    3. Working with the lighting system is fun
    4. I like working with the lighting system on
    5. I like that the lighting system shows me if I can use the entrances
- Social Influence (SI):

1. People who are important to me think that I should act as the lighting system suggests
2. The instructor of this course has been helpful in the use of the system
3. In general, the study of Creative Technology has supported the use of the lighting system
4. When there is a lecture in the SmartXp I would act as the lighting system suggests

- Facilitating Conditions (FC):
  1. I have the resources necessary to use the lighting system
  2. The lighting system is compatible with other systems I use
  3. I have the knowledge necessary to use the lighting system
  4. A specific person is available for assistance with the lighting system
  5. The instructions for the use of the lighting system are clear
- Self-efficacy (SE):
  1. I would know how to interact with this system if...
     - there was no one around to tell me how to act
     - there was a help tool with the instructions
     - there was someone around to instruct me
- Anxiety (ANX):
  1. I feel apprehensive about the lighting system
  2. The lighting system is intimidating to me
  3. I feel anxious that the lighting system will influence my work
- Behavioral Intention (BI):
  1. I plan to interact with the lighting system in the next 2 months
  2. I predict I would act as the lighting system indicates the next (college) year
  3. I intend to act as the lighting system indicates during the remaining years of my bachelor Creative Technology
- Actual Usage (USE):
  1. Have you interacted with the system?

  - Yes
  - Not, not yet
  - No, I don't intend to

2. Elaborate on the previous answer

- Feedback (FB):

1. Do you have feedback, tips or additional information concerning the lighting system?

Appendix F

UTAUT linear regression results, dependent construct: BI

Descriptive Statistics

	Mean	Std. Deviation	N
BI	2.9167	1.03295	52
PE	2.8654	.95525	52
EE	2.4663	.81804	52
ATUT	2.5462	.97909	52
SI	2.9231	.74019	52
FC	2.4885	.81014	52
ANX	3.9231	.99589	52
USE	1.79	.696	52
SE	1.85	.573	52
Gender	1.40	.534	52
Age	1.85	1.144	52

Figure F.1: Descriptive statistics

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	PE	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	EE	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	USE	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: BI

Figure F.2: Correlations

Correlations

		BI	PE	EE	ATUT	SI	FC	ANX	USE	SE	Gender	Age
Pearson Correlation	BI	1.000	.721	.592	.628	.671	.467	-.133	.366	.055	.122	-.066
	PE	.721	1.000	.429	.844	.742	.224	-.190	.098	-.117	.040	-.134
	EE	.592	.429	1.000	.414	.487	.709	-.314	.297	.375	.077	.062
	ATUT	.628	.844	.414	1.000	.740	.375	-.270	.150	-.113	.170	-.200
	SI	.671	.742	.487	.740	1.000	.322	-.263	.244	.052	.055	-.089
	FC	.467	.224	.709	.375	.322	1.000	-.319	.361	.334	.152	.057
	ANX	-.133	-.190	-.314	-.270	-.263	-.319	1.000	-.052	.048	.023	.041
	USE	.366	.098	.297	.150	.244	.361	-.052	1.000	.212	-.029	.057
	SE	.055	-.117	.375	-.113	.052	.334	.048	.212	1.000	.015	.023
	Gender	.122	.040	.077	.170	.055	.152	.023	-.029	.015	1.000	-.314
	Age	-.066	-.134	.062	-.200	-.089	.057	.041	.057	.023	-.314	1.000
Sig. (1-tailed)	BI	.	.000	.000	.000	.000	.000	.173	.004	.349	.195	.320
	PE	.000	.	.001	.000	.000	.055	.089	.245	.204	.390	.172
	EE	.000	.001	.	.001	.000	.000	.012	.016	.003	.295	.330
	ATUT	.000	.000	.001	.	.000	.003	.027	.144	.213	.114	.078
	SI	.000	.000	.000	.000	.	.010	.030	.041	.356	.348	.264
	FC	.000	.055	.000	.003	.010	.	.011	.004	.008	.142	.343
	ANX	.173	.089	.012	.027	.030	.011	.	.356	.369	.437	.386
	USE	.004	.245	.016	.144	.041	.004	.356	.	.066	.418	.344
	SE	.349	.204	.003	.213	.356	.008	.369	.066	.	.459	.436
	Gender	.195	.390	.295	.114	.348	.142	.437	.418	.459	.	.012
	Age	.320	.172	.330	.078	.264	.343	.386	.344	.436	.012	.
N	BI	52	52	52	52	52	52	52	52	52	52	52
	PE	52	52	52	52	52	52	52	52	52	52	52
	EE	52	52	52	52	52	52	52	52	52	52	52
	ATUT	52	52	52	52	52	52	52	52	52	52	52
	SI	52	52	52	52	52	52	52	52	52	52	52
	FC	52	52	52	52	52	52	52	52	52	52	52
	ANX	52	52	52	52	52	52	52	52	52	52	52
	USE	52	52	52	52	52	52	52	52	52	52	52
	SE	52	52	52	52	52	52	52	52	52	52	52
	Gender	52	52	52	52	52	52	52	52	52	52	52
	Age	52	52	52	52	52	52	52	52	52	52	52

Figure F.3: Variables Stepwise analysis

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	PE	EE	USE
1	1	1.950	1.000	.03	.03		
	2	.050	6.219	.97	.97		
2	1	2.896	1.000	.01	.01	.01	
	2	.056	7.202	.00	.75	.68	
	3	.048	7.744	.99	.24	.31	
3	1	3.797	1.000	.00	.01	.00	.01
	2	.107	5.960	.00	.23	.03	.72
	3	.054	8.421	.08	.30	.97	.03
	4	.042	9.482	.91	.47	.00	.24

a. Dependent Variable: BI

Figure F.4: Collinearity diagnostics

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.3077	4.8513	2.9167	.84225	52
Residual	-1.43680	1.29726	.00000	.59800	52
Std. Predicted Value	-1.910	2.297	.000	1.000	52
Std. Residual	-2.331	2.105	.000	.970	52

a. Dependent Variable: BI

Figure F.5: Residual statistics

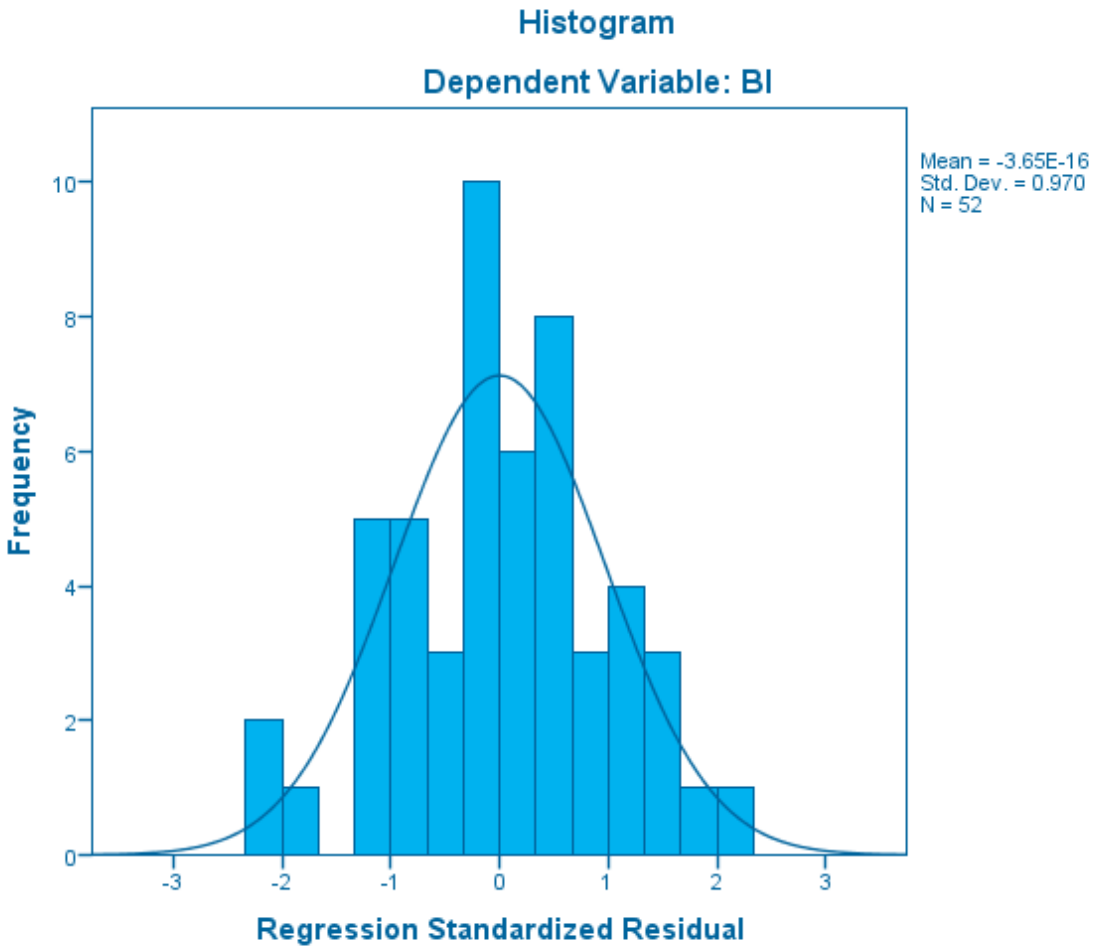

Figure F.6: Normal histogram

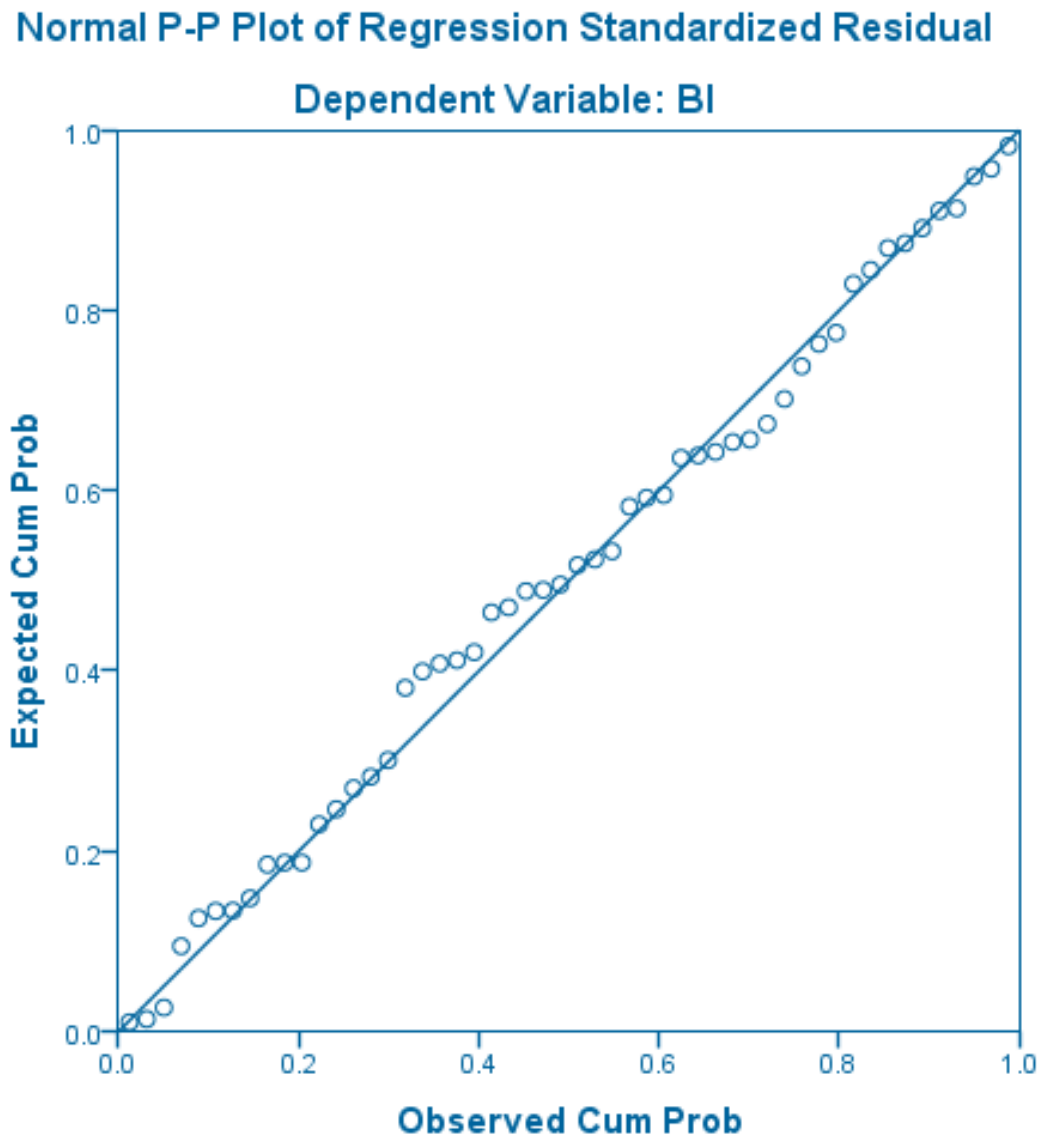

Figure F.7: Standardized residual P-P Plot

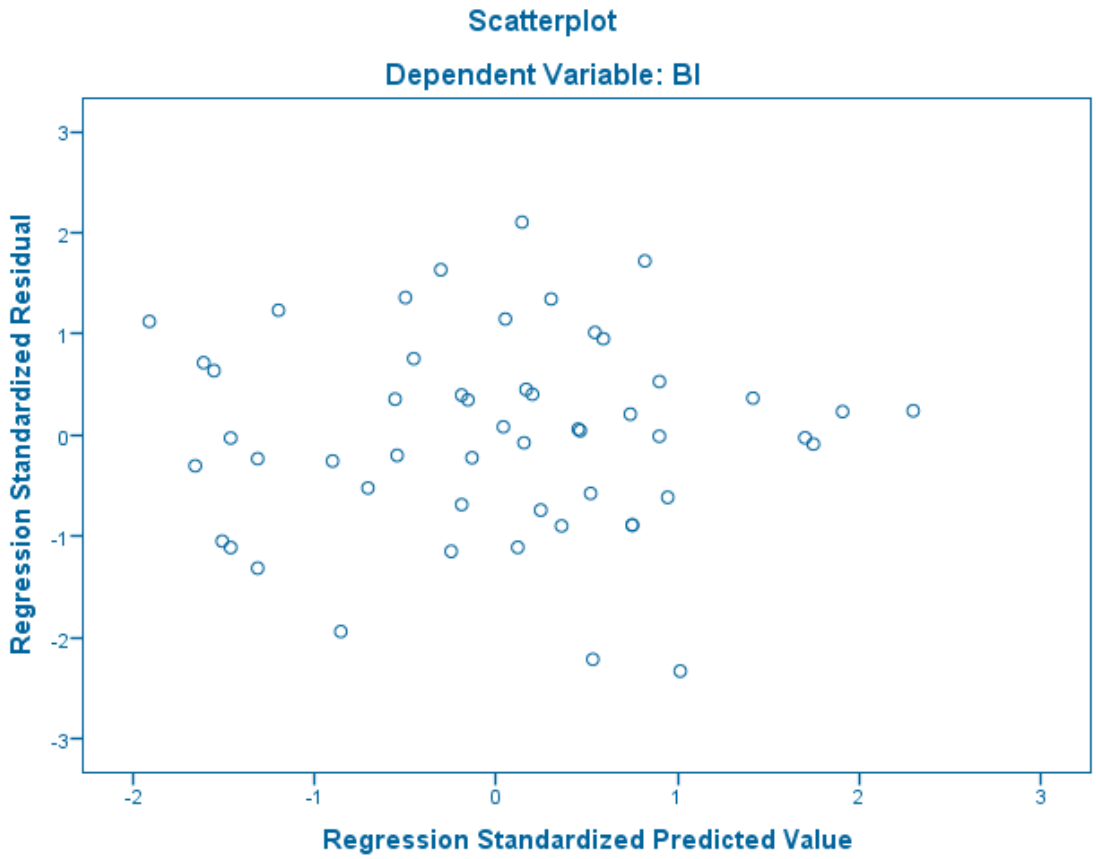

Figure F.8: Standardized residual scatterplot

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.721[a]	.520	.510	.72289	.520	54.134	1	50	.000	
2	.786[b]	.618	.602	.65154	.098	12.550	1	49	.001	
3	.815[c]	.665	.644	.61641	.047	6.745	1	48	.012	2.268

a. Predictors: (Constant), PE

b. Predictors: (Constant), PE, EE

c. Predictors: (Constant), PE, EE, USE

d. Dependent Variable: BI

Figure F.9: Model summary

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	28.288	1	28.288	54.134	.000[b]
	Residual	26.128	50	.523		
	Total	54.417	51			
2	Regression	33.616	2	16.808	39.595	.000[c]
	Residual	20.801	49	.425		
	Total	54.417	51			
3	Regression	36.179	3	12.060	31.739	.000[d]
	Residual	18.238	48	.380		
	Total	54.417	51			

a. Dependent Variable: BI

b. Predictors: (Constant), PE

c. Predictors: (Constant), PE, EE

d. Predictors: (Constant), PE, EE, USE

Figure F.10: ANOVA

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.683	.320		2.135	.038	.040	1.325					
	PE	.780	.106	.721	7.358	.000	.567	.992	.721	.721	.721	1.000	1.000
2	(Constant)	.065	.337		.192	.849	-.612	.742					
	PE	.619	.106	.572	5.851	.000	.406	.831	.721	.641	.517	.816	1.226
	EE	.437	.123	.346	3.543	.001	.189	.686	.592	.452	.313	.816	1.226
3	(Constant)	-.343	.355		-.966	.339	-1.058	.371					
	PE	.628	.100	.581	6.270	.000	.426	.829	.721	.671	.524	.815	1.228
	EE	.348	.122	.275	2.852	.006	.103	.593	.592	.381	.238	.750	1.334
	USE	.338	.130	.227	2.597	.012	.076	.599	.366	.351	.217	.910	1.098

a. Dependent Variable: BI

Figure F.11: Coefficients

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	EE	.346[b]	3.543	.001	.452	.816	1.226	.816
	ATUT	.066[b]	.357	.723	.051	.287	3.478	.287
	SI	.303[b]	2.143	.037	.293	.449	2.226	.449
	FC	.321[b]	3.541	.001	.451	.950	1.053	.950
	ANX	.003[b]	.035	.972	.005	.964	1.037	.964
	USE	.298[b]	3.320	.002	.429	.990	1.010	.990
	SE	.142[b]	1.452	.153	.203	.986	1.014	.986
	Gender	.093[b]	.950	.347	.134	.998	1.002	.998
	Age	.031[b]	.310	.758	.044	.982	1.018	.982
2	ATUT	.004[c]	.023	.982	.003	.284	3.518	.280
	SI	.187[c]	1.376	.175	.195	.414	2.414	.414
	FC	.189[c]	1.519	.135	.214	.490	2.041	.421
	ANX	.094[c]	1.004	.321	.143	.898	1.114	.759
	USE	.227[c]	2.597	.012	.351	.910	1.098	.750
	SE	-.010[c]	-.100	.921	-.014	.764	1.309	.632
	Gender	.073[c]	.819	.417	.117	.994	1.006	.812
	Age	-.012[c]	-.128	.898	-.019	.964	1.037	.790
3	ATUT	-.037[d]	-.235	.815	-.034	.281	3.554	.277
	SI	.127[d]	.958	.343	.138	.399	2.507	.399
	FC	.127[d]	1.038	.305	.150	.466	2.146	.419
	ANX	.084[d]	.948	.348	.137	.896	1.116	.698
	SE	-.037[d]	-.385	.702	-.056	.755	1.324	.605
	Gender	.085[d]	1.013	.316	.146	.991	1.009	.745
	Age	-.019[d]	-.225	.823	-.033	.963	1.038	.739

a. Dependent Variable: BI

b. Predictors in the Model: (Constant), PE

c. Predictors in the Model: (Constant), PE, EE

d. Predictors in the Model: (Constant), PE, EE, USE

Figure F.12: Excluded variables

Coefficient Correlations[a]

Model			PE	EE	USE
1	Correlations	PE	1.000		
	Covariances	PE	.011		
2	Correlations	PE	1.000	-.429	
		EE	-.429	1.000	
	Covariances	PE	.011	-.006	
		EE	-.006	.015	
3	Correlations	PE	1.000	-.421	.035
		EE	-.421	1.000	-.284
		USE	.035	-.284	1.000
	Covariances	PE	.010	-.005	.000
		EE	-.005	.015	-.005
		USE	.000	-.005	.017

a. Dependent Variable: BI

Figure F.13: Coefficient correlations

Appendix G

UTAUT linear regression results, dependent construct: USE

Descriptive Statistics

	Mean	Std. Deviation	N
USE	1.79	.696	52
PE	2.8654	.95525	52
EE	2.4663	.81804	52
ATUT	2.5462	.97909	52
SI	2.9231	.74019	52
FC	2.4885	.81014	52
ANX	3.9231	.99589	52
SE	1.85	.573	52
Gender	1.40	.534	52
Age	1.85	1.144	52
BI	2.9167	1.03295	52

Figure G.1: Descriptive statistics

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	1.069	.274		3.904	.000	.519	1.619					
	BI	.247	.089	.366	2.782	.008	.069	.425	.366	.366	.366	1.000	1.000

a. Dependent Variable: USE

Figure G.2: Correlations

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.308	1	3.308	7.741	.008[b]
	Residual	21.365	50	.427		
	Total	24.673	51			

a. Dependent Variable: USE

b. Predictors: (Constant), BI

Figure G.3: Variables Stepwise analysis

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.366[a]	.134	.117	.654	.134	7.741	1	50	.008	2.156

a. Predictors: (Constant), BI

b. Dependent Variable: USE

Figure G.4: Collinearity diagnostics

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	BI	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: USE

Figure G.5: Residual statistics

Correlations

		USE	PE	EE	ATUT	SI	FC	ANX	SE	Gender	Age	BI
Pearson Correlation	USE	1.000	.098	.297	.150	.244	.361	-.052	.212	-.029	.057	.366
	PE	.098	1.000	.429	.844	.742	.224	-.190	-.117	.040	-.134	.721
	EE	.297	.429	1.000	.414	.487	.709	-.314	.375	.077	.062	.592
	ATUT	.150	.844	.414	1.000	.740	.375	-.270	-.113	.170	-.200	.628
	SI	.244	.742	.487	.740	1.000	.322	-.263	.052	.055	-.089	.671
	FC	.361	.224	.709	.375	.322	1.000	-.319	.334	.152	.057	.467
	ANX	-.052	-.190	-.314	-.270	-.263	-.319	1.000	.048	.023	.041	-.133
	SE	.212	-.117	.375	-.113	.052	.334	.048	1.000	.015	.023	.055
	Gender	-.029	.040	.077	.170	.055	.152	.023	.015	1.000	-.314	.122
	Age	.057	-.134	.062	-.200	-.089	.057	.041	.023	-.314	1.000	-.066
	BI	.366	.721	.592	.628	.671	.467	-.133	.055	.122	-.066	1.000
Sig. (1-tailed)	USE	.	.245	.016	.144	.041	.004	.356	.066	.418	.344	.004
	PE	.245	.	.001	.000	.000	.055	.089	.204	.390	.172	.000
	EE	.016	.001	.	.001	.000	.000	.012	.003	.295	.330	.000
	ATUT	.144	.000	.001	.	.000	.003	.027	.213	.114	.078	.000
	SI	.041	.000	.000	.000	.	.010	.030	.356	.348	.264	.000
	FC	.004	.055	.000	.003	.010	.	.011	.008	.142	.343	.000
	ANX	.356	.089	.012	.027	.030	.011	.	.369	.437	.386	.173
	SE	.066	.204	.003	.213	.356	.008	.369	.	.459	.436	.349
	Gender	.418	.390	.295	.114	.348	.142	.437	.459	.	.012	.195
	Age	.344	.172	.330	.078	.264	.343	.386	.436	.012	.	.320
	BI	.004	.000	.000	.000	.000	.000	.173	.349	.195	.320	.
N	USE	52	52	52	52	52	52	52	52	52	52	52
	PE	52	52	52	52	52	52	52	52	52	52	52
	EE	52	52	52	52	52	52	52	52	52	52	52
	ATUT	52	52	52	52	52	52	52	52	52	52	52
	SI	52	52	52	52	52	52	52	52	52	52	52
	FC	52	52	52	52	52	52	52	52	52	52	52
	ANX	52	52	52	52	52	52	52	52	52	52	52
	SE	52	52	52	52	52	52	52	52	52	52	52
	Gender	52	52	52	52	52	52	52	52	52	52	52
	Age	52	52	52	52	52	52	52	52	52	52	52
	BI	52	52	52	52	52	52	52	52	52	52	52

Figure G.6: Normal histogram

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.32	2.30	1.79	.255	52
Residual	-1.056	1.684	.000	.647	52
Std. Predicted Value	-1.856	2.017	.000	1.000	52
Std. Residual	-1.615	2.576	.000	.990	52

a. Dependent Variable: USE

Figure G.7: Standardized residual P-P Plot

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions	
				(Constant)	BI
1	1	1.944	1.000	.03	.03
	2	.056	5.873	.97	.97

a. Dependent Variable: USE

Figure G.8: Standardized residual scatterplot

Coefficient Correlations[a]

Model			BI
1	Correlations	BI	1.000
	Covariances	BI	.008

a. Dependent Variable: USE

Figure G.9: Model summary

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	PE	-.346[b]	-1.866	.068	-.258	.480	2.083	.480
	EE	.124[b]	.756	.453	.107	.649	1.540	.649
	ATUT	-.132[b]	-.776	.442	-.110	.606	1.650	.606
	SI	-.003[b]	-.018	.985	-.003	.550	1.819	.550
	FC	.243[b]	1.662	.103	.231	.782	1.278	.782
	ANX	-.003[b]	-.026	.979	-.004	.982	1.018	.982
	SE	.192[b]	1.475	.147	.206	.997	1.003	.997
	Gender	-.075[b]	-.562	.576	-.080	.985	1.015	.985
	Age	.082[b]	.614	.542	.087	.996	1.004	.996

a. Dependent Variable: USE

b. Predictors in the Model: (Constant), BI

Figure G.10: ANOVA

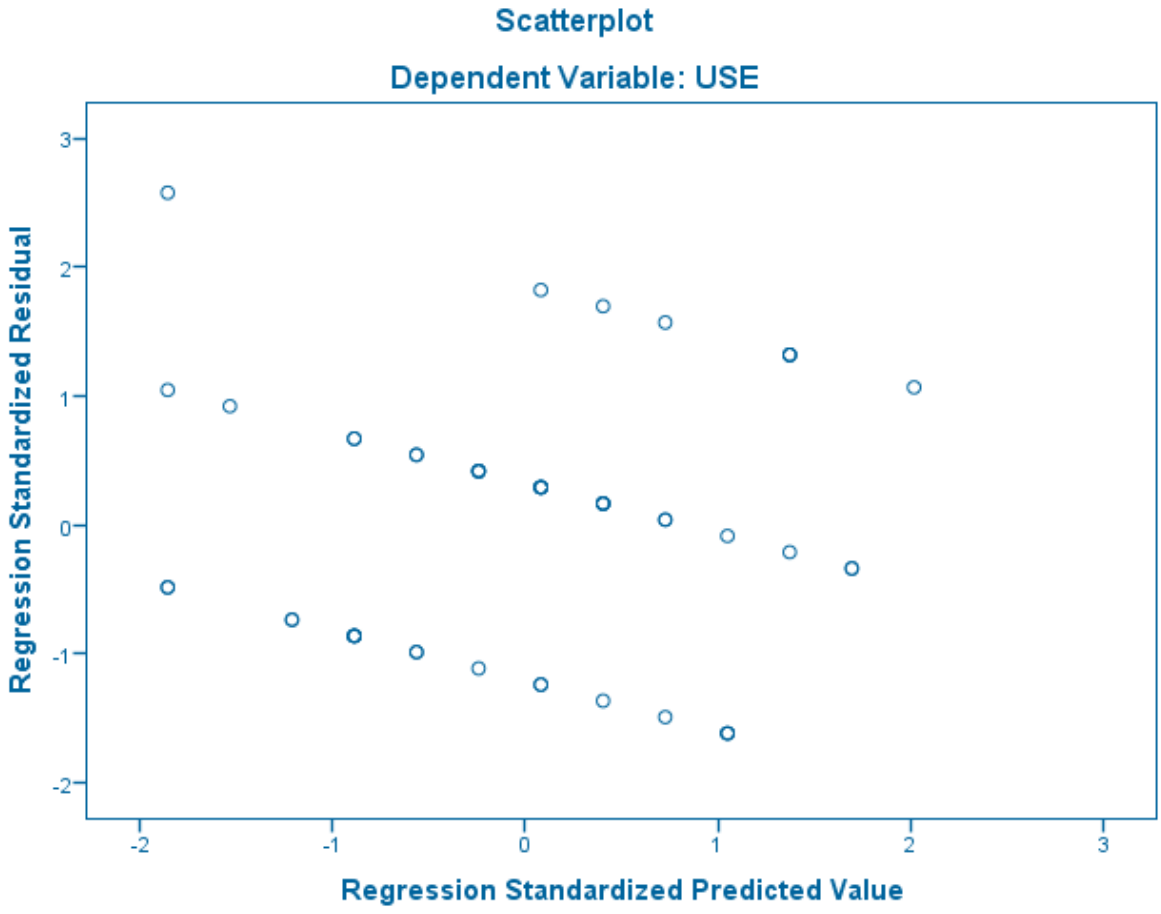

Figure G.11: Coefficients

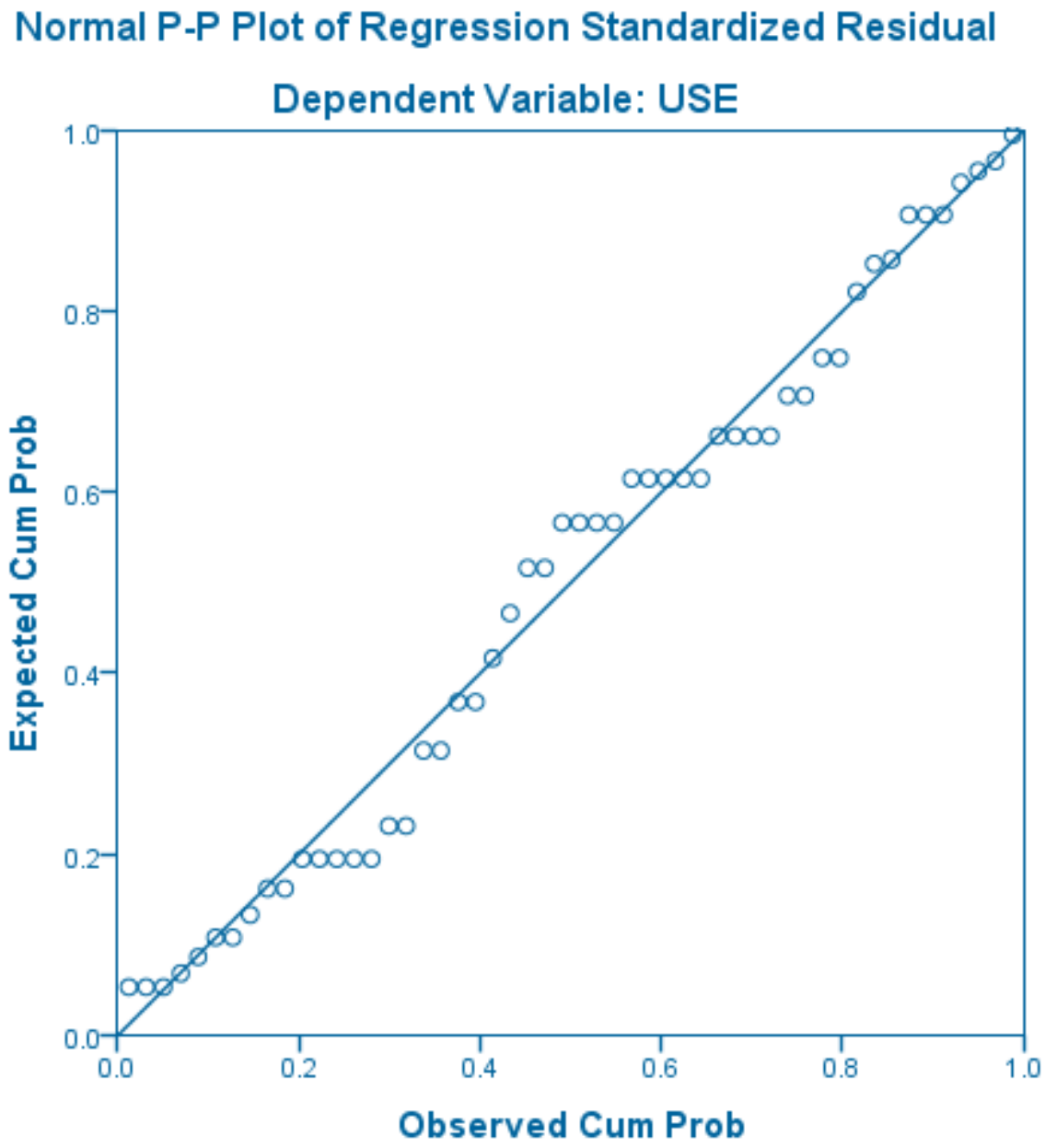

Figure G.12: Excluded variables

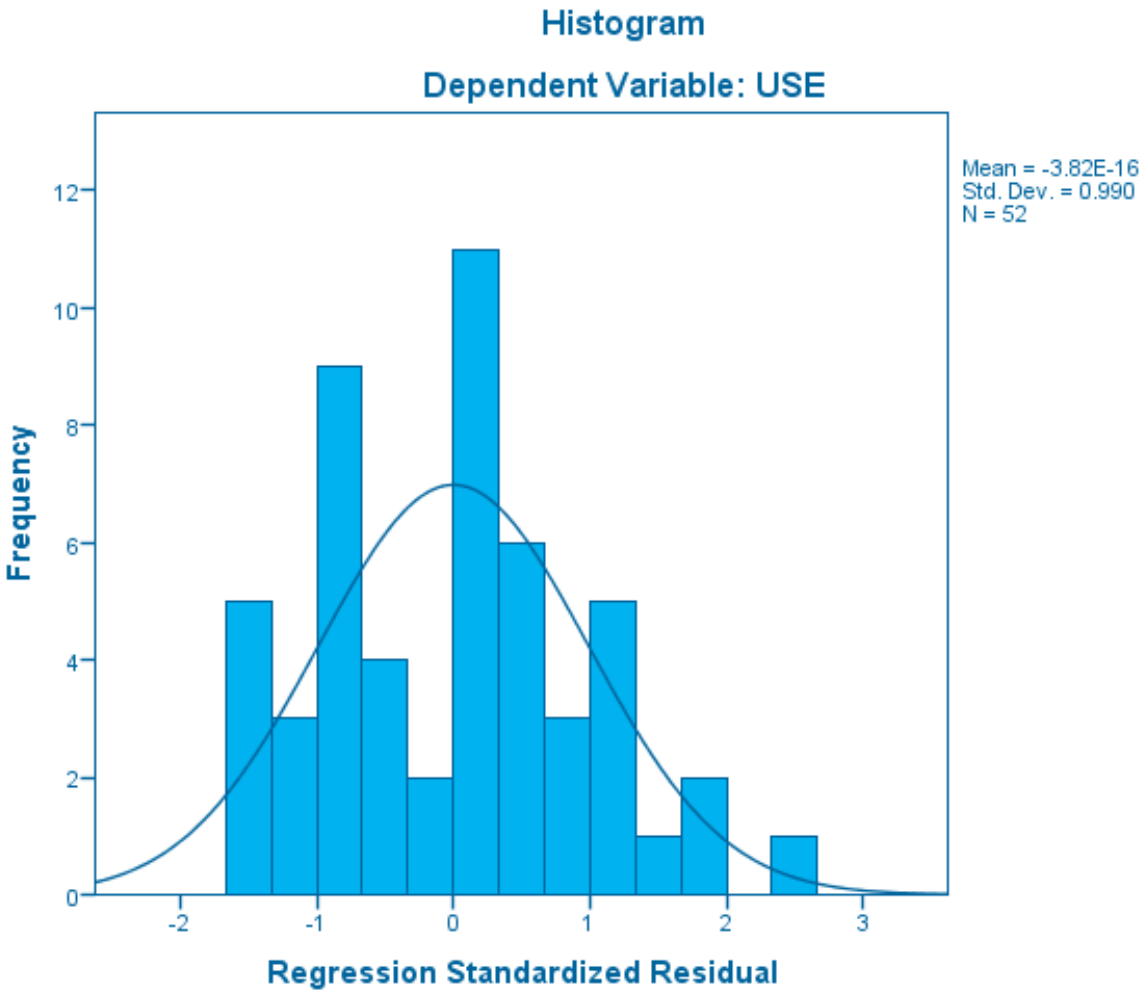

Figure G.13: Coefficient correlations

Appendix H

UTAUT path analysis

Sample Correlations (Group number 1)

	USE	BI_3	BI_2	BI_1	PE_1	PE_2	PE_3	PE_4	PE_5	FC_1	FC_2	FC_3	FC_4	FC_5
USE	1.000													
BI_3	.205	1.000												
BI_2	.260	.730	1.000											
BI_1	.419	.427	.488	1.000										
PE_1	.263	.642	.580	.389	1.000									
PE_2	.092	.593	.540	.345	.606	1.000								
PE_3	.022	.658	.510	.361	.600	.818	1.000							
PE_4	-.125	.556	.380	.313	.527	.497	.493	1.000						
PE_5	.185	.639	.711	.364	.735	.589	.574	.464	1.000					
FC_1	.359	.256	.334	.459	.310	.045	.044	.222	.180	1.000				
FC_2	.256	.150	.145	.216	.286	.085	.093	.033	.129	.584	1.000			
FC_3	.398	.111	.283	.439	.164	.008	-.060	-.027	.118	.755	.440	1.000		
FC_4	.045	.226	.164	.154	.168	.175	.163	.101	.203	.277	.273	.260	1.000	
FC_5	.278	.302	.424	.557	.255	.119	.103	.316	.249	.698	.340	.691	.248	1.000
ANX_1	-.118	-.274	-.258	-.072	-.397	-.041	-.064	-.183	-.346	-.413	-.173	-.350	-.123	-.333
ANX_2	-.004	-.192	-.233	.031	-.359	.000	-.055	-.192	-.418	-.319	-.140	-.220	-.196	-.259
ANX_3	-.016	.050	-.102	.086	-.220	.175	.209	.052	-.233	-.138	-.148	-.197	-.133	-.028
SI_1	.114	.547	.460	.369	.445	.583	.491	.579	.544	.130	.033	.144	.171	.251
SI_2	.106	.476	.392	.471	.415	.506	.406	.366	.436	.116	.051	.168	.035	.390
SI_3	.160	.446	.198	.209	.361	.218	.324	.293	.282	.216	.120	-.024	.301	.090
SI_4	.326	.539	.508	.354	.710	.537	.462	.367	.531	.253	.243	.212	.294	.346
ATUT_1	.195	.691	.690	.368	.830	.666	.665	.512	.683	.311	.211	.119	.254	.338
ATUT_2	.261	.512	.399	.320	.592	.683	.635	.417	.440	.303	.343	.173	.314	.158
ATUT_3	.146	.418	.272	.238	.556	.488	.509	.424	.473	.311	.395	.130	.356	.225
ATUT_4	-.061	.509	.420	.257	.582	.556	.683	.538	.473	.258	.242	.030	.483	.293
ATUT_5	.066	.686	.480	.377	.576	.587	.531	.713	.468	.182	.035	.048	.111	.303
EE_1	.327	.526	.414	.423	.438	.322	.355	.461	.450	.542	.317	.366	.314	.517
EE_2	.334	.309	.390	.533	.320	.212	.261	.302	.280	.504	.103	.513	.161	.605
EE_3	.238	.454	.503	.367	.299	.111	.121	.275	.512	.527	.218	.491	.331	.540
EE_4	-.056	.013	.133	.219	.135	-.063	.004	.097	.096	.382	.297	.424	.225	.509

	ANX_1	ANX_2	ANX_3	SI_1	SI_2	SI_3	SI_4	ATUT_1	ATUT_2	ATUT_3	ATUT_4	ATUT_5	EE_1	EE_2	EE_3	EE_4
USE																
BI_3																
BI_2																
BI_1																
PE_1																
PE_2																
PE_3																
PE_4																
PE_5																
FC_1																
FC_2																
FC_3																
FC_4																
FC_5																
ANX_1	1.000															
ANX_2	.816	1.000														
ANX_3	.577	.627	1.000													
SI_1	-.214	-.145	-.161	1.000												
SI_2	-.037	-.017	.104	.582	1.000											
SI_3	-.186	-.253	-.200	.454	.304	1.000										
SI_4	-.414	-.256	-.213	.464	.248	.227	1.000									
ATUT_1	-.475	-.431	-.157	.484	.391	.365	.753	1.000								
ATUT_2	-.150	-.091	.133	.480	.354	.399	.538	.663	1.000							
ATUT_3	-.248	-.311	-.119	.402	.245	.517	.489	.547	.657	1.000						
ATUT_4	-.265	-.300	-.110	.399	.173	.400	.548	.710	.579	.722	1.000					
ATUT_5	-.340	-.209	.045	.574	.463	.272	.593	.691	.564	.411	.439	1.000				
EE_1	-.162	-.120	.077	.383	.392	.401	.461	.388	.324	.376	.353	.302	1.000			
EE_2	-.247	-.319	-.015	.294	.382	.233	.323	.413	.298	.204	.242	.306	.498	1.000		
EE_3	-.386	-.396	-.089	.291	.261	.221	.157	.310	.161	.228	.225	.227	.426	.433	1.000	
EE_4	-.409	-.371	-.188	.003	.190	-.039	.159	.231	-.019	.135	.185	.106	.236	.449	.449	1.000

Condition number = 330.157

Eigenvalues
10.924 3.849 2.499 1.760 1.408 1.210 1.004 .836 .803 .736 .658 .579 .528 .471 .376 .359 .339 .276 .238 .211 .191 .153 .130 .107 .101 .064 .061 .059 .036 .033

Figure H.1: Correlation table for the UTAUT model constructs compiled with the AMOS

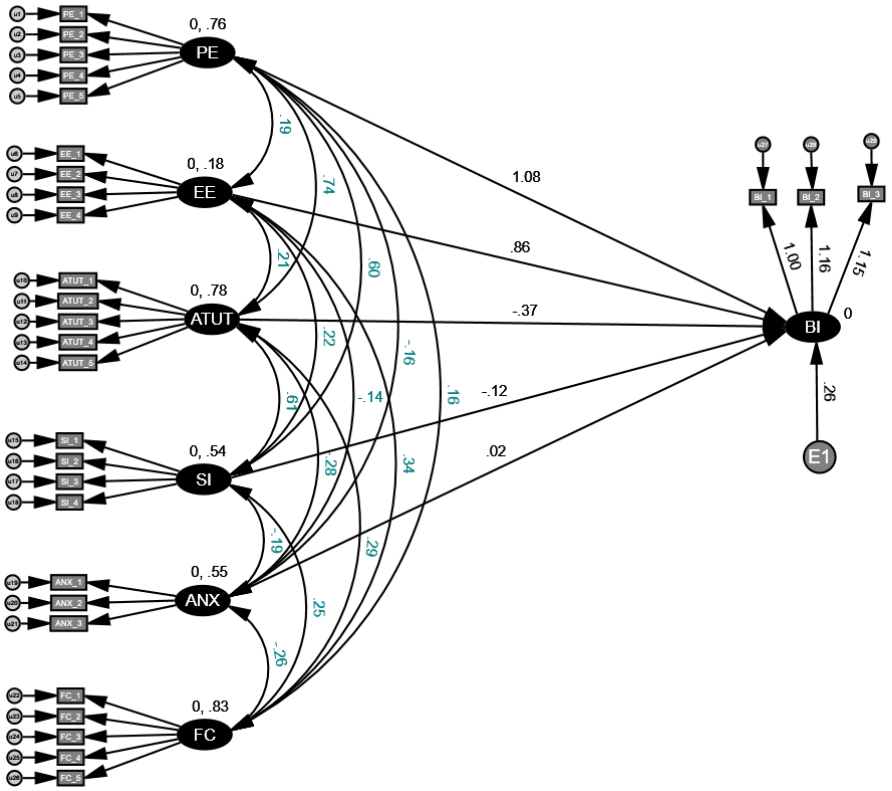

Figure H.2: Coefficient correlations

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
BI	<---	PE	1.076	1.374	.783	.433	par_35
BI	<---	EE	.865	.713	1.214	.225	par_36
BI	<---	ATUT	-.369	.722	-.510	.610	par_37
BI	<---	ANX	.020	.225	.088	.930	par_38
BI	<---	SI	-.124	1.449	-.085	.932	par_39
BI	<---	E1	.264	.151	1.747	.081	par_42
EE_4	<---	EE	1.000				
EE_3	<---	EE	1.744	.565	3.086	.002	par_1
EE_2	<---	EE	1.662	.551	3.014	.003	par_2
EE_1	<---	EE	2.026	.657	3.082	.002	par_3
ATUT_5	<---	ATUT	1.000				
ATUT_4	<---	ATUT	.980	.179	5.477	***	par_4
ATUT_3	<---	ATUT	.900	.185	4.864	***	par_5
ATUT_2	<---	ATUT	1.062	.197	5.391	***	par_6
ATUT_1	<---	ATUT	1.147	.171	6.725	***	par_7
SI_4	<---	SI	1.000				
SI_3	<---	SI	.630	.185	3.400	***	par_8
SI_2	<---	SI	.705	.171	4.120	***	par_9
SI_1	<---	SI	1.000				
ANX_3	<---	ANX	1.000				
ANX_2	<---	ANX	1.366	.259	5.276	***	par_10
ANX_1	<---	ANX	1.352	.258	5.242	***	par_11
FC_5	<---	FC	1.000				
FC_4	<---	FC	.355	.147	2.420	.016	par_12
FC_3	<---	FC	.988	.149	6.640	***	par_13
FC_2	<---	FC	.588	.148	3.972	***	par_14
FC_1	<---	FC	1.106	.148	7.474	***	par_15
PE_5	<---	PE	1.000				
PE_4	<---	PE	.983	.209	4.712	***	par_16
PE_3	<---	PE	1.017	.162	6.277	***	par_17
PE_2	<---	PE	1.081	.173	6.260	***	par_18
PE_1	<---	PE	1.031	.166	6.197	***	par_19
BI_1	<---	BI	1.000				
BI_2	<---	BI	1.164	.271	4.300	***	par_40
BI_3	<---	BI	1.146	.258	4.434	***	par_41

Figure H.3: Coefficient correlations

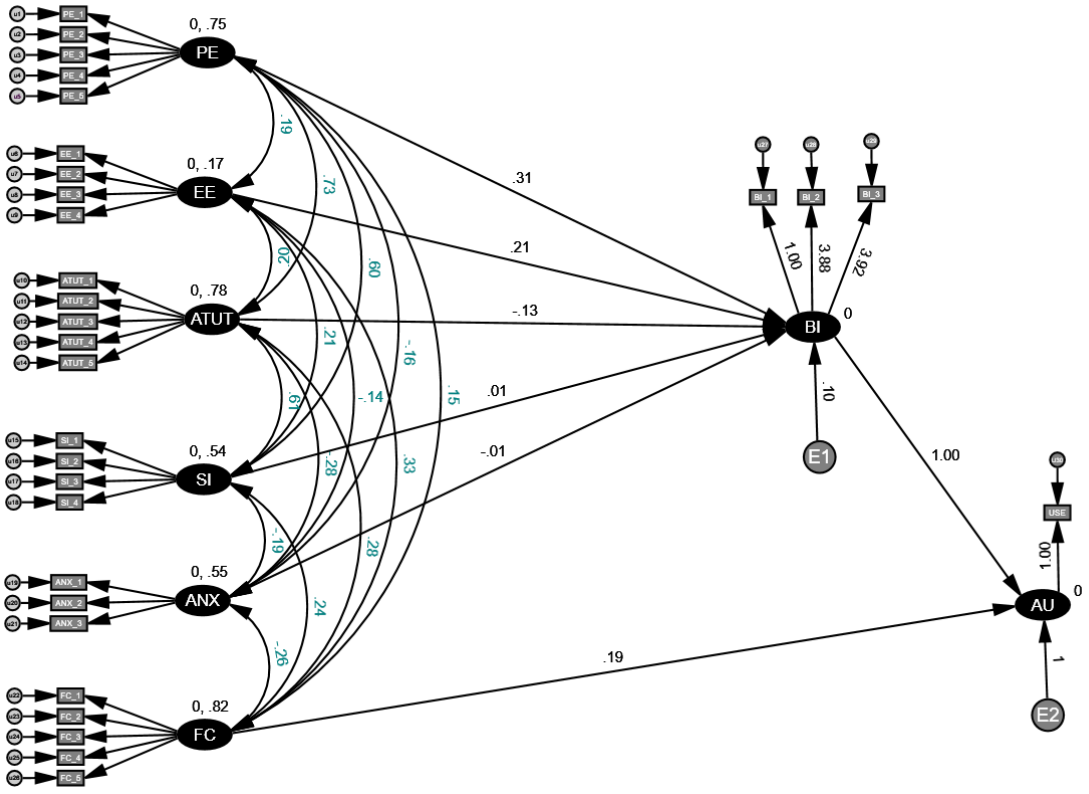

Figure H.4: Coefficient correlations

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
BI	<---	PE	.313	.408	.767	.443	par_35
BI	<---	EE	.208	.218	.952	.341	par_36
BI	<---	ATUT	-.128	.215	-.596	.551	par_37
BI	<---	ANX	-.009	.068	-.135	.893	par_38
BI	<---	SI	.009	.424	.022	.982	par_39
BI	<---	E1	.096	.048	1.977	.048	par_42
AU	<---	BI	1.000				
AU	<---	FC	.194	.115	1.693	.090	par_43
EE_4	<---	EE	1.000				
EE_3	<---	EE	1.783	.595	2.996	.003	par_1
EE_2	<---	EE	1.700	.580	2.930	.003	par_2
EE_1	<---	EE	2.111	.700	3.013	.003	par_3
ATUT_5	<---	ATUT	1.000				
ATUT_4	<---	ATUT	.977	.179	5.469	***	par_4
ATUT_3	<---	ATUT	.898	.185	4.859	***	par_5
ATUT_2	<---	ATUT	1.062	.197	5.399	***	par_6
ATUT_1	<---	ATUT	1.147	.170	6.742	***	par_7
SI_4	<---	SI	1.000				
SI_3	<---	SI	.633	.185	3.417	***	par_8
SI_2	<---	SI	.701	.171	4.097	***	par_9
SI_1	<---	SI	1.000				
ANX_3	<---	ANX	1.000				
ANX_2	<---	ANX	1.359	.258	5.270	***	par_10
ANX_1	<---	ANX	1.358	.259	5.245	***	par_11
FC_5	<---	FC	1.000				
FC_4	<---	FC	.354	.148	2.388	.017	par_12
FC_3	<---	FC	1.001	.151	6.630	***	par_13
FC_2	<---	FC	.598	.149	3.999	***	par_14
FC_1	<---	FC	1.118	.151	7.418	***	par_15
PE_5	<---	PE	1.000				
PE_4	<---	PE	.986	.210	4.701	***	par_16
PE_3	<---	PE	1.020	.163	6.245	***	par_17
PE_2	<---	PE	1.085	.174	6.234	***	par_18
PE_1	<---	PE	1.034	.168	6.170	***	par_19
BI_1	<---	BI	1.000				
BI_2	<---	BI	3.880	1.494	2.597	.009	par_40
BI_3	<---	BI	3.923	1.490	2.633	.008	par_41
USE	<---	AU	1.000				

Appendix I

Volume results

20-06		Section 1	Section 2	Section 3	Section 4
9:45	Average	66.2	66.9	65.1	66.8
	Max	73.4	76.2	72.7	75.2
11:45	Average	65.1	73.0	65.6	65.8
	Max	74.4	76.5	74.6	76.3
13:40	Average	70.7	66.0	69.3	67.2
	Max	74.8	72.2	76.0	81.0
15:21	Average	64.5	67.7	65.0	63.2
	Max	69.1	72.7	71.4	70.5
21-06		**Section 1**	**Section 2**	**Section 3**	**Section 4**
9:45	Average	66.2	64.7	65.5	68.3
	Max	73.4	74.4	74.3	74.6
11:45	Average	63.8	65.6	63.0	62.7
	Max	68.3	75.5	74.3	75.5
13:45	Average	67.8	65.6	63.7	63.1
	Max	77.2	70.4	69.6	67.1
15:45	Average	65.4	65.5	64.6	63.2
	Max	70.8	71.3	69.2	69.5
22-06		**Section 1**	**Section 2**	**Section 3**	**Section 4**
9:45	Average	65.9	68.0	64.6	62.9
	Max	75.4	77.9	72.8	73.4
11:45	Average	64.7	69.4	68.6	68.7
	Max	76.6	84.3	77.6	80.5
13:45	Average	68.9	68.7	67.0	64.5
	Max	74.6	83.7	77.2	78.5
15:45	Average	64.0	67.9	64.0	65.6
	Max	69.9	75.5	69.9	70.7
23-06		**Section 1**	**Section 2**	**Section 3**	**Section 4**
9:45	Average	66.6	67.9	65.3	69.2
	Max	71.5	76.2	71.1	77.6
11:45	Average	66.8	69.1	65.2	66.0
	Max	78.2	84.7	71.8	72.8
13:45	Average	68.4	67.2	65.4	63.8
	Max	75.9	77.1	73.4	72.8
15:45	Average	64.7	66.7	64.3	64.4
	Max	70.4	73.4	69.6	70.1

Figure I.1: Screenshot of the results of dB measurments during week 25

Appendix J

Interview plan

1. **Opening**: What use cases have you overseen in the SmartXp?
    - Summarize the answer and follow-up by naming all the possible educational use cases:
        (a) Lecture
        (b) Tutorials, practicals and colstructure
        (c) Presentations
        (d) Supervised project time
2. **Follow-up** Per use case ask the following questions:
    (a) Which sections of the SmartXp do you use during the use case?
    (b) What behavior do you want to see from the students that attend your the use case?
    (c) What behavior is desired of the other students that are in the SmartXp during the use case?
3. **Closing**: Do you have other remarks about the SmartXp or the lighting system?
    - What do you like about the SmartXp?
    - What in the SmartXp would you change?

Appendix K

Interview 1

K.1 Use cases

K.1.1 Question: What type of educational use cases have you overseen in the SmartXp?

2. Lectures
3. Lectorials/Colstructure
4. Assisted self study
5. Supervised project
6. Demo market
7. Conference

K.2 Lecture

K.2.1 Question: Which sections of the SmartXp do you use during a lecture?

Section 2 and 3.

K.2.2 Question: What behavior do you want to see from the students that attend your lecture?

I need them to be focused, awake and asking questions. Right now the attention span in section 1 is greater than in section 2, and in the back of section 2 there

is the facebook border. Behind the facebook border the attention span is close to zero. Sometimes I walk around to improve the attention in the back. Extra screens in section 2 and extra speakers would help.

K.2.3 Question: What behavior is desired of the other students that are in the SmartXp during a lecture?

During a plenary lecture the whole SmartXp needs to be quiet. Especially section 4, during a lecture there behavior is destructive and distracting. During other use cases it does not really matter. The behavior of students that walk around depend on the group. But during a lecture walking is not a problem when they do it quietly.

K.3 Lectorials and Colstructures

K.3.1 Question: Which sections of the SmartXp do you use during a lectorial/colstruction?

For questions and answers I use section 3. Especially the smartboard in that section is useful. I would like to involve section 2 in this Q and A by displaying the answers that where given in section 3 on screens in section 2. A replay button would be nice.

K.3.2 Question: What behavior do you want to see from the students that attend your lectorial/colstruction?

That the students go sit in the front rows. Section 3 needs to be inviting to them, so they go to the Q and A and ask questions.

K.3.3 Question: What behavior is desired of the other students that are in the SmartXp during a lectorial/colstruction?

When they don't disturb it does not matter. So they can do and sit what and where they want as long as they do it quietly.

K.4 Assisted self study

K.4.1 Question: Which sections of the SmartXp do you use during assisted self study?

The students can sit wherever they like. Only section 4 is less ideal because it is out of sight. But when the older students help the students that attend the self study it would be nice to use section 4 as well.

K.4.2 Question: What behavior do you want to see from the students that attend your assisted self study?

Depends on the content of the self study. During a mathematical self study I can imagine that the students need concentration. With a breadboard Arduino self-study collaboration and self sufficiency is important. Local interaction should be stimulated. Also, the student assistants need to walk around and go to the students that have questions. I noticed that the student assistants tend to sit in a corner in the front and do not notice all the students with questions.

K.4.3 Question: What behavior is desired of the other students that are in the SmartXp during assisted self study?

Same as Question K.3.3.

K.5 Supervised project

K.5.1 Question: Which sections of the SmartXp do you use during supervised project?

The students sit where they want, it depends on what they need for their project, only section 4 is not suitable for project work . But behind the dividers is hard to supervise because they are out of sight. I use section 3 to have meetings with the groups.

K.5.2 Question: What behavior do you want to see from the students that attend your assisted self study?

I want the students to move furniture and sit towards each other, to use a screen and board. Basically to make their own corner. In section 3 there are a lot of meetings following up on each other, it would be nice to have the lights work as a timer, so the meeting group knows they have to wrap it up and the next group knows they have to get to the meeting.

K.5.3 Question: What behavior is desired of the other students that are in the SmartXp during assisted self study?

Does not matter, they can do what they want.

K.6 Demo market

K.6.1 Question: Which sections of the SmartXp do you use during a conference/demo market?

The sections 1 to 3 are used for a demo market. It is hard that there is no plenary welcoming talk. Therefore, a demo market does not have a distinguished start and end.

K.6.2 Question: What behavior do you want to see from the students that attend your conference/demo market?

Depends on the demo market. Walking around and testing other projects is wanted, and to explain your own project if needed.

K.6.3 Question: What behavior is desired of the other students that are in the SmartXp during a conference/demo market?

To walk around and try out the projects.

K.7 Conference

K.7.1 Question: Which sections of the SmartXp do you use during a conference?

During a conference there is often a presentation setup in section 3 and poster presentations in section 1 and 2.

K.7.2 Question: What behavior do you want to see from the people that attend your conference?

You would like to make a clear switch between presentations and time to look at the posters. You could use lounge music, to indicate that the social mixer has started.

K.8 Other remarks about the SmartXp or the lighting system?

I like the SmartXp, it is a flexible and attractive space. The attention span students have in the SmartXp should not be underestimated and could be improved. It is hard to get information from one side to the other. Sometimes the oxygen level in the room is low and the temperature is high. I think the machines the SmartXp has available for usage should be more visible. i.e. the laser cutters and 3d printers. Also Alfred is tucked away in this corner behind closets, I would open this up and give him and the facilities more visibility. The storage of poster boards, installations and other stuff you may use can be improved. It should be easy to grab, but also out of the way when you do not need it.

Appendix L

Interview 2

L.1 Use cases

L.1.1 Question: What type of educational use cases have you overseen in the SmartXp?

2. Lectures

3. Lectorials/Colstructure

6. Demo market

L.2 Lecture

L.2.1 Question: Which sections of the SmartXp do you use during a lecture?

I use section 2 and 3, but I want the students to sit at the front as much as possible.

L.2.2 Question: What behavior do you want to see from the students that attend your lecture?

I want the students to be awake, attentively, focused, directed and them to ask question when they don't understand something. The atmosphere needs to be pleasant and the students need to feel free to ask questions.

L.2.3 Question: What behavior is desired of the other students that are in the SmartXp during a lecture?

They need to be quiet, otherwise they have to sit somewhere else.

L.2.4 Question: Which entrances may be used during a lecture?

Only entrance 1 may be used, for students that need to go to Alfred. Entrance 2 and the stairs need to be of limit.

L.3 Lectorials and Colstructures

L.3.1 Question: Which sections of the SmartXp do you use during a lectorial/colstruction?

The students can sit where they want, if they have questions they can come to the front or raise their hand to get help. The higher the educational year, the more freedom and independence. There should be enough room for the student assistants and the teacher to walk around.

L.3.2 Question: What behavior do you want to see from the students that attend your lectorial/colstruction?

Collaboration is good. The students should be relaxed and feel free to ask questions. Section 3 should be inviting and accessible. Student assistants should actively walk and ask if students need help.

L.3.3 Question: What behavior is desired of the other students that are in the SmartXp during a lectorial/colstruction?

They can talk, but they should not distract.

L.6 Demo market

L.6.1 Question: Which sections of the SmartXp do you use during a conference/demo market?

Depends on the group, if they need to darken their surroundings, etc. Dividers are recommended when the demo session is small.

L.6.2 Question: What behavior do you want to see from the students that attend your conference/demo market?

L.8 Other remarks about the SmartXp or the lighting system?

I like the SmartXp for work lectures, I don't like the theater for lectures. The beamer that made noise was a nuisance, the attention span is lower and the people that walk around are distracting. I like that the SmartXp is the home of Creative Technology, but that also makes this environment a social space for Creative Technology students. Therefore the lecturer is a guest instead of the host. More plants in the SmartXp would be nice and whiteboards for the SmartTech module. I would like to use the smart board more.

Appendix M

Interview 3

M.1 Use cases

M.1.1 Question: What type of educational use cases have you overseen in the SmartXp?

2. Lectures

5. Supervised project

6. Demo market

M.2 Lecture

M.2.1 Question: Which sections of the SmartXp do you use during a lecture?

The lectures I have in the SmartXp facilitate up to 100 students, we then use section 2 and 3.

M.2.2 Question: What behavior do you want to see from the students that attend your lecture?

The should pay attention to the lecture, and should not fall asleep. I like them to react to the questions that I ask and I always ask the students to close their laptops during a lecture.

Question: If the students may not use their laptops, do they still need tables?

Yes, because many student make notes and therefor need a table and enough light to be able to write.

M.2.3 Question: What behavior is desired of the other students that are in the SmartXp during a lecture?

They should make less noise. The usage of entrance 2 is very disturbing, and also the walking around is distracting. They are allowed to be in the SmartXp during a lecture, but quietly.

M.2.4 Question: Which entrances may be used during a lecture?

Entrance 1 is fine if they are silent, but the stairs and entrance 2 should be off limits.

M.5 Supervised project

M.5.1 Question: Which sections of the SmartXp do you use during supervised project?

I mainly have supervised project or self study in Carre.

M.5.2 Question: What behavior do you want to see from the students that attend your assisted self study?

The students are mainly working in groups, I walk around to help, and if I am not around, they know where to find me.

M.6 Demo market

M.6.1 Question: Which sections of the SmartXp do you use during a conference/demo market?

Mainly section 2 and 3, but occasionally section 1 is used as well, but often a part of the section.

M.6.2 Question: What behavior do you want to see from the students that attend your conference/demo market?

At least 1 student should attend to the stand, to explain what the installation does and how it works. Further walking around and inspecting the projects of the other groups is recommendable. The atmosphere should be lively. The merrier the better.

M.6.3 Question: What behavior is desired of the other students that are in the SmartXp during a conference/demo market?

It is fine if other students are attending the demo market.

M.8 Other remarks about the SmartXp or the lighting system?

The SmartXp is a bad room for a lecture, the room is to long and narrow. If the floor would have a slope, this would bring the students in the back more in contact with the lecturer. I like the industrial feel of the SmartXp better than the clean office setup of the designlab. Further the sound in section 2 is not sufficient to keep the attention of the students in the back, I coop with this problem by walking around and asking questions during the lecture.

About the system: Why blue during a lecture? Wouldn't white light with a dark environment be better? We used to have a box on the table as the Carre rooms still have, there you could select the use case and the light would change. But during a lecture the audience light was too low to be able to make notes. It is therefor important to think about the user tasks during the use case.

Bibliography

[1] B. Li, Q. Zhai, R. Luo, and F. Ying, “Atmosphere Perception of LED Dynamic Lighting with Color Varied in Cool and Warm Hue,” *IEEE*, 2016.

[2] Z. Xiu and H. Li, “Smart Lighting System with Brightness and Color Temperature Tunable,” *Proceedings - 2014 7th International Symposium on Computational Intelligence and Design, ISCID 2014*, vol. 2, pp. 183–186, 2015.

[3] P. Hue Dev, “Meet Philips Hue {@ONLINE},” 6 2017. [Online]. Available: http://www2.meethue.com/nl-nl/

[4] B. WeMo, “Belkin WeMo smart lights {@ONLINE},” 6 2017. [Online]. Available: http://www.belkin.com/us/F5Z0489-Belkin/p/P-F5Z0489;jsessionid=150027B07D6AADFCF52C3191F1BF0CFE/

[5] L. Scene Control, “Light Wave RF Scene Control System {@ONLINE},” 6 2017. [Online]. Available: https://www.lightwaverf.com/products/scene-control/#fndtn-lw-moodremote

[6] C. Jin, H. Noguchi, J. Qiu, H. Wang, Y. Sun, and Y. Lin, “The effect of color light combination on preference for living room,” *Solid State Lighting (SSLCHINA), 2015 12th China International Forum on*, pp. 139–142, 2015.

[7] M. Sokolova and A. Fernández-Caballero, “A Review on the Role of Color and Light in Affective Computing,” *Applied Sciences*, vol. 5, no. 3, pp. 275–293, 8 2015. [Online]. Available: http://www.mdpi.com/2076-3417/5/3/275/

[8] N. Camgöz, C. Yener, and D. Güvenç, “Effects of hue, saturation, and brightness on preference,” *Color Research & Application*, vol. 27, no. 3, pp. 199–207, 6 2002. [Online]. Available: http://doi.wiley.com/10.1002/col.10051

[9] L.-C. Ou, M. R. Luo, A. Woodcock, and A. Wright, “A study of colour emotion and colour preference. Part I: Colour emotions for single colours,” *Color Research & Application*, vol. 29, no. 3, pp. 232–240, 6 2004. [Online]. Available: http://doi.wiley.com/10.1002/col.20010

[10] A. Fernández-caballero, “A Review on the Role of Color and Light in Computing, Affective,” no. August, 2015.

[11] C. Fu, C. Li, G. Cui, M. R. Luo, R. W. G. Hunt, and M. R. Pointer, “An investigation of colour appearance for unrelated colours under photopic and mesopic vision,” *Color Research & Application*, vol. 37, no. 4, pp. 238–254, 8 2012. [Online]. Available: http://doi.wiley.com/10.1002/col.20691

[12] M. M. Aslam, “Are You Selling the Right Colour? A Crosscultural Review of Colour as a Marketing Cue,” *Journal of Marketing Communications*, vol. 12, no. 1, pp. 15–30, 3 2006. [Online]. Available: http://www.tandfonline.com/doi/abs/10.1080/13527260500247827

[13] B. Koo and Y. Kwak, “Color appearance and color connotation models for unrelated colors,” *Color Research & Application*, vol. 40, no. 1, pp. 40–49, 2 2015. [Online]. Available: http://doi.wiley.com/10.1002/col.21857

[14] S. Kurt and K. K. Osueke, “The Effects of Color on the Moods of College Students,” pp. 1–12, 2014.

[15] V. Logan-Clarke and J. Appleby, “What is color therapy,” in *Color Therapy Healing Workshops. Bognor Regis, UK*, 2009.

[16] K. Van Wagner, “Color psychology: How colors impact moods, feelings and behaviours,” *Psychology*, vol. 2009, 2009.

[17] J. Kopacz, *Color in three-dimensional design*. McGraw Hill Professional, 2004.

[18] Z. O. Connor and Z. O. Connor, “Colour psychology and colour therapy : Caveat emptor COLOR FORUM Colour Psychology and Colour Therapy : Caveat Emptor,” no. April, 2017.

[19] R. Gong, Q. Wang, Y. Hai, and X. Shao, “Investigation on factors to influence color emotion and color preference responses,” *Optik - International Journal for Light and Electron Optics*, vol. 136, pp. 71–78, 5 2017. [Online]. Available: http://linkinghub.elsevier.com/retrieve/pii/S0030402617301699

[20] M. Hårleman, “Colour emotion in full-scale rooms,” no. Hårleman, pp. 223–226, 2004.

[21] V. Ortiz-García-Cervigón, M. V. Sokolova, R. M. García-Muñoz, and A. Fernández-Caballero, “LED Strips for Color- and Illumination-Based Emotion Regulation at Home,” pp. 277–287, 2015. [Online]. Available: http://link.springer.com/10.1007/978-3-319-26410-3_26

[22] B. Fabio, B. Chiara, L. R. Ornella, B. Laura, and F. Simonetta, "Non visual effects of light: An overview and an Italian experience," *Energy Procedia*, vol. 78, pp. 723–728, 2015. [Online]. Available: http://dx.doi.org/10.1016/j.egypro.2015.11.080

[23] Y. Gao, H. Wu, J. Dong, and G. Q. Zhang, "Constrained optimization of multi-color LED light sources for color temperature control," *2015 12th China International Forum on Solid State Lighting (SSLCHINA)*, pp. 102–105, 2015. [Online]. Available: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=7360699

[24] V. P. Titar, E. N. Lebed, and A. M. Naboka, "PERCEPTION OF ELECTROMAGNETIC WAVES VISIBLE TO THE HUMAN EYE," pp. 129–130, 2016.

[25] S. T. Yousuf Azeemi and S. M. Raza, "A critical analysis of chromotherapy and its scientific evolution," *Evidence-based Complementary and Alternative Medicine*, vol. 2, no. 4, pp. 481–488, 2005.

[26] M. Dumont, M. Dumont, and C. Beaulieu, "Light exposure in the natural environment : Relevance to mood and sleep disorders Light exposure in the natural environment : Relevance to mood and sleep disorders," no. March, 2016.

[27] M. Grandner, "Light exposure is related to social and emotional functioning and to quality of life in older women," no. April, 2017.

[28] Q. Yao, L. Yuan, and Y. Bian, "Establishment of Vision Effect Diagram for Optimization of Smart LED Lighting," *IEEE Photonics Journal*, vol. 8, no. 4, 2016.

[29] G. Curcio, L. Piccardi, F. Ferlazzo, A. M. Giannini, C. Burattini, and F. Bisegna, "LED lighting effect on sleep, sleepiness, mood and vigor," *EEEIC 2016 - International Conference on Environment and Electrical Engineering*, pp. 0–4, 2016.

[30] A. Plepys and J. L. Richter, " Public Procurement Barriers in Promoting Market Uptake of In- novative LED Lighting EU Policies and Public Procure- ment Swedish public procurement and," pp. 1–8, 2016.

[31] P. Gill, K. Stewart, E. Treasure, and B. Chadwick, "Methods of data collection in qualitative research: interviews and focus groups," *British dental journal*, vol. 204, no. 6, pp. 291–295, 2008.

[32] S. Michie, L. Atkins, and R. West, "The behaviour change wheel: a guide to designing interventions," *Needed: physician leaders*, vol. 26, 2014.

[33] R. H. Thaler and C. R. Sunstein, *Nudge*, 2008.

[34] B. Della, "How a little nudge can lead to better decisions," *Financial Times*, vol. 1511, 2015.

[35] S. Taylor and P. A. Todd, "Understanding information technology usage: A test of competing models," *Information systems research*, vol. 6, no. 2, pp. 144–176, 1995.

[36] B. H. Wixom and P. A. Todd, "A theoretical integration of user satisfaction and technology acceptance," *Information systems research*, vol. 16, no. 1, pp. 85–102, 2005.

[37] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS quarterly*, pp. 319–340, 1989.

[38] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," *MIS quarterly*, pp. 425–478, 2003.

[39] F. D. Davis, R. P. Bagozzi, and P. R. Warshaw, "User acceptance of computer technology: a comparison of two theoretical models," *Management science*, vol. 35, no. 8, pp. 982–1003, 1989.

[40] P. J. Hu, P. Y. K. Chau, O. R. L. Sheng, and K. Y. Tam, "Examining the technology acceptance model using physician acceptance of telemedicine technology," *Journal of management information systems*, vol. 16, no. 2, pp. 91–112, 1999.

[41] R. Raitoharju, "Comparing the acceptance of information technology among public and private healthcare sector employees in Finland," *International journal of healthcare technology and management*, vol. 8, no. 1-2, pp. 84–96, 2007.

[42] F. Akbar, "What affects students acceptance and use of technology?" *Dietrich College Honors Theses*, 2013. [Online]. Available: http://repository.cmu.edu/hsshonors/179%5Cnfiles/541/179.html

[43] C. Carlsson, J. Carlsson, K. Hyvonen, J. Puhakainen, and P. Walden, "Adoption of mobile devices/servicessearching for answers with the UTAUT," in *System Sciences, 2006. HICSS'06. Proceedings of the 39th Annual Hawaii International Conference on*, vol. 6. IEEE, 2006, pp. 132a–132a.

[44] X.-p. Gao, J. H. Xin, T. Sato, A. Hansuebsai, M. Scalzo, K. Kajiwara, S.-s. Guan, J. Valldeperas, and M. Jose, "Analysis of cross cultural color emotion Analysis of Cross-Cultural Color Emotion," no. May 2014, 2007.

[45] H. Sharp, a. Finkelstein, and G. Galal, “Stakeholder identification in the requirements engineering process,” *Proceedings. Tenth International Workshop on Database and Expert Systems Applications. DEXA 99*, pp. 1–5, 1999.

[46] S. Michie, M. Richardson, M. Johnston, C. Abraham, J. Francis, W. Hardeman, M. Eccles, J. Cane, and C. E. Wood, “Behavior Change Technique Taxonomy,” *Annals of Behavioral Medicine*, vol. 46, no. 1, pp. 81–95, 2013.

[47] D. B. Aktekin and Y. Şimaşek, “A new model for chromotherapy application,” *Color Research and Application*, vol. 37, no. 2, pp. 154–156, 2012.

[48] J. Laforest, L.-M. Bouchard, and P. Maurice, *Guide to organizing semi-structured interviews with key informant: safety diagnosis tool kit for local communities*. Institut national de sant{é} publique Qu{é}bec, 2009.

[49] J. A. Veitch and S. L. McColl, “A critical examination of perceptual and cognitive effects attributed to full-spectrum fluorescent lighting,” *Ergonomics*, vol. 44, no. 3, pp. 255–279, 2001.

[50] C. QUEST, “Quality Enhancement Support Team (QUEST), Student Experience Questionnaire (SEQ) {@ONLINE},” 7 2017. [Online]. Available: https://www.utwente.nl/en/ces/celt/toolboxes/quality-evaluation-accreditation/quest/#evasys

[51] D. Gefen, D. Straub, and M.-C. Boudreau, “Structural equation modeling and regression: Guidelines for research practice,” *Communications of the association for information systems*, vol. 4, no. 1, p. 7, 2000.

[52] T. Zhou, Y. Lu, and B. Wang, “Computers in Human Behavior Integrating TTF and UTAUT to explain mobile banking user adoption,” *Computers in Human Behavior*, vol. 26, no. 4, pp. 760–767, 2010. [Online]. Available: http://dx.doi.org/10.1016/j.chb.2010.01.013

[53] H. M. Kok, “Quadrigram data visualization of the color connotation survey {@ONLINE},” 5 2017. [Online]. Available: http://www.quadrigram.com/hosting/heleen_kok/color_connotation/

[54] Frederick and D. Roberts, “MathBits Correlation Coefficient,” 5 2017. [Online]. Available: https://mathbits.com/MathBits/TISection/Statistics2/correlation.htm

[55] M. Bekdash, V. S. Asirvadam, N. Kamel, and D. K. Y. Hutapea, “Identifying the Human Attention to Different Colors and Intensities Using P300,” pp. 538–541, 2015.

[56] M. V. Sokolova, A. Fernández-Caballero, L. Ros, J. M. Latorre, and J. P. Serrano, “Evaluation of Color Preference for Emotion Regulation,” 2015, pp. 479–487. [Online]. Available: http://link.springer.com/10.1007/978-3-319-18914-7_50