The Learning Style Game

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Readers Guide

Before reading the master's thesis you are advised to try the attached game. The game can be located at: www.graphicbirds.dk/FSLQ

Please note that the game has sound at it is advised to wear headphones.

When reading this report you are advised to do so in chronological order. References to the appendix and external references are marked with square brackets. Internal references are in Italics, listing the chapter name and in which section to find it. E.g.: [Felder & Silverman's Learning Style Inventory, *chapter 2.3.4*].

External references will state author and year e.g.: [Curry 1984] in the body of the text, and can be found in the end of the report under "References".

The Reference List will be noted under author and year. Example:

[Curry, 1983] Curry, Lynn: "An Organization of Learning Style Theory and Constructs" Division of Continuing Medical Education, Dalhousie University Halifax, NS B3H 4H7 [April 1983].

Extra materials and appendices can be found on the included CD and will be marked as [CD] whenever material is referred.

The Learning Style Game

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1 Introduction and Motivation

Key words: cognitive style, learning style, E-learning. Elicit, Multimedia Learning, Digital Game, learning strategy.

In the design of e-learning courses in most organisations the users' learning styles are rarely taken into account. Often the e-learning courses are designed from a "one-design fit all" principle. There have been done attempts with the use of learning style adaptive systems (LSAS), which would match the learning material with the user's preferred learning styles. But, most of the research behind LSAS is based on data gathered from self-reported multiple-choice questionnaires, which is used to reflect the students' learning style. However this might not be the best method to make a LSAS. Research has shown that a persons' learning style is not constant and develops through experience. Even though the LSAS claim to be adaptive it might in fact be static because the learning style questionnaire is only filled out once and therefore does not take into account the fact that people might change their learning styles.

The Initial Problem Statement for this master's thesis is.

"How and to what extend can an interactive game-like questionnaire be designed to give a more complex picture of a persons contextual learning style and later recognize change in the learning style?"

2 Pre-analysis

Most of the research found in this master's thesis suggests that there have not been conducted much empiricism on learning style outside of the educational field i.e. in universities. Obviously universities have great interest in having measurements and models to personalise learning to the individual student in order to give him/her the best possible learning environment. However, since organisations have begun to demand further education from their employees e-learning thus learning styles has become much more relevant. Learning in organizations unlike in universities is more restricted by time. While students at a university spend most of their time studying, employees spend most of their time working on different assignments which leave them to go through the e-learning, in their spare. Therefore, designing the e-learning course such that it matches the learning material with the employees preferred learning styles, is very important. However, today's learning style questionnaires involve having to consider how one thinks he/she learns best, or what he/she prefers when learning new material. However, if ones learning style is inconsistent and changes with experience how should the employees know what they prefer when learning. Furthermore, having to fill out a self-reported learning style questionnaire every time one has to take an e-learning course can be a very tiresome business, especially after a long days work. Furthermore, there is the risk that the employees would rush through filling out the learning style questionnaire, hence not providing the LSAS with the correct data. What if this tiresome affair of filling out a learning style questionnaire was entertaining and done while play a small game, which would reflect ones learning style without one having to make any decisions about one learning style e.g. if one only had to play angry birds[1] in order to get ones learning style.

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[1] Copy right Rovio®

http://www.rovio.com/en/our-work/games/view/1/angry-birds

2.1 The Cognitive and Learning Style Principles

Since the middle of the 20th century there have been done much work within the field of learning styles. In the hesitant beginning of research within the field of *cognitive* and *learning styles* the tests and theories were mainly developed by psychologists and most of this work was developed to determine individual perception of concept. However, researchers from other fields have been conducting research within the field of cognitive and learning style as well. This has left the field of cognitive and learning styles very wide and to some extends confusing [Cassidy, 2004]. Furthermore, it seems that a definition of "style" has not been clarified and therefore has lead to confusion in the use of the term among researchers [Rayner and Riding, 1997]. Therefore, to clarify the term "style" in this master's thesis the following chapter will go through an argumentative definition of the concept style.

In order to design a Game like questionnaire, which dynamically determine the users learning style through play, one must first understand what the terms cognitive and learning style entails. This is not a straightforward task. Cognitive and learning styles have been in development as mentioned since the mid 20th century. However, it seems that most of the research done on cognitive and earning styles has been done with the goal of developing better models to determine peoples' learning style. Cassidy (2004) notes that many of the learning style models have received little attention since their development. She further states that if supplementary work is not done on already developed models and concepts the problem of too many different cognitive and learning style models and confusing terminology will continue to grow. Cassidy (2004) furthermore, notes that one should clarify whether the goal is to develop a new instructional method for learning or if the desire is to measure learning and the relation to achievement. Cassidy (2004) furthermore, suggests that one should become familiar with the field of cognitive and learning style and that one should become conversant with its idiosyncrasies, weaknesses, terms and definitions [Cassidy, 2004 p. 440].

When the terms cognitive and learning styles are mentioned one could think this refers to *ability* e.g. ones ability to learn in different way. However, this is not far from correct. According to Sternberg (1999) *ability* and *style* have two different but connected definitions within the field of cognitive and learning style research. The term *ability* refers to how well

someone can do something and style refers to the style in which some likes to do something. A style therefore is the preferred way of using the ability someone has [Stash, 2007]. According to Curry (1984) learning ability is: "The individual's potential performance given a defined setting and a defined task demand" [Curry 1984, p. 4].

The term learning style is often used in research papers interchangeable with cognitive style [Cassidy, 2004]. However, this According to Cassidy (2004), Curry (1983), Price (2004) and Rayner and Riding (1997) is incorrect use of the two much different concepts. Cognitive style and learning style is very much two different, however still inseparable concepts. Cassidy (2004) mentions that some researchers frequently have used the terms "learning style" and "cognitive style" imprecisely in theoretical and empirical accounts of the topic. Therefore, to avoid mixing the two terms the following section will bring light to already made definitions of the both cognitive style and learning style.

The most agreed on definitions of cognitive and learning style according to Rayner & Riding (1997) and Stash (2007) is:

(The term) *"Cognitive style relates to an individual's habitual mode of understanding, remembering, problem solving, thinking and perceiving material" [Rayner & Riding, 1997; Stash 2007, p. 105].*

(The term) "Learning style can be described as individual differences in how an individual teaches him/herself new material" [Rayner and Riding, 1997][Price, 2004].

Other researchers have contributed to the definition of cognitive and learning style. Here is one definition that so to say combines cognitive and learning style.

 "People have different cognitive styles that influence how they organise and process information, influencing their learning performance." [Lo et al. 2011]

However, these definitions do not explain the difference between the two terms. In some way one might argue that the two definitions can be perceived similarly, which could explain the interchangeable use of cognitive and learning style. Therefore, in order to paint a much clearer picture of the difference, and resemblance between the two terms the following section will investigate categorisations done on cognitive and learning style theories. To

begin with this master's thesis will start with the earliest categorisation of developed models and end with a much recent categorisation.

2.2 Curry's Three Strata Onion Model

Curry (1983) provides a depictive definition of the term cognitive and learning style, which she refers to as a concept. According to Curry (1984) most of the models developed to measure cognitive and learning styles seems to lack grounded empirical work [Curry, 1983]. Based on this notion Curry developed her three strata onion model see Figure 1.

Instructional format preference indicator

Information processing style

Cognitive personality style
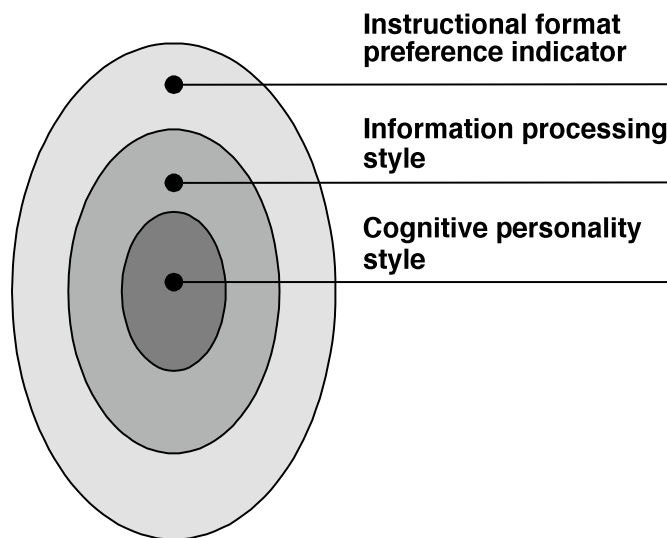
Figure 1: Representation of Curry's (1983 p. 19) three strata onion model

2.2.1 Instructional Format Preference Indicator

Curry's three strata onion model starts with the outermost stratum *"Instructional Format Preference Indicator"*. Examples of research done in this area include Rezler & Rezmovic (1981). Curry describes this stratum as the most observable and as the one, which refers to the individual's preferred choice of learning environment (i.e. classroom, group work, or individual). She suggests that this stratum is the least stable and the most easily influenced of the three strata.

2.2.2 Information Processing Style

The Middle stratum *"Information Processing Style"* Curry describes as the individual's intellectual approach to assimilate information. Because the environment does not directly influence this stratum Curry suggests that the measure of this style is more stable than the

outermost stratum, however, can still be modified by the *learning strategies.* The middle stratum is considered the intersection between the cognitive style and the learning environmentally offered choices [Riding, 1997]. The "information Processing Style" is concerned with an individual's mode to use experience, facts, recall as opposed to an orientation, analysis of data, derivation of principles, concepts or relations among observed facts. These modes all involve reflection, reorganisation or critical questioning of information. Examples of measures done in this area include the learning style Inventories of Kolb (1984), which will be explained in the next chapter. Curry has categorised this stratum as dealing with the information processing style [Curry, 1983 p. 11].

2.2.3 Learning Strategies

Curry (1983) describes the term *learning strategy* as the mechanism or strategy an individual uses to translate the particular information into, for the individual, a meaningful form.

2.2.4 Cognitive Personality Style

The innermost stratum *"Cognitive Personality Style"* is described as the individual's mode of adapting and assimilating information. This adaptation does not interact directly with the environment, but is an underlying relatively permanent personality dimension. As with the definitions of the terms cognitive and learning style both "Information Processing Style" and "Cognitive Personality Style" seem similar however, there is a difference. The "Cognitive Personality Style" stratum is concerned with the individual's deep structure of personality and the measure retained from this stratum has to do with predicting an individual's behaviour [Curry 1983, p.13]. Examples of models developed to measure this stratum include the work of Witkin et al. (1977), and Myers-Briggs Type Indicator. Both of these theories will be explained in depth in [Witkin Field Dependent /Field Independent styles, *chapter 2.3.3*] and [Myers-Briggs Type Indicator, *chapter 2.3.2*].

Recent Categorisations of Cognitive and Learning styles

Curry's approach on categorising cognitive and learning styles and testing the models for reliability and validity was one of the very first attempts towards boiling down a complex set of terms into an understandable concept. However, since Curry's categorisation there have been developed many new models. Coffield et al (2004) did an extensive study on 71 cognitive and learning style models and tested them for reliability and validity. They concluded that out of the 71 only 13 models were reliable and valid. Coffield et al. (2004) furthermore, concluded that the reason for the extensive amount of models were due to lack of communication within the field of pedagogy and psychology [Coffeld et al. 2004 p. 150]. Curry (1983), Rayner & Riding (1997), Cassidy (2004) Coffield et al. (2004), (Price, 2004) and Stash (2007) through their categorisation have come to the joint conclusion that though there have been developed many models to measure cognitive and learning style most of the research are a-like in the sense the most of research seek to elicited peoples' cognitive and learning style in order to advance learning. In Riding and Cheema's analysis of over 30 learning styles models they propose two new fundamental basic dimensions of cognitive styles or "meta-styles" in which information is processed and represented namely the bi-polar scale *wholist-analytic* and *verbal-imager* cited in Riding (1997) and Stash (2007). Riding's categorisation however was based on comparing the different cognitive and learning styles with his cognitive style model. This model was however in numerous cases proven not reliable [Coffield et al. 2004][Peterson, Deary & Austin, 2002]. Peterson, Deary & Austin's, (2002) analysis of Riding's Cognitive Style Analysis showed that only one dimension of two bi-polar scales were reliable namely the wholist-analytic, which they had based directly on Witkin's et al. (1977) Field dependent/ Field independent taxonomy [Peterson, Deary & Austin, 2002][Coffield et al, 2004].

In this master's thesis the author has chosen to focus on the categorisation done by Coffield et al. (2004) and Stash (2007). Even though Stash's categorisation was directly based on Coffield's categorisation her focus was on other cognitive and learning styles models, which are important for this paper. Both categorisations relay on a schema called the learning style family developed by Coffield et al. (2004 p. 9). Furthermore, Curry's three strata onion model will be used as a guideline for the final model of the defined terms cognitive and learning styles.

As Cassidy (2004) suggested a clear conceptual framework should be established such that the results and outcomes from the Learning Style Inventories (Hereafter referred to as LSI) can be dealt with within a clear conceptual framework. This master's thesis' focus is on whether or not a Learning Style Game (Hereafter mentioned as LSG) can elucidate ones cognitive and learning styles as precise as today's forced choice self-reporting LSI's. This means whether or not a game through playing can determine the player's learning style. Therefore, the first thing to determine is how the user's learning styles can be elucidated through playing a game.

2.3 The Learning Style Inventories

In the previous chapter it was found that in order to make a well-defined learning style framework and contribute to the research of cognitive and learning science one should use already developed research. Therefore, to create a game, which contributes to the development of a unified framework of cognitive and learning style theory the following section will investigate different LSI's. This will be done to fully understand the theory developed to measure peoples' cognitive and learning styles such that this theory can be incorporate into a game. As found in [The Cognitive and Learning Style Principles, *chapter 2.1*] some of the cognitive and learning style models were found reliable and valid while others did not fulfil this requirement. Therefore, the following chapters' will focus on different learning style inventories found relevant for research of this master's thesis. Furthermore, to clarify this the following section will go through the different learning style inventories from Curry's stratum "Information Processing Style" and from Coffield's et al. (2004) model *"Families of Learning Styles"* leading to choice of using Felder & Silverman's Learning Style Inventory.

### 2.3.1 Kolb's Learning style Inventory

Kolbs LSI was developed in the 1970s and is one of the most influential learning style models [Stash, 2007].

Kolb defines learning style as the process whereby knowledge is created through the transformation of experience [Kolb, 1984]. The starting point of Kolb's theories on learning models begin with experience, which he describes as knowledge resulting from the

transaction between social knowledge and personal knowledge [Kolb, 1984]. Kolb in his research of learning reach the conclusion that the research within learning style not only require the need for psychological hence epistemology is as important for the understanding of individual learning preferences [Stash, 2007]. Kolb's approach towards learning style is categorised into four leaning modes. These learning modes were developed based on an epistemology/psychological analogy i.e. learning is done through knowledge which stems from experience [Kolb, 1984 p. 22]. The four stages in Kolb's cycle of learning (illustrated in Figure 2) include the following learning modes

- Concrete Experience (CE - feeling)

- Abstract Conceptualization (AC - Thinking)

- Active Experimentation (AE doing)

- Reflective Observation (RO - watching)

Based on the four above-mentioned modes a person can have four different learning styles, which are a combination of two learning modes e.g. one can have the learning style (CE/RO) which is called the Diverging style.
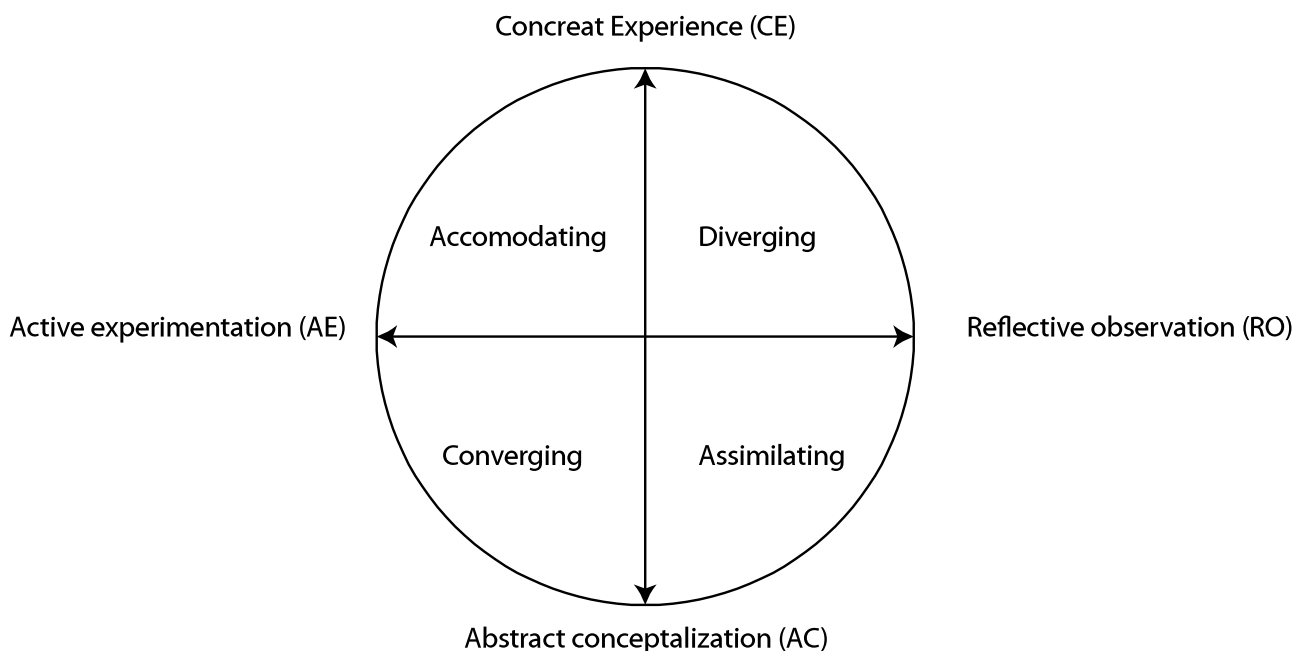
Figure 2: Kolb's cycle of learning modes.

The four learning styles make up for the following description taken from [Stash, 2007 p. 104].

- ***Diverging style (CE/RO)*** *subject with this style preference emphasises concrete experience and reflective observation; is imaginative; is aware of meaning and value; view concrete situations form different perspectives; adapts through observation rather than through action; is interested in people – feeling oriented; superior in generating alternatives hypothesis and ideas. General characteristic question for this learning type is "Why?" These learners respond best when they can see the connection between their concrete experiences, interest and future and the learning material*

- ***Assimilating style (AC/RO)*** *subjects with this learning style prefers abstract conceptualisation and reflective observation. People with this style are particular good ad inductive reasoning, creating theoretical models. This person is more concerned with ideas and abstract concepts than people. However the main focus is more on logical soundness and preciseness of the idea rather than there practical value. A characteristic question of this style is "What?" This type of learning learns best when information is presented in an organised, logical fashion and benefit from reflection.*

- ***Converging style (AC/AE)*** *subjects with this learning style rely primarily on abstract conceptualisation and active experimentation; they have great advantage in problem solving; decision making and practical execution of ideas; does best in conventional intelligence tests; prefer dealing with technical problems rather than interpersonal issues; Knowledge is organised through hypothetical-deductive reasoning. The characteristic question of this learning type is "How?" This learning type respond to best to hands-on well defined tasks and learn by trial and error in an environment that allows them to fail safely.*

- ***Accommodation style (CE/AE)*** *subject with this learning style emphasises experience and active experimentation likes doing things, carrying out plans and getting involved in new experiments; good at adapting to changing circumstances; solving problems in an intuitive, trial and error manner; at ease with people, however sometimes seen as impatient and "pushy". The characteristic question for this learning type is "What if? "*

> *This learning type likes to apply using learning material in practice for solving real world problems. [Stash 2007 p. 104]*
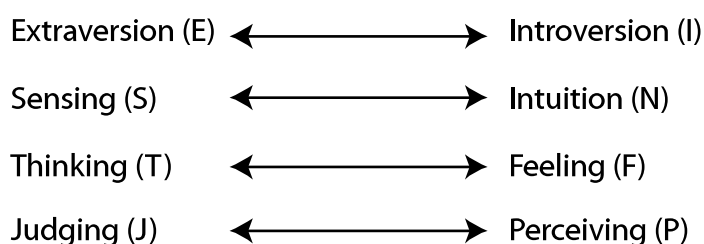
Even though Kolb is one of the few researchers who focuses on combining learning with knowledge his method of collecting data requires that subjects to know how they best learn. The subjects have to finish 12 sentences like "I learn best from …" with a sentence that refers to one of the four learning modes (Quoted from [Stash 2007, p. 104]).

2.3.2 Myers-Briggs Type Indicator

The Myers-Briggs Type Indicator (MBTI), which was developed by Katherine Cook Briggs and her daughter Isabel Briggs Myers in 1962, is one of the most known type indicators to indicate personality type. MBTI's theory is primarily influenced by the work of Jung [Coffield et al., 2004]. The model involves four different bi-polar scales (Illustrated in Figure 3) of opposite preferences giving an indication of how people interpret and interact with the outer world.

Myers-Briggs Type Indicator

Extraversion (E) ⟷ Introversion (I)

Sensing (S) ⟷ Intuition (N)

Thinking (T) ⟷ Feeling (F)

Judging (J) ⟷ Perceiving (P)

Figure 3: The four bi-polar scales of Myers-Briggs Type Indicator

The following description of the four bi-polar type indicators cited in Stash (2007, p. 102) and Coffield et al. (2004) categorisation.

Extraversion and Introversion gives an indication of how a person relates to the world

- **Extraversion (E)** includes - try things out, focus on the world around them, like working in teams, develops ideas through discussion.

- **Introversion (I)** includes thinking things through, focus on the inner world of ideas, working best when alone, and developing ideas through thinking.

Sensing and Intuition is an indication of how a person absorbs and processes information

- **Sensing (S)** includes - concrete, realistic, practical, detail-oriented, focus on facts and procedures, Sensing learners like learning facts and solving problems through well established methods. Dislike surprises, carful with detail, prefer new knowledge to have connection to the real world. They are slow problem solvers however present better outcomes than Intuitive people.

- **Intuition (N)** – Abstract, imaginative, concept-oriented, focus on meaning and possibility, Intuitive learners prefer to discover new relationships and can be innovative in their approach to problem solving, Work fast, dislike repetition and work which requires memorising and routine calculation, However are prone to errors and often get lower results than Sensors.

Thinking and Feeling relates to a persons decision making

- **Thinkers (T)** sceptical, then to make decisions based on logic and rules.

- **Feelers (F)** appreciative, then to make decisions based on personal and humanistic considerations.

Judging and Perceiving relates to how a person manages his/her life

- **Judging (J)** Organised, set and follow agendas, make decisions quickly, dislike surprises and need-advanced warnings, seek closure even with incomplete data.

- **Perceiving (P)** disorganised, adapt to changing circumstances, gather more information before making a decision, enjoy surprises and spontaneous happenings, resist closure to obtain more data.

The MBTI is a 93 forced-choice questionnaire where the subjects have to make their decision based on which of the presented statement that relates most to them. The final result is reflected in a four letter personality style e.g. ENTP (Extraversion, Intuitive, Thinking, Perceiving). Some researchers prefer to exclude MBTI because they feel that it goes beyond the scope of learning style i.e. can also be used to determine personality type [Stash, 2007][Coffield et al., 2004]. However, elements of this inventory are very useful which will be presented later in the report.

2.3.3 Witkin Field Dependent /Field Independent styles

Witkins test is an important concept in the understanding of individual differences in motor skills performance [Coffield et al., 2004]

Witkin et al. (1977) have developed three test used to study the cognitive styles Field Dependent and Field Independent (Hereafter referred to as FD/FI) the first one is Rod and Frame test, second one is the body adjustment test and the least is the Group Embedded Figure Test. The Rod and Frame test is situated in a fully dark room where the only the rod and the frame are the only thing illuminated. The rod and frame are placed on two separated rotating device, which both can be rotated clockwise and counter clockwise (Illustrated in Figure 4).
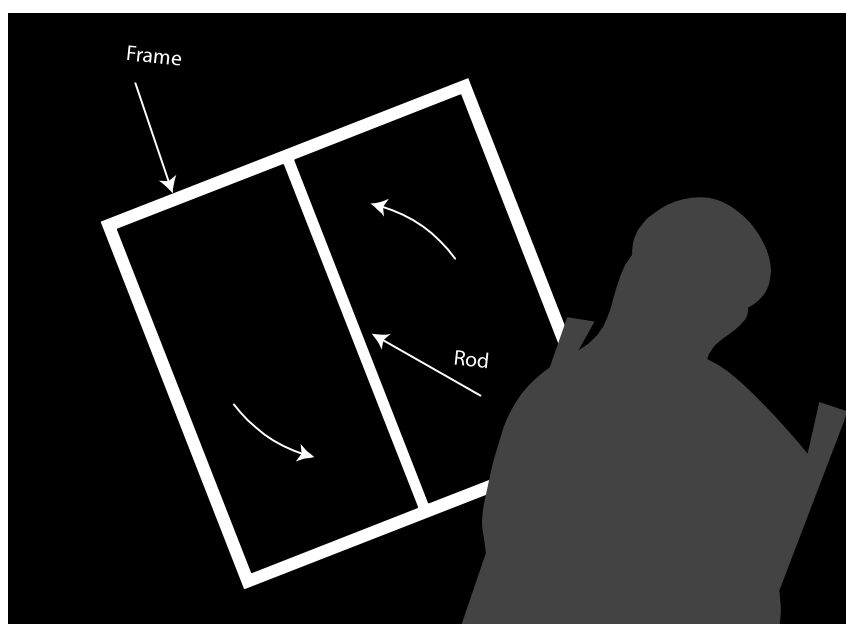
Figure 4: Illustration of the Rod and Frame Test Within et al. (1977)

The test subjects' job is to rotate the rod to the position he finds upright [Witkin et al. 1977]. Witkin et al. (1977) found that this technique could determine individual differences among people based on their performance. Furthermore, Witkin et al. (1977) found that for some people the rod was upright when it was aligned with the frame's rotation. For other people the rod was assumed upright when aligned with their body position rather than their surroundings. These people Witkin et al. (1977) defined at the extremes on the bi-polar scale of FD/FI [Witkin et al., 1977].

The third test is called the Embedded Figure Test (Hereafter referred to as EFT). This test evaluates a person's ability to recognise primitive objects such as a triangle in a complex figure. The test of the EFT is conducted by showingn the subjects the primitive figure and then removed it. The subjects then have to locate the before showed primitive figure in the presented complex figure (Illustrated in Figure 5).
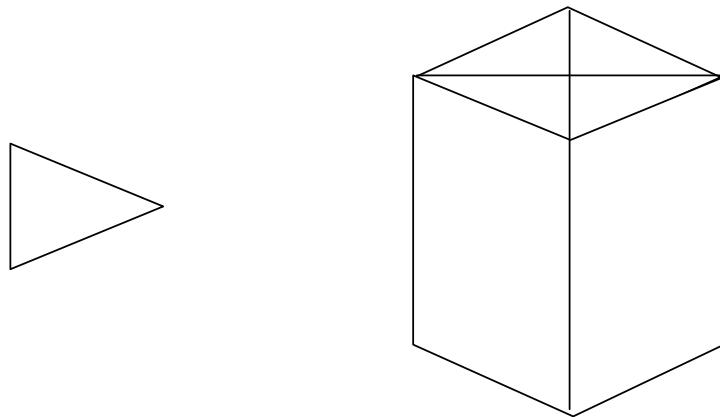
Figure 5: Example of a figure from the EFT.

The complex figure is constructed by using the lines in a combination such that the primitive figure appears to no longer be part of the complex figure, however it is represented in various sub wholes. Witkin et al. describes the EFT as being similar to the rod and frame test where the complex surrounding visual framework represents the frame and the primitive figure represents the rod. Witkin et al. (1977) bases the scoring of the test subjects on the time taken to locate the primitive figure in the complex figure. To describe the connection between the three tests Witkin et al. (1977) explains that the subjects who aligns rod with the frame are likely to also struggle with locating the primitive figures [Witkin et al. 1977].

Even though Witkin's et al. (1977) model of FD/FI was developed to observe difference in peoples' choice of education compared to their cognitive style the author of this master's thesis found the FI/FD research is of great importance for this study. While there have been developed many self-reporting questionnaires relaying on peoples *academic self-efficacy* there have been developed few models which observe and evaluate subjects based on their task solving ability.

2.3.4 Felder & Silverman's Learning Style Inventory

Felder & Silverman's LSI was originally developed as a tool for engineering teachers to match learning material with their students preferred learning styles. Felder and Silverman's idea was the through establishing a suitable teaching style the dropout rate of engineering students would decrease and the world would not have lost potentially great engineers [Felder & Silverman, 1988]. Felder and Silverman based much of the theory of their Learning Style Dimensions (Hereafter referred to as LSD) on elements from both Kolb's LSI and MBTI. One can say that Felder and Silverman's (1988) LSI is a further development of the two cognitive and learning style theories with the addition of a new and important dimension, namely the focus of teaching style in connection to learning style. Felder and Silverman's LSI was originally divided in to five different LSD Sensory/Intuitive, Visual/Verbal, Inductive/Deductive, Active/Reflective and Sequential/Global. However, Felder later discovered that the inductive/Deductive LSD had no relevance and was therefore reduced to four dimensions [Felder & Silverman, 1988,]. For each of the LSDs there is a teaching style dimension (Hereafter referred to as TSD) connected.

The following section will provide a depictive description of Felder & Silverman's different LSD.

The LSDs **Sensory/Intuitive** Felder and Silverman (1988) described as relating to the learners *"Perception"*. This dimension is directly taken from the MBTI [Felder & Silverman, 1988] [Stash, 2007]. The connected TSD is *"Concrete and Abstract"*, which is inspired by Kolb's CE/AC [Felder & Silverman, 1988].

The LSDs **Visual/Verbal** are labelled *"Input"'* These LSDs are connected to the different modalities, used to interact or process perceived learning information. Visual-sights pictures, diagrams, symbols; Verbal – sound words and text. Felder and Silverman (1988) describes a third modality kinaesthetic, which include touch, taste and smell. This modality, Felder and Silverman (1988) explain, has more to doe with an active learning style since kinaesthetic is moving related and had therefore been incorporated in the next LSD. Felder and Silverman (1988) state that people learn through the use of their preferred modality and that if the learning material is presented in their none-preferred modality they often neglected this material, hence, miss important learning material. Therefore the connected TSD has to

present, the learning material through means of both visual and textual content [Felder & Silverman, 1988]. However, as will be publicized in *[*Multimedia Elements*, chapter 3.1.1*]*, this can be somewhat complicated to incorporate when designing an e-learning course.

The LSDs **Active/Reflective** has to do with the *"Processing"* of the perceived learning input. This dimension is closely related to MBTI cognitive styles Introvert/Extravert. Furthermore, as mentioned in description of Visual/Verbal, the active learner has much in common with the modality kinaesthetic [Felder & Silverman, 1988 p. 678]. The connected TSD is *Student Participation*. Both the Active and Reflective learners are mismatched in classroom lectures where they do not have time to either participate in an activity such as solving math or to reflect upon the theory being taught.

The LSDS **Sequential/Global** are related to how the learner understand and is therefore labelled *"Understanding"*. Sequential as the name suggests understand in a sequential manner, meaning that they follow a step-by-step learning curve. Whereas Global learners follow a complex learning curve where they suffer long periods of not understanding the learning material. The Global learner will eventually understand the learning material and this is where the Global learner outdoes the Sequential learner. Global learners have the ability to see connections with what they have learned and other material, hence are more creative and innovative [Felder & Silverman, 1988]. The Sequential learner on the other and is much better suited for studying at universities due to the sequential structure of a semester. The TSD for the LSDs Sequential/Global is labelled *"Perspective"*. The teaching style for the Sequential learner is provided by any school system, however to reach the global learner the teacher need to provide a bigger picture or goal of the class and has to point out the context and the relevance of the course. Furthermore, the Global learner should have the freedom to use his/her own methods rather then using the professors and should be presented with creative exercises [Felder & Silverman, 1988 p. 697]. According to Stash (2007) and Coffield et al. (2004) Felder and Silverman's LSDs Sequential/Global are closely related to Riding's (1991) bi-polar dimensions Wholist/Analyst, which as mentioned by Stash's (2007 p. 100) can be aligned along Witkin's FD/FI styles.

Although Felder & Silverman's LSI originally was developed for the education of engineers the concept of the dimensions can, and has been adapted to many e-learning environments with

great success [Graf et al., 2007]. The Felder & Silverman LSI has even been proven suitable for technological enhanced learning[2] [Graf et al., 2007].

Therefore, the author of this master's thesis has chosen to use Felder & Silverman's LSI as the method for collecting the subjects' cognitive and learning style. The LSI will also provide a basis for the development of the LSG's.

2.4 Adaptive Educational Hypermedia

In the previous chapters the theory and concept of cognitive and learning styles were investigated. However, in order to develop a game, which makes use of the theories one need to look at how this can be adapted in practice. Therefore, for the purpose of understanding how other researchers have implemented these theories will the following section go through a number of examples found relevant for this master's thesis.

2.4.1 iWeaver

In the PhD project by Wolf (2002) on developing a learning style base adaptive e-learning game one of the main focuses was on not presenting the subjects with too much information also known as cognitive overload [Wolf, 2007]. Wolf (2002) based this on a study done by Clark & Mayer (2002), which showed that too much information would inhibit the learning. Clark & Mayer (2002) also found that if the subjects where presented with the right combination of media the learning could be promoted. Wolf's approach towards the development of an adaptive learning style system focuses on both the user experience and on the adaptation of the users learning style. The LSDs of Wolf's (2002) adaptive learning style system is based on Dunn & Dunn's LSI and is therefore the only article in this section, which does not use any of the reviewed LSI. In Curry's (1983) evaluation of reliability and validity she recorded Dunn and Dunn's LSI as one of the 21 models that demonstrated sufficient reliability and validity [Curry 1984, p. 23]. However, According to Coffield's el at. (2004) Dunn & Dunn's LSI is primarily used for the teaching of elementary schools. Dunn & Dunn worked with the theory that cognitive styles were influenced by genetic and fixed inherited traits, however with some influence from the environmental factors. Furthermore, the Dunn & Dunn LSI is rooted in the belief that styles should be worked with and not changed [Coffield, et al.

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[2] E-learning courses

2004, p. 11]. This suggests that the use of Dunn & Dunn's LSI for an adaptive learning style system is counter productive because the system does not need to be adaptive of the LSI used suggests that learning styles are fixed. However, this is not the most important aspect of Wolf's PhD. Wolf focuses on developing a system, which takes the user experience into account. This is evident through his concern with designing an adaptive system, which focuses on the students' learning and not only on eliciting the students' learning styles. However it seems that thought Wolf has these thoughts he struggles with finding a solution to elicit the students' learning styles. Wolf ended up with concluding that he needs to use the Bayesian Theorem to evaluation the students' learning styles. The main component retrieved from this research is focus of designing the adaptive learning style system with the users cognitive load in mind. This area will be a vital element of the design of the LSG.

2.4.2 Web-based learning system

Lo et al.'s (2011) study on an adaptive learning system provides a focus, which is very similar to the research of this master's thesis, namely to determine the subjects' learning style through their behaviour. Lo et al.'s (2011) problem statement however is somewhat different. Where the goal of this master's thesis is to uncover subjects' learning style through the decisions done in a game, Lo et al. (2011) tried to uncover the subjects' cognitive style through a web-based learning system, which uncovers the subjects' learning style by observing their browser behaviour. Lo et al. (2011) states that it should be possible to extract psychological traits from observing subjects browsing behaviour. Lo et al (2011) uses Myers-Briggs type indicator to model the different cognitive styles. The type indicator has been widely accepted both for its validity and reliability and its use on adults. Lo et al. (2011) sat up a testing construct, which included a multi-layered Feed Forward Neural Network (MLFF). This model consisted of three layers: input-layer, hidden -layer and output-layer.

The structure of categorising the different cognitive styles was done via classification i.e. making a statistic pattern recognition through a set of data provided from the observed browser behaviour.

The method in which the subjects were tested was a subjective and objective test, which consisted of first having the test subjects fill out a self-reported evaluation questionnaire regarding their cognitive style. This was done such that they for correlation between the self-

reported evaluation questionnaire and the objective method, which as mentioned before gathered data through observing browser behaviour. In Brown et al. (2006) version of an Adaptive Educational Hypermedia (Hereafter referred to as AEH) they designed the web application in the same manner as Lo et al. (2011). However Brown et al. (2006) concluded that there was no significant difference between the matched and mismatched cognitive styles of the students. They further, explain that this could be due to the fact that the students who were selected were students at a higher educational level and that they already were efficient learners. Furthermore, Brown et al. (2006) question the cognitive style element of being static and explain that because the students had filled out the LSI long before the use of the AEH the LSI data was no longer valid.

Though learning from a pedagogical point of view is important the technology driving it is equally as important. Technology can be seen as a hindrance for the subjects learning [Clark & Mayer 2002]. However it can also be seen as a great help. Wolf (2002) suggests that the development of a computer generated learning style driven system could reach much more subjects during a learning scenario. Wolf compares this with a classroom teaching where there are e.g. 25 subjects and only one teacher. He argues that the teacher in no means has the capacity to teach each subject in his/her preferred learning style, hence leaving the subject in a situation where he/she has not learned as much as other subjects might have. In this situation the computer generated learning style system has its advantage. Because of the computer generated learning system's functionality there is one server to 25 subjects, which can present the learning material in the manner the subject prefer [Wolf 2002]. Another downfall with the teacher subject scenario is that teachers are not aware of their own learning style and therefore unconsciously tend to teach in their preferred learning style [Stash, 2007][Felder & Silverman, 1988].

2.4.3 Evaluation of Adaptive Educational Hypermedia from 2000 - 2011

Though there have been much focus on the development of an adaptive educational hypermedia (AEH) one should use the research of incorporating the cognitive and learning style theory into AEH's with caution [Akbulut & Cardak, 2011]. In Akbulut and Cardak content analysis of AEH systems they reach the conclusion that very few of the developed AEH's are adequate in their evaluation of both the student modelling and the use of the LSI's. For the further development of an AEH they stress the importance of using the corrects LSI and that one when developing a AEH should consider the facets that most LSI have been developed for the purpose of face to face classroom educational use and not as in the case of the AEH's for computer generated educational use [Akbulut & Cardak, 2011]. They furthermore address the issue in which the AEH's collect data for the student modelling. For the AEH's reviewed in this master thesis the student modelling has been done through the use of a self-reported LSI where the students have to evaluate their own learning style through a long tiresome and time-consuming questionnaire. This could lead to a less valid student model hence the students could be less motivated to read and reflects upon the context and the relevance of the answers they give [Akbulut & Cardak, 2011][Graf et al., 2009]. Akbulut & Cardak further noted that though there are better methods for creating student models such as observing their behaviour while they are using the AEH. However, this method is not a straightforward task, because getting sufficient and relevant information to build a robust and thorough automatic systems can be a challenge [Akbulut & Cardak, 2011][Graf et al., 2009]. Furthermore, Akbulut & Cardak stress the fact that there have been made indication towards the students awareness of their own preferred learning style. This refers to how the students' learning style is being evaluated. The students' learning material has been matched based on the data from the self-reported LSI. They suggest that the provided data should have been derived through an observation of behaviour in the AEH. One issue with matching the students' learning material with the self-reported LSI data is, according to Akbulut & Cardak that the students' learning style as mentioned in Kolb's Learning style Inventory is influenced by knowledge, therefore not constant. Meaning that the matched learning material will eventually be mismatched. Akbulut & Cardak conclude their analysis with stressing the need for a system, which evaluates the students while they are use the system, and not as in the case of the reviewed AEH's after having completed the semester. Thus basing the evaluation

of the students' performance on data collected in the beginning of a semester will give the indication that matching the students' learning styles have made no significant difference in their learning. An example of an AEH, which takes this into account, is the AEH developed by Dorça et al. (2012). However since this was made in 2012 their research have not been part of the Akbulut & Cardak's evaluation. It furthermore, suggests that they have read this paper. In the research of Darça et al. they focus on evaluating the Learning Style Model (Hereafter referred to as LSM) of students over a period of time during student performance. They propose that a reliable LSM requires that the system dynamically updates the LSM while evaluation the students' performance [Dorça et al., 2012]. Dorça et al. 's AEH was as many of the examples in this master's thesis based on Felder & Silverman's LSI. Based on this LSI they designed a complex AEH consisting of three strategies for automatically detecting student's LSM. Each of these three strategies was designed with a complex Bayesian Network setup. The AEH however was not tested on real student but in a simulated system. Through these initial results they concluded the approach was reliable for testing on real students [Dorça et al., 2012].

2.5 Defining the Concept of Learning Style

The terms cognitive and learning styles is in the master's thesis defined based on three different yet similar definitions. The first definition related to cognitive style and is derived from Rayner & Riding, and Stash's definition of cognitive style, which can be found in the chapter [The Cognitive and Learning Style Principles, *chapter 2.1*]. Furthermore, the definition of learning style will be based on Kolb' s defines that learning style is the process whereby knowledge is created through the transformation of experience [Kolb, 1984]. Finally the last part of the definition will be based on Lo et al.'s (2011) definition that people have different cognitive styles, which influence how they organise and process information. This cognitive style influences their learning performance. Furthermore, learning style in this master's thesis is perceived as a concept in, which there are three elements; Learning Environment, Learning Strategy and Cognitive Style. To illustration this, Curry's (1983) onion strata model has been used (illustrated in Figure 6). The outermost layer "Learning Environment" relates to Felder and Silverman's (1988) theory on teaching style dimensions whereas the environment is how the learning material is presented to the subjects [Instructional Format Preference Indicator].
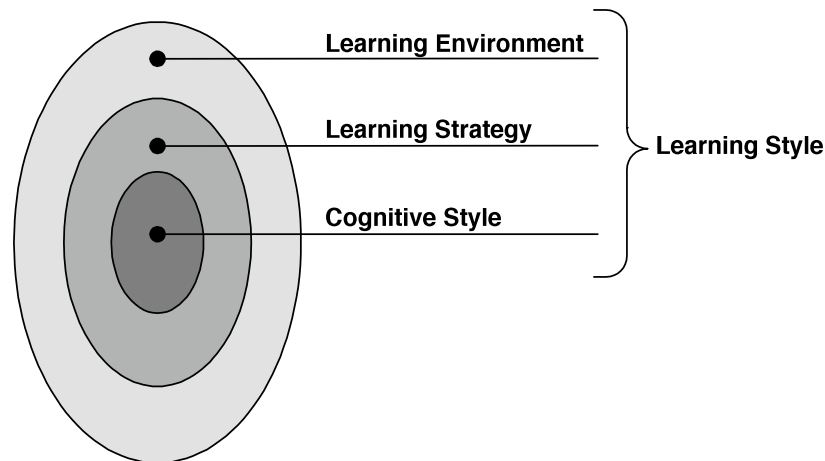
Figure 6: The Learning Style Concept Model.

The middle-most layer, which is called *"Learning Strategy"*, will be based on Felder and Silverman's learning style inventory. The reason for this is firstly that the questionnaire has been tested useful for e-learning courses [Graf et al., 2007]. This layer of the model is of the most importance for this study due to the scope of retrieving subjects' learning style through contextual measurements within a game.

Lastly the innermost layer *"Cognitive style"* will be based on elements from Witkin et al.'s (1977) theory on FD/ FI. The methods of the Rod and Frame Test and Embedded Figure Test were chosen to determine whether the subjects' LSD is Sequential or Global. The dimensions Sequential/Global Stash's (2007) concluded were closely related to the theory of Witkin's et al. (1977) FD/FI. The styles Active/Reflective is also placed in this layer due to their origin from MBTI which as mentioned are closely related too personality traits and therefore also closely related to cognitive style.

2.6 Conclusion of the pre-analysis

Most of the reviewed AEH's focus is on updating the system according to the subjects learning style. As research has indicated that learning styles can vary from different tasks [Wolf, 2002][Akbulut & Cardak]. However, because the subjects have to fill out a self-reported LSI before the system can evaluate them the AEH's are prone to be inconsistent. The downfall with this approach is that the AEH needs to evaluate the subjects through the results obtained from the LSI, which might not be reliable data [García et al., 2005][Akbulut & Cardak][Graf et al., 2009]. If the LSI is too long people have a tendency to become inpatient, hence not filling out the questionnaire with the same enthusiasm as when they started [García et al., 2005]. While most of the AEH focuses is on creating a system, which tailors the learning material based on the subjects' learning styles. It seems that there have not been done any attempts towards developing a method that can collect information about the subjects learning style without them having to fill out a LSI. However, it seem like the only focus has been on creating AEH's that contain concepts such as psychology and epistemology, which of course are relevant for creating an AEH. Furthermore, it seems that the initial step of designing an LSI, which focus on entertaining the user while they provide data via the LSI have been neglected. One can say that the researchers have been somewhat arrogant in their method of collecting data for their AEH's. Learning is of course a serious and important area, however, the researcher should consider the phrase: Catching flies with honey. Meaning that if the researchers want the data from the LSI to be reliable and not suffer the issues mentioned earlier they must provide the subjects with entertainment. The scope of this master's thesis is not to contribute with a new AEH since this has already been done in numerous attempts. However the scope of this master's thesis is to develop a new and updated entertaining version of the traditional LSI. This is where the scope of this thesis differs from other tries to depict subjects' learning styles. While the subjects' learning style have been determined through a self-reported LSI with question based on peoples' own academic self-efficiency this report will focus on developing a LSG that will determine peoples' LSDs through how they solve tasks in a game. One can argue that the game is the 21^{first} century's version of the LSI. However, making an entertaining game, which holds learning elements is not a straightforward task. According to Van Eck (2006) there have been done many attempts on developing entertaining educational games. He states that because these games have been developed by academics with no game development background, such as researchers from

the previous mentioned AEH's there is a danger of "academizing" the games or as Zimmermann said cited by Van Eck "sucking the fun out of it" [Van Eck, 2006 p. 3]. This suggests that educational games should be developed by both game designers academics with an educational background in learning [Van Eck, 2006][Akbulut & Cardak, 2011].

This master's thesis will focus on converting the traditional LSI to a LSG. Furthermore, the only outcome of the game should be to enlightening the subjects of their learning style. Although the intention of the AEH's have been to make a tailored learning experience through using the subjects preferred LSDs. The author of this master's thesis would like stress the important of informing the students of their LSD [Felder & Silverman 1988][Graf et al. 2009].

3 Final Problem Statement

From the investigation done in the pre-analysis chapter it was clear that the attempt of developing a digital game that could elicit subjects' LSDs through interaction within a game had not been done. However, as concluded the focus has merely been on extracting their learning style in most cases after they had finished learning a specific topic. The intention of the LSG is to determine the LSDs through entertaining the subjects. In comparison with the AEH, which detect change in learning style through a learning session the LSG seek to find the subjects' elicit learning style through their interaction with game elements.

Furthermore, it was found that though the research has been thorough within the field of psychology and epistemology there have been little to no focus on the user experience hereunder entertainment.

The proposal of this master's thesis is that digital game elements can be designed to elicit the subjects' LSDs, which could be done through gathering data about the subjects' interaction. It is believed that the LSG could give a result as precise as today's standard self-reported LSI, however much more entertaining. Furthermore, it is believed that if the game is designed with an entertaining focus the task of "filling out" a LSI through playing games would not feel as tedious thus resulting in a true indication of the subject' LSD [Akbulut & Cardak, 2011] [García et al., 2005].

The scope of this master's thesis is to redesign the LSI through testing different digital game elements efficiency for eliciting the subjects' LSDs through playing a game. The result would then form the basis of an in the future redesigned LSI that no more bores the subjects.

The investigation lead to the following final problem statement:

How and to what extend can digital game elements, based on Felder & Silverman's Index of Learning Styles, be designed to uncover subjects' preferred learning style dimensions?

4 Analysis

Through the pre-analysis and later clarified in the final problem statement it was concluded that the scope of this report is to develop digital game elements, which would form the basis research for a future entertaining LSI. However, before the digital games can be developed one first needed to establish the structure of the games and how the different LSDs would be represented in a digital game, which could form the guidelines for a LSG. The following chapter will give a clear definition of both the game tasks connected to the LSDs and how they are combined into a digital game representation of the LSD.

4.1.1 Multimedia Elements

The over all design of the game has to be very simple since the subjects have to be tested in various games. Therefore, is the over all design of the game based on Nolan Bushnell from Atari phrase: "A good game has to be easy to learn but hard to master". For the initial test of the different digital games the goal is to evaluate whether the theory, which will lead to the games would in fact give an indication of the subjects LSDs. This meant that the test subjects are in reality testing the digital games for their ability to be used for eliciting the subjects' LSDs. The construct of the LSG had to be setup such that they think they are being tested for their LSD. The test setup was constructed in this manner because the author believed that if the test subjects where told that the data collected from their test is in fact for the evaluation of the digital games and the theory attached, they might play the game with other intentions. The intention of the LSG and the evaluation of the digital games is of cause to gather data for an in the future LSG, which will be able to gather information based on subjects' scores in the LSG. For now, however, the test subjects work as the important factor of testing the digital games. In conjunction to the evaluation of the games ability to elicit the subjects' LSDs one must first define the multimedia elements and how the different media are used to achieve this. In the game design Clark & Mayer's (2002) book on e-learning and the Science of Instruction will be used as a guideline for the development of the LSG. Though there have been many suggestions towards relevance of using multimedia in educational science [Clark & Mayer 2002] there are also arguments, which suggests that the media in it self does not have any influence on the learning gain. It has furthermore been suggested that learning is influenced more by the content and instructional strategy than by the type of medium [Clark 1994]. However, what is Clark really implying with the notion that media does not influence

learning? To answer this one must first define what media is in the context to this thesis. According to Doolittle's (2002) walkthrough of different definitions of multimedia, media refers to the tools, being used to deliver the instructional content of a e-learning course e.g. movies, music, audio, plain text, animation and photographs. This definition is comparable with the argument of Clark (1994) who suggests that media is the mere vehicle that delivers instruction but do not influence learning achievement. Furthermore, Clark argues that any given media must be present in order of learning to occur and that certain types of media are more efficient for certain learning goals [Clark 1994]. Since the medium in this thesis has some relevance in the form of designing a game that can elicit the subjects' LSD this argument has some relevant point of views towards the design of the LSG. The LSGs were not developed to teach nor was it expected that the use of these game would enhance learning. However, as for the design of them the argument suggests that the LSGs should be based on the content, in this case the theory of preference from the different LSDs, and not the media, which would drive the LSGs. In account to this Clark (1994) further argues that the teaching style has influence on the learning gain. This argument is in conjunction to the theory of Felder & Silverman's TSD which focuses on accommodating for the LSD of the students by in cooperating students' preferred LSD in the teaching. Likewise this could be compared to the design of the LSGs. While the overall focus is on the theory which defines the content of the games it is the means of the media, which makes it possible to interact with the games and through the interaction provides the system with data for evaluation. Based on these notations the structure and use of multimedia tools will adhere the above analysis of Clark (1994).

Clark & Mayer (2002) start the process of designing an e-learning course by defining the performance which they referrer to as the performance analysis. This stage takes in to account two very important questions. What is the goal of the game i.e. what does the course seek to give the subjects? This question can easily be answered. The answer is the LSG seeks to enlighten the subjects of their LSD. The second question asks how and what media this should be done through. The answer is a digital game.

Though there is no learning taught in the LSG the subjects still have to perform tasks, which is being either demonstrated or told. Therefore, in order to design a framework that to say holds the subjects hand while being guided through the game the instructional methods and media

elements needs to be designed [Clark & Mayer 2002 p. 90]. Clark & Mayer (2002) suggests that when using animation to convey narrative one should not use onscreen text because it hinders the learning, due to cognitive overload. They give the example that when the eye is engaged with reading onscreen text it cannot simultaneously be looking at graphics, which causes cognitive overloads. They further suggests that one presents the onscreen text through speech, thereby hindering cognitive overload because the eye will be processing the graphics while the ears are processing the word via the speech. Therefore, in order to avoid cognitive overload and because the product of the report is a game with many animated characters it was decided not to use any onscreen text in the LSG.

4.2 Game Design

Good game play is often mentioned when referring to the evaluation of games. However this does not say anything about the game. According to Costikyan (2002) this is like saying that it is a good book. So how does one create a good book or in the context of this report how does one create a good LSG? The next section will focus on the overall game design of the LSG and the means used to achieve "good" game play.

4.2.1 Every game is interaction

According to Costikyan (2002) interaction and game are two interchangeable words use to express the same action. Meaning that if a person refers to a game as being interactive it bares no resemblance to a computer game. It merely refers to any sort of game that one can interact with. This could be a board game, football, basketball, or a role-playing game. In short every game is interactive [Costikyan, 2002]. So if every game is interaction how is the interaction in the context of the digital games? Interaction covers many different medias [Ryan, 2001 p. 206]. Therefore before moving along with this chapter a short definition of the *interactive* game is needed. Interactivity can be many things and the term stretches from interactive books where the reader has the choice of structuring the outcome of the book as he/she prefers to online MUDs[3] [Ryan, 2001]. Therefore, when using the term one must declare how it is used in regards to the subject. The definition of interaction in this report will be derived from Ryan's (2001 p. 206) seven variables of interaction.

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[3] Multi-User Dimension

1. *"To determine plot"* which covers a multiple-choice session where the user has the choice of doing A or B. This variable however has not influence on the LSG.

2. *"To shift perspective on the textural world"* among the topics this variable covers the on found relevant for the interactivity within LSG was entering a new world. This interactivity was picked with the different sub-games in mind. Every time the subjects enter a sub-game they were presented to a new problem statement hence a new world.

3. *"To explore the field of the possible"* The purpose of the interactive is not to determine the plot it is rather to explore. The intention of the LSG was to encapsulate the LSQ in a game narrative in which the subjects could explore rather than developing a complex plot.

4. *"To keep the textural machine going"* The user moves the cursor over an image which then would animate indicating clickability.

5. *"To retrieve documents"* among others referred to a textbook like system which guides the user/student through educational material thus making the student his/her own tutor. This seemed to hold resembles the concept of e-learning which also was the argument for it being included.

6. *"To play games and problem solve"* This variable is somewhat self-explanatory.

7. *"To evaluate the text"* This variable was included due the interactivity the subjects have to perform when evaluating the their results and the game.

Apart from the above-mentioned interaction variables the links to the sub-games will be destroyed when subjects has visited and completed the tasks. This will be done to work as a "guide" through the game and because that it is not possible to change the score of the game, hence changing ones learning style. Having established the variables of the interactivity in the LSG the next step is to the assigning task and measurements based on the defined LSDs.

4.2.2 Approach to learning style measurements

Having discussed cognitive and learning style as a concept and identified the dimension of learning as being Felder & Silverman's the next step is to look at the evaluation of data. Felder & Silverman's LSQ was developed as a tool for engineer instructors as the means of

structuring a better, more suited lecture for the students [Felder & Silverman, 1988] and not as it will be used in this report for an e-learning game developed for detecting learning style, the TDS can still be directly adapted. If one compares the structure of the game with the learning style concept model developed in [Defining the Concept of Learning Style, *chapter 2.5*] the e-learning game is the learning environment i.e. the TSD because it provides the information, which the subjects need to process. This however means that the LSG needs to be in charge of "grading" the subjects' interaction, hence the grading concludes their LSD. This should be done through a system evaluates the subjects performance during game time [Dorça et al. 2012]. The framework devoted to evaluate the subjects is highly inspired by García's et al. (2005) way of structuring the different tasks required for the different LSQ's.

4.2.3 Objective Method

To evaluate the data retrieved from the subjects' scores one first needed to determine the different variables and their importance for the system. As the game is measuring for different traits within the domain of Felder & Silverman's LSQ the variables need to represent these domains, namely: Perception, Input, Processing and Understanding can be found in [Felder & Silverman]. As in the case of Garcia et al., (2005) the system will be evaluating the subjects based on the four LSDs. Meaning that for each game there will be a situation where one of the four dimensions is the key dimension being tested in the game. Here the task is to evaluate the time taken per game and/or how many answers they answered correct in the game. This was done through determining tasks, which reflect elements from the different dimensions. This is based on Felder & Silverman's description of what the LSD prefer [Felder & Silverman's Learning Style Inventory, *chapter 2.3.4*] and on theory from both Witkin's FD/FI [Witkin Field Dependent /Field Independent styles] and from Clark (1994) and Clark & Mayer (2002) guideline for using multimedia tools to drive the instructions [Multimedia Elements, *chapter 3.1.1*]. In order of keeping the tasks clear they were divided in to three levels and one index page whereof the different LSD will be incorporated as the tasks see Figure 7.
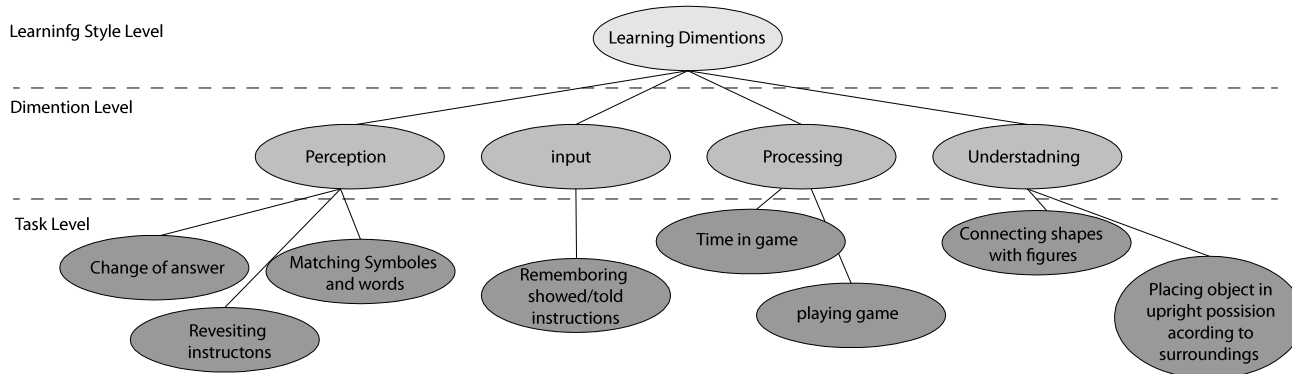
Figure 7 The flow of tasks according to the LSD - Inspired from García et al. (2005).

To determine the Perception dimension the setup is looking at how much time the subject spends viewing the figures before answering, change of answers, and ability to understand symbols and text. If the subjects' learning style is Sensory he/she will struggle with the combining of symbols and text and will therefore spend more time on games dependent of his/her ability with these elements. Furthermore, the subject with the LSD Sensory would, if allowed spend some of the time revisiting instructions. Subjects with the bi-polar learning style Intuitive will however solve games with symbols and text with ease. He/she will however not spend much time on evaluating their answers and unlikely to change answers or revisit instructions. This could lead to many unseen mistakes in the case of the intuitive whereas the sensory would have noticed the mistake.

To determine the *"Input"* dimensions a game will bee developed where the subjects first are instructed on how to do something. This instruction is done either by showing it (Visual) or by telling it (Verbal). The evaluation will then be based on how many correct answers they had.

To determine the *"Processing"* dimensions a setup of how much time is spend before entering a game and how much time is spend in the game and the time spend from answering one answer to the next answered question will be used to evaluate this there will be made two buttons of action before entering a game. These buttons will have two options written on them. The first is watch again and the other is start game. The first button is related to Perception dimension and the other is related to the Processing dimension. The evaluation is done as the following; if the subject presses the start game button fairly quick after having been introduced to the game they will get a point in learning style Active. However if the

button is pressed much later than expected it would seem that the subject needed to reflect on the instruction before entering the game hence getting a point in learning style Reflection.

The last dimension *"Understanding"* is the most complex dimension to evaluate. How can one evaluate if the subject has understood something when the game is not teaching the subject anything? To evaluate the *"Understanding"* dimensions the game will be build based on Within's et al. (1977) method of evaluation cognitive style of FD/FI namely the Embedded Figure Test and the Frame and Rod Test [Witkin Field Dependent /Field Independent styles]. These games will evaluate the subjects from performance. Witkin's et al. (1977) test has been proven reliable and valid for testing cognitive styles.

4.3 Game structure and tasks

For a game to be entertaining there need to be struggle. If there is not struggle in the game it simply is not a game [Costikyan, 2002]. As clarified in the previous section on Approach to learning style measurements the game structure has to include the four dimensions Processing, Input, Perception and Understanding. These dimensions are directly derived from Felder and Silverman's LSI. However the tasks or the games that are going to evaluate the subject still need to be clarified. In Wolf's (2002) iWeaver AEH he had divided the learning styles into different tasks in the system and through this scored their learning style. This approach and the approach of García et al. (2005) branch structure will be adapted to the LSG. It was decided that the LSG should consist of three game levels of which would contain a number of games. Each game level would have a learning style of focus and a subset of learning styles in which one could gather points. These games were highly inspired by the instruments of Witkin and the multimedia tool indexation of Wolf (2002).

The task for the LSD Perception was in the previous section defined as change of answer, Matching symbols and words, and revisiting instructions. This will be clear in sessions where the subject has to drag and drop elements. The task covering revisiting instructions will be presented as a button of where the subjects after an instruction is provided the choice of getting the instructions showed again. For the matching of symbols and words there will be designed a game that will challenge the subjects ability of combining words with symbols. This will be done through a simple memory cards game where the subjects will be evaluated

on the spend time and on how many tries it took them to complete the game. For the tasks involved for the *"Perception"* dimensions there will only be designed one game.

For the LSD of "*Input*" there are designed two tasks where one has to performing a task based on instructions given by a character in the game. The first game consists of the instructor showing the subjects what to do and the second game consisted of the instructor telling the subjects how to perform the task. The subjects will then be evaluated both on how many of the instructed elements he/she had correct and on how much time was spend on performing the task.

The LSDs of "*Processing"* is based on the time taken to complete the game and on how much time the subjects spent before entering a game. An example of this could be if the subject does not spend much time before entering the game chances are that his/her LSD is "Active" however if he/she spends more time on entering the game than the previous subject did he/she might have the LSD "Reflective", hence giving the indication of having to think about what have just been instructed. Here it should be noted that there have not been done any test on how much time people with the LSD "Reflective" spend in average before entering a game. This data will however be gathered in the test of the game.

The last LSD *"Understanding"* will be games, which are directly based on the concept of two of Witkin et al (1977) three FD/FI measurement methods namely the rod and frame and the EFT. In the case of the rod and frame method the evaluation will be based on the degrees of the frame and the degrees of the rod. Meaning if the rod is placed in an angle of 0 +- 5 degrees the rod is assumed upright and if the rod is placed in an angle, which corresponds to the frame the rod is assumed not upright. For the EFT the evaluation is based on how many of the showed embedded figures the subjects have located and on how much time they spend on it.

The test of the different LSD would be designed to evaluate if there has been any correlation between what the digital game had evaluated and the results from FSLSI i.e. if the test data shows that the subjects with the LSD sensory (based on the Felder & Solomon LSQ) are slower at solving the memory game than subjects with LSD intuitive, then there is evidence for that the game is correctly designed to measure the LSD sensory/intuitive. However if the data shows otherwise the digital game has failed and must be redesigned. While it is somewhat naïve to base the gathered data from the digital game on the results of a LSI based on the

downfalls of a LSI suggested in [Evaluation of Adaptive Educational Hypermedia from 2000 - 2011, *chapter 2.4.3*]. However, one must keep in mind that creating digital games for evaluating subjects' LSDs has not been done in the same manner before. Therefore, one must first evaluate the results through the results from the LSI. However, the goal in the future is to discard the LSI and use the LSG as the basis for evaluating subjects' LSDs.

4.4 Game and Visual Aesthetics

Having established the interaction elements of the digital game elements the next step is to investigate what theories the aesthetic elements would follow. There have been developed many aesthetic theories on how to design a compelling artificial game world one of which is the aesthetic theory of Ryan (2001). When addressing the virtual world Ryan uses the term immersion, which she compares to the state one is in while reading a good novel. Ryan further states that the readers are aware of the fact that the world in the novel is not real:

> *"The question is not whether the created world is as real as the physical world, but whether the created world is real enough for you to suspend your disbelief for a period of time"* [Ryan 2001, p. 89]

Ryan defines this as the textural world [Ryan 2001]. Ryan's description of the textural world is a reality, which is constructed by a language that refers to objects, characters and locations through linguistic expressions. She depicts that the reader builds up the textural world in their imagination through information provided by the cognitive models such as real-life experience and cultural knowledge including knowledge derived from other texts [Ryan 2001]. What does this have to do with the artificial world of digital games? One could compare Ryans's (2001) notion that the textural world represents a world on paper in which the reader disappears into with game designer Adams' (2009) notion that a game world is represented by graphical animated and interactive elements which the player chooses to imagine themselves into. Furthermore, according to Adams (2009, p. 49), the term "suspension of disbelief", which is often used in the game, industry has come to mean immersion. Adams explains the game words as the following:

> *A game world is an artificial universe, an imaginary place in which the events of the game occur. When the player enters the magic circle and pretends to be somewhere else, the game world is the place she pretends to be [Adams 2009, p. 84].*

Adams' description of the game world and Ryan's description of the textual world is somewhat similar. Both emphasise the fact that the subjects' believe that the world is real. Whereas Ryan describes the textual world as being real enough to suspend ones disbelief Adams describes the game world as the place where the player pretends to be. One could conclude that both Adams and Ryan are describing the same state only through different media. Although the immersion of the subjects is not part of the scope of this Thesis there are still some important elements to be include when designing an artificial game world. Furthermore the theories raise important aspects to consider when dealing with aesthetics in relation to content and character design. One could compare immersion in a textural world to the cognitive process of a character designer. When a character designer starts designing the character for a game, cartoon or a computer image generated animated film he/ she is introduced to the character via the textural world in the shape of the script. The character designer is influenced by the same cognitive models as the reader is when understanding the textural world of the script [Ryan 2001]. The character designer bases the design of the character on his imagination, cultural knowledge, real-life experience and research from others artwork, invoked by the script. Whether it is for an animated shot or for a game the characters are the most important aspect. This is especially evident in Disney's twelfth principle appeal [Thomson & Johnston 1995, p. 69]. However this word requires some explanation. Appeal as one might think does not suggest cuddly bunnies or floppy kittens [Thomson & Johnston 1995]. Appeal refers to elements which people like to see, i.e. charm, pleasing design, simplicity, communication, and magnetism. Thomson & Johnston described this further by using the example of one's eye. One's eye likes to look at objects or people, which we fine pleasing or as mentioned appealing once our eye has found a appealing character or objects it will keep coming back [Thomson & Johnston 1995]. For the designing of appealing character animators from Walt Disney's studios' had to use elements from all of the twelve principles. It was said that if a character lacks appeal it is because one of the other eleven elements are poorly designed [Thomson & Johnston 1995]. For the designing of the characters the designers at Walt Disney Studios' has three choices of style when designing

characters [Furniss 2008]: form, texture and line. The shapes of forms can be described as organic or geometric. Organic shapes typically are those in nature and tend to be curved soft and irregular. They usually impact a comforting feel. Geometric forms are the shapes, which are often associated with mathematical figures. They tend to give the feeling of structure and strength [Furniss 2008]. Texture refers to the way a surface looks: Smooth, rough, velvety, hairy, crystallized and so on. Texture creates visual interest and subtly provides information to viewers. Line quality is the domain of 2D animation where artists have many choices. Hard-edged lines are rigid and firm Gestural lines are free flowing and spirited and can energize a work. Most production medias tend to use Hard-edged lines because it is faster [Andersen 2012].

Because the focus of this thesis is on making a LSG, which is entertaining while it elicit the subjects' LSDs the final product needs to encapsulate the aesthetics derived from game designing principles such as having a goal, struggle and task solving. Among these elements are elements such as adhering the style of the game and narrative. E.g. In a game where the aesthetic style is based on Walt Disney's twelve principles the characters and the environment would have to rely on these principles i.e. the character would be able to squash and stretch, the drawings should be solid and the objects should adhere the slow in slow principle. The overall definition of aesthetics in this report is drawn from the definition on immersion, Ryan's textural world and on the aesthetic theories from animated sequences with respect to Walt Disney's twelve principles [Thomson and Johnston 1995]. Furthermore, the characters will rely on part of Ryan's definition of emotional immersion in which the characters are created as pseudo-human being who mimic the dimensions and aspects of real-life people and therefore have to act according to the environment of which they are represented.

4.5

Reliability and Validity

In Felder & Spurlin's (2005) setup for determining reliability and validity they indicated that there were a correlation between two of the four LSD namely the sensing/intuitive and global/sequential. Further they sat Cronbach's coefficient alpha accordingly to Tuckman's cited in Felder & Spurlin's (2005). The quality being measured reflects a preference or an attitude for which the accepted alpha is 0.05 or greater.

This same approach will be used in the evaluation of reliability and validity in this report. Furthermore, in order to detecting the reliability of the LSG there needs to be a quantifiable correlation between the above mentioned two LSDs Sensing/Intuitive and Global/Sequential. The reason for this is due to use of the Felder & Solomon LSI in the game and in the questionnaire. As the study is measuring whether a game can uncover certain preference adopting the method of Felder & Spurlin (2005) should give the preferred indication of the digital game's reliability and validity in regards to the Felder & Solomon LSI.

4.5.1 Classical Concepts of Reliability

The measure should be consistent and stable over time, meaning that it should give comparable results if administered under comparable conditions [Sechrest, 1984][Andersen, Hansen & Lumbye, 2012].

- Inter-rater reliability: How well test conductors agree on the results gathered

- Test-retest reliability: The measure should be stabile enough, such that a retest provides the same results as the initial test.

- Parallel forms: How consistent the method is comparable to other similar methods

- Internal consistency reliability: The degree to which multiple cases in the test share the same characteristics. This can be expressed using Cronbach's alpha.

4.5.2 Construct of Validity

The other key factor is the validity, which means the measure should assess the intended construct, and can be assessed in the following factors: [Sechrest, 1984] [Andersen, Hansen & Lumbye, 2012].

- Face validity: How well the method addresses the test material and appear to measure the construct (subjective to the test conductors)

- Content validity: The measurement should match the content domain of the material meaning it should be compatible with theories within its intended domain.

- Criterion-related and construct validity: How comparable the method is to other measures of criteria.
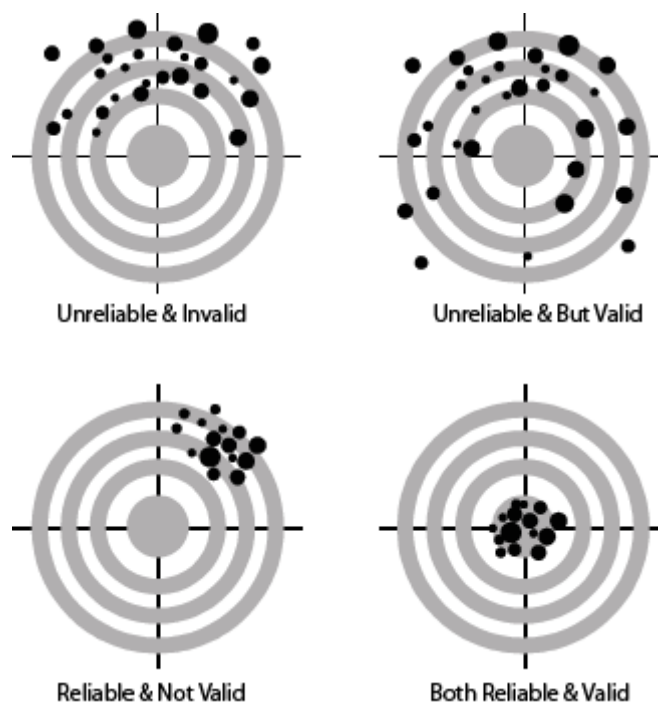
Figure 8: visual representation of the four different reliability and validity stages [Andersen, Hansen & Lumbye, 2012]

5 Method

The framework for this study relies on a combination of a subjective and an objective measurement method. The subjective method consists of a self-reported LSI to determine the subjects' cognitive and learning styles [Conclusion of the pre-analysis, *chapter 2.6*]. The LSI used in this study is designed by; Felder and Solomon[4], which will work as the data that the LSG will be compared with. The game design of the LSG will therefore be designed based on the Felder & Silverman's LSD theory. The objective method involves a number of problem solving games where the subjects before playing the games will be introduced to the game by an instructor. Each game will be tested for its ability of eliciting LSDs through an evaluation of the subjects' results. If there is significant difference in the results between subjects who based on the Felder & Solomon's LSI are e.g. Sensory and Intuitive, game can be used for evaluating LSDs. Using a LSI for evaluating the result from the LSG might be an issue as mentioned in [Conclusion of the pre-analysis, *chapter 2.6*]. However, the evaluation will still have to be done through using the results from the LSI. Moreover, the original issue was connected with the use of the static result of a LSI taken at the beginning of a university semester. In the case of the LSG the evaluation will happen within a short time span hence, it will be considerable more reliable.

5.1 Felder & Silverman's Learning Style Questionnaire

The LSG for the subjective part of the method is directly based on Felder & Silverman's LSI. There have not been made any adjustment towards the form and the content of the questionnaire. The only adjustment there have been made is the conversion of the online version uploaded by Felder [Felder & Solomon]. The LSI is a 44-item questionnaire with two forced-choice questions A or B, where one has to evaluate the 44 questions based on the given two answers A or B. The answers are then evaluated based on a scoring system where A is scored plus one and B is scored minus one [Felder & Solomon]. The points are then divided into the bi-polar scale of the learning dimensions evaluated from score ratio of 5 to 11 and -5 to -11. Furthermore there are LSDs, which are more dominating and if there is a tie this LSD will be applied in favour of the other.

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[4] Felder & Silverman developed the theory for the LSDs and Felder & Solomon developed the LSI based on Felder & Silverman's theory

The Learning Style Game

Example question from Felder-Silver Learning Style Questionnaire

This first question relates to the Processing LSD namely whether the subjects' are active A) or reflective B).

I understand something better after

A) Trying it out

B) Thinking it through

This second question represent an example of how the LSD Perception would look. In this example subjects can chose sensory A) or intuitive B).

I would rather be considered

A) Realistic.

B) Innovative.

This question is a typical representation of the LSD Input question. Whereas the A) is Visual and B) is Verbal.

When I think about what I did yesterday, I am most likely to get

A) A picture.

B) Words.

This last question is an example of how questions regarding Understanding are formulated in the Felder & Solomon LSQ. Whereas A) represent A) is the Global dimension and B) is the Sequential dimension.

I tend to

A) Understand details of a subject but may be fuzzy about its overall structure.

B) Understand the overall structure but may be fuzzy about details.

For a better overview of the LSI see [CD Appendix A] or visit the [Felder & Solomon].

5.2 *Game genre*

Even though the LSG is going to be designed as a game with no educational elements it was decided to base the design on elements from the genre of e-learning. The e-learning genre is defined by Clark & Mayer (2002 p. 13) as being instructions delivered on a computer either by Internet, Intranet or CD-Rom. Most e-learning courses contain features such as instructional methods i.e. examples and practice to help learning, content relevant to the learning object, and media elements i.e. words and pictures to deliver the learning material, which seeks to improve knowledge, skills and performance [Clark & Mayer, 2002]. Furthermore, the LSG of needs to include regular game feature such that the subjects might find the game entertaining. Therefore, in order to add entertainment to the game the genre will be a combination of standard e-learning features and a graphical adventure game. This will allow the subjects to assume the role of the protagonist in an interactive narrative where the goal is to solve different puzzles in order to gain their LSDs. The genre graphical adventure game was chosen due to the possibility of including an interactive narrative. This type of game is especially good for including literature and film elements [Adams, 2009 p.547]. There are many similarities between an adventure game and an e-learning game. The driven factor is in both genres the narrative. In comparison the instructor, introducing the learners to a puzzle, which they have to solve, can be seen as the narrator in an adventure game. Furthermore, both game genres are controlled by small games like scenarios where the subjects have to solve puzzles in order to reach the next level. The two genres are even similar in their construction of plot. The original adventure games did not have a plot. The only thing an adventure game offered were a space to explore and solve puzzles [Adams, 2009] much like a traditional e-learning course. However, one can argue that the plot of an e-learning course is to educate. Even though many of today's adventure games are designed in 3d the design of the LSG will be in 2d. This was decided because the author of this thesis has more experience with creating 2d games.

5.3 Narrative interactivity

"Creating an exiting interactive narrative requires the ability of creating an immersive experience, and the classic narrative structures are the most-tested recipe for keeping the user spell bounded" [Ryan 2001, p.244].

The above citation is, according to Ryan (2001), the views of developers of interactive texts in the commercial sector. According to them there are little to no potential of combining narrative with interactivity. In addition to this statement there has been much debate about the place of narrative within games [Adams 2009]. Although this debate is beyond the scope of this report there are still some important elements to consider. As the focus of the LSG is to make a game, which can elicit the subjects' LSDs while entertaining them, one must consider how this best can be implemented. First of all making a game, which entertains while evaluation the subjects requires some type of understanding of what entertainment is. The genre of the LSG was chosen to be an adventure game, and according to Adams (2009) this genre requires narrative. Adams (2009) furthermore, gives four reasons for why to include narratives in games. On of the reasons are that adding narratives to the game would add significantly to the entertainment value of the game. Adams (2009) states that a game without narrative is a competition, which is exiting however, artificial. Furthermore he stated that the player would feel a sense of purpose through the narrative. The goal of the LSG is to play a number of different games based on the theory behind the LSDs. Therefore, adding narratives to the LSG will according to Adams' (2009) theory make the tedious task of completing a number of games in order to get ones LSDs entertaining. Ryan (2001) argues that the compatibility of narrative and interactivity relay on how narrow the narrative is defined.

For a more depictive definition Ryan divided the narrative structure into three forms of interactivity related to the narrative:

- Sequential interactivity: The system controls the events without much user involvement ordered in a temporal sequence: "The king died, then the queen died". There is no causal connection between the events.

- Causal interactivity: Causal events linked together by interpretation: "The king died, then the queen died of grief"

- Dramatic interactivity: A narrative structure that relies on the Aristotelian principles of storytelling [Ryan 2001, p. 245].

In relation to the above three defined interactivity types where the subjects are presented with a narrative and plays to solve a problem. The structure of the game narrative could be compared to sequential interactivity where the subjects have very little influence on the process of the game.

For the purpose of constructing a storyline, which the subjects can follow in order to feel a sense of purpose one needs to add a narrative, which relates to the content of the LSG. Clark & Mayer (2002) defines e-learning content as the stage where the tasks are developed in coherence with the educational objective. Therefore, the next step is to design the flow of the story. However due to time limitations the narrative of the game will be shortened down to a simple script and the complexity of the game challenges will be held at a minimum. The script can be found in [Appendix B]. Due to the nature of the digital game the storytelling can be somewhat different from subject to subject. As mentioned in [Every game is interaction, *chapter 3.2.1*] the interactivity of the game will be clickable elements hereunder links, menus and games. Furthermore, it was decided that the subjects after having finished one of the digital games, would not be able to play it again because the links would "self-destruct" [Every game is interaction, *chapter 3.2.1*]. This was decided due to the fact that they would be able to change their outcome, and therefore not provide true results of their performance in the game. Therefore, the choice of the storytelling fell on Ryan's interactive narrative structure "The Maze" (The maze is illustrated in Figure 9). This model was chosen because it, according to Ryan, has the characteristics of an adventure game where the subjects will try to find the path from the starting point to the ending of the game. As the chosen genre of the game is a graphic adventure game the maze structure is perfect. Furthermore, the maze structure makes room for designing a system, which will evaluate the different states of the game and then change according to the game state.
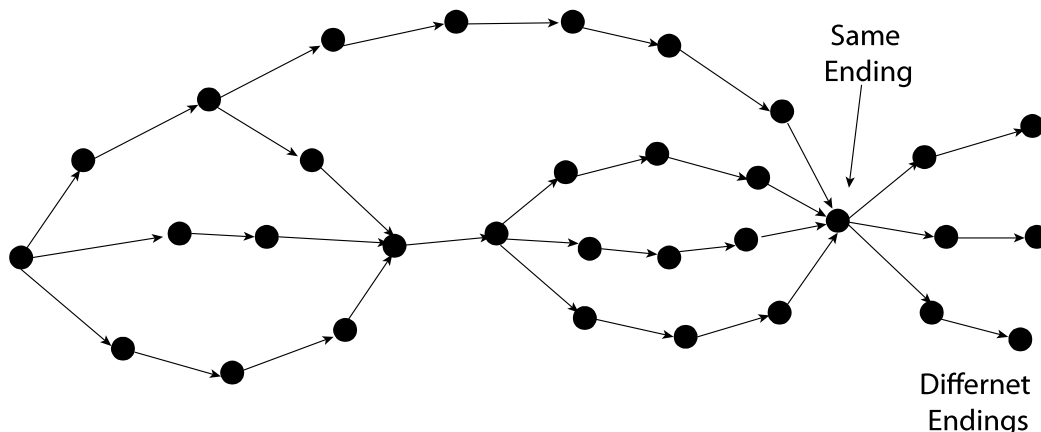
Figure 9: The maze structure of an adventure game [Ryan 2001, p. 251].

The maze structure of LSG would look as shown in Figure 10. Though this maze design is somewhat simple there still is somewhat complex. First of all the order of how one completes the games has no influence on the narrative or on the ending. Furthermore, there is placed an evaluation state in the three games *"Game 03-02", "Game 02-02"* and *"Game 01-01"* which will check the state of the games. If the subjects have completed all three games the evaluator will send the subjects to the *"Ending"*. The forced FSLQ[5] in the maze structure of the LSG the subjects would be told that they have to complete a LSI before they cal play the game. After the subjects have filled out the LSI they will be sent back to the starting point.

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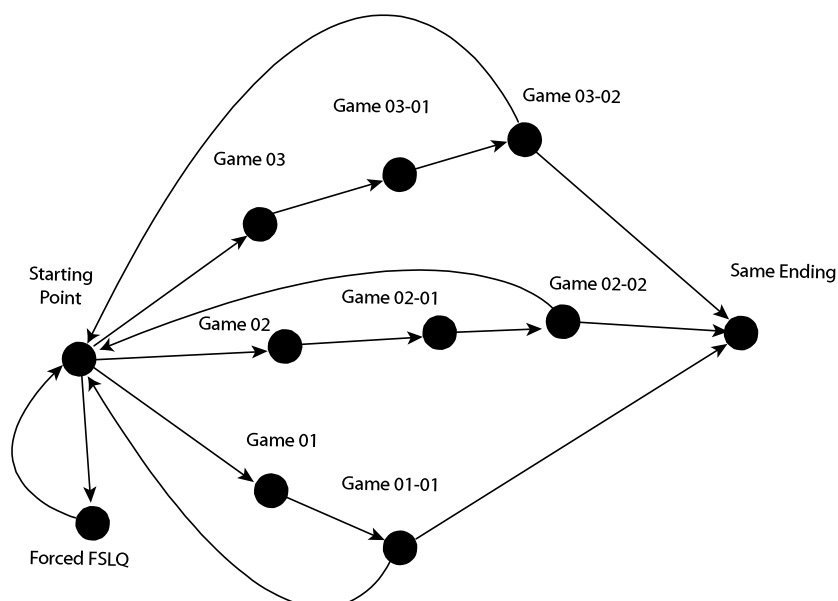
[5] Felder Solomon Learning Questionnaire

Figure 10: The semi-maze structure of the LSG.

The maze structure of the game is designed to include Aarseth's two types of experience, cited by Ryan (2001, p. 251), namely aporia and epiphany. Where the different states of the games showed in the Figure 10 represents the state in which the subject will get the experience of epiphany, through solving puzzles. For the aporia this occurs when the play reaches a game for which the challenge is too hard for them. At this point there are no other way of getting further other than either solving the puzzle or using the menu to change level. The happy ending is the final scene where the subjects receive their LSDs from the game. As mentioned in [Game Design, *chapter 3.2*] the test setup of the game will not reflect LSDs based on the results in the game but from the LSI. In a future version of the LSG the LSDs will be provided from the game and not the LSI.

6 Requirement Specification

Based on the analysis, the specified final problem statement and the method, the following specification of requirements are established:

- A self-reported questionnaire for checking to gather data, which the evaluation of the learning style game will be based on.

- Challenges should incorporate Felder & Silverman's four learning style dimensions.

- An introduction to the world, in the form of an animated, narrator introducing the subjects to the game and user interface.

- The game should be a mix of the two genres; Adventure game and e-learning game.

- Subjects should be able to navigate through the game through the use of the mouse.

- The user interface should be simple and intuitive rather than complex and confusing.

- The game should be able to register the users interacting within the game.

- The game should be able to gather the subjects' data from the test.

7 Design

Having established the concepts needed to evaluate learning style in a LSG, the next step is to design an aesthetically pleasing interactive environment that the subjects can interact with. In [Multimedia Elements, *chapter 3.1.1*] it was decided that the LSG should be a digital game, which is will be played on a computer. The LSG will therefore be developed in Adobe Flash, which requires that the computer is capable of showing swf[6]. The requirement of the hardware is that it should be capable of calculating graphical images, as the genre of the game is a graphic adventure game. Because it was chosen in [Game genre, *chapter 4.2*] to make the game in 2d quality of the artwork can be very high. In the following chapter the design process of the two main parts of the project; the aesthetic design that accommodates the LSD theories, and the design of the characters will be presented.

7.1 The Conceptual Storyboard

The task of the animator or level designer is, to convey the emotions of the script into facial expressions and exaggerated poses [Kerlow, 2009]. The flow of the conceptual storyboard should work as a guideline for the artists as it is the visual interpretation of the script [Kerlow 2009, p. 326]. As mentioned in [Game and Visual Aesthetics, *chapter 3.4*] the characters of the story should represent their environment and one should be able to relate to the characters authenticity. The composition of the game is also very important in relation to the narrative of the game. Therefore, before beginning to draw the storyboard one must first decide on the format. This is especially important to have decided prior to the storyboarding phase because it the format dictates the size of the storyboard frame. If the storyboard is designed before the format has been chosen the composition of the objects could be wrong [Bacher 2008]. Therefore, the first task it to decide on the format. As the game was designed for computers the format had to represent the resolution of the average computer screens worldwide. According to W3Schools.com, which is an online documentation website for most web programming languages i.e. HTML, CSS, JavaScript etc. and where web developers can get an overview of different browser, display and operation system statistics, the average person uses a display resolution higher than 1024x768 pixels [W3Schools, 2011]. They base their

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[6] Shock Wave Files

statistic on the monitoring of peoples log-files. Therefore based on this information it was decided to make the format 1024x768 pixels. Therefore, based on these facts the pixel format was set to 1024x768 pixels, since this was the average screen resolution. Having decided the pixel format the next step is to design the game narrative. For this the storyboard as mentioned is a very useful tool, thus if the story is not told properly through still images in the storyboard phase it might ruin the entire game narrative [Kerlow 2009]. A good example of a well-designed storyboard can be seen in Figure 11, which shows the progression of one frame in ILM's Rango.

Figure 11: Shows the process of a single frame from the storyboard to the final shot in ILM's Rango [Fxguide.com 2012].

The settings of the graphical universe in the LSG are inspired by a circus/carnival, hence the analogy of the fortune-teller who reveals ones future or as in the LSG reveals ones LSDs. Furthermore, it is important for the author that the subjects can relate to environment both from experience of being at the circus as a child and the mysterious atmosphere this kind of place encapsulates. As the subject will spend much time in this environment both the graphics and the composition of the game scene is designed such that it will appear appealing to the subjects. Having designed the characters and written the script makes the process of designing the storyboard a fairly simple task. The only complicated task is to make an engaging composition for the viewers. The design of the environment will be done such that the subjects will chose to imagine them self's into the game as mentioned in [Game and Visual Aesthetics, *chapter 3.4*]. This will be done through a well-designed Mise-en-Scene [Bordwell &

Thompson 2010]. According to Bordwell & Thompson there is a resemblance between a film shot and a painting. As with a painting a film shot is constructed from an array of colour and shapes. Bordwell & Thompson explain that before one starts to read the picture as a 3d space Mise-en-scene guides the attention of the viewer through cues and by emphasising elements in the frame [Bordwell & Thompson 2010 p. 148]. For the composition in the game and storyboard the focus will mainly be on creating a balanced composition where few elements will guide the attention of the subjects to the characters and the games. This was decided s due to the importance of the characters' introduction of the game and the importance of the games in the LSG. Furthermore, the author found it important to create a balanced composition because according to Bordwell & Thompson, filmmakers often make an unbalanced an image in order to signalling the viewer that something will change in the frame. This is very much unwanted in the case of the LSG because the focus needs to be on the task at hand and not on changes in animation or the frame. Part of the storyboard is illustrated in Figure 12
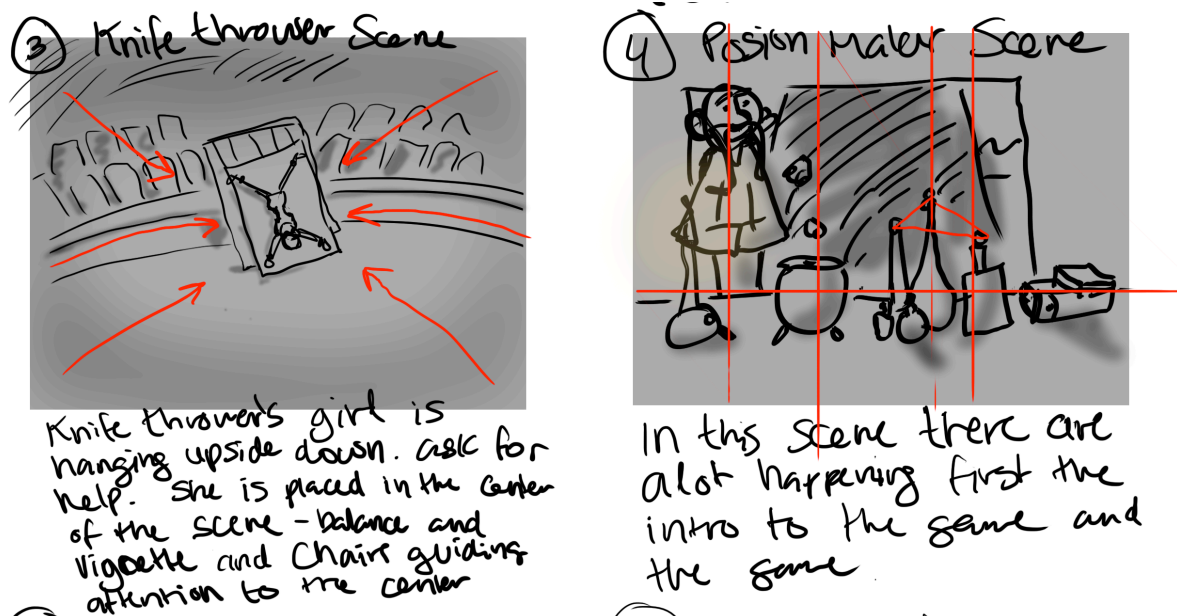
Figure 12: Example from the storyboard. For the entire storyboard see [CD Appendix C]

According to Bacher (2008) one of the concept artists behind the storyboard and concept art of Walt Disney films such as Beauty & The Beast, The Lion King and Mulan, does a good film consist of a well-planned composition of different staged shots, like the ones of thumbnail sketches [Bacher 2008], which can also be referred to as the conceptual storyboard [Kerlow

2009]. As can be seen in Figure 12 the first frame, number three "Knife Thrower Scene" guides the attention of the viewer towards the centre where the game and narrative is taking place. The reason for this is to because the game setup required that the subjects' focuses on the knife thrower girl who they have to place in an upright position. *[Witkin Field Dependent /Field Independent styles, chapter 2.3.3*]. In the Second frame number four "Poison Maker scene" the composition, is based on the technique "framing within the frame" [Bacher 2008] This technique deliberately directing the attention of the viewer on to the table where the game objects are placed. In this way makes sure that the bottles are the first thing that the subjects see in the game and then when the Poison maker addresses them he will be en focus. Furthermore, to make sure that the subjects see the bottles first and the poison maker the bottles have been placed directly in the centre of the golden ratio.

7.2 *Character and scene design*

When character designers receive the script there formal work is to interpret the script characters into visual characters. First of all one must clarify how the functionality of the character being designed should be. Meaning how much animation is the character going to perform. This is important because it relates to the structure of the character design. Luckily this can be determined through the use of the storyboard. Furthermore, one has to determine the visual style of the both the character and the environment. As mentioned in [Game genre, *chapter 4.2*] the game will be designed as a 2d graphical adventure game. Therefore, to accommodate this the artwork was designed through the use of the standard animated cartoon techniques of Walt Disney *[Game and Visual Aesthetics, chapter 3.4*]. Furthermore, the look of the characters will be designed such that their role in the game is clear. As Kerlow (2009) suggested the character is defined through subtle visual elements such as posture, hand movement, facial expression, timing and how he/she moves. On the more technical hand this means that one should take all these subtle but important aspects into account when setting up the design and structure of the character. Furthermore, because the characters has to be designed for use in Adobe Flash[7], which is a vector graphic based program, all the

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[7] http://www.adobe.com/products/flash.html

artwork will first be sketched in Adobe Photoshop[8] and later traced in Adobe Illustrator[9] see Figure 13

Figure 13: Shows the design process of the fortune-teller from sketch to final design.

The cartoon like stroke and overall visual look of the characters is achieved by using the blob tool in Illustrator combined whit the use of a Wacom Intuos 3 tablet[10]. As mentioned in [Game and Visual Aesthetics, *chapter 3.4*] the 2d cartoon artist has the option of choosing between different line styles whereas Hard-edged lines are rigid and firm Gestural lines are free flowing and spirited and can energize the work. For the aesthetically look of the characters the Gestural lines is chosen because this type of stroke added a higher degree of complexity to both the character and the appeal [Thomson & Johnston 1995]. The setup for achieving the gestural stroke and overall visual look of the characters can be seen Figure 14.

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[8] http://www.adobe.com/products/photoshop.html?promoid=KFOIE

[9] Illustrator is also vector based
http://www.adobe.com/products/illustrator.html?promoid=KFNVY

[10] The gestural stroke can only be achieved on a computer if one uses a pressure sensitive tablet/digitiser.
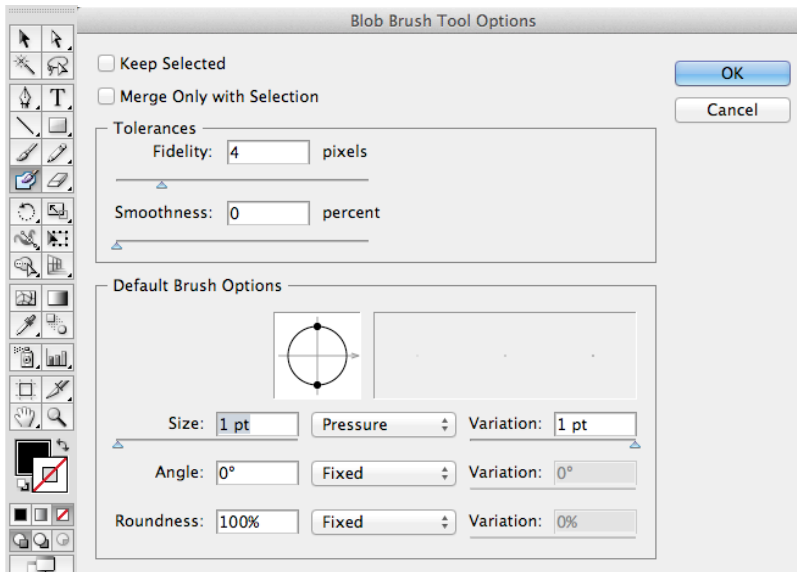
Figure 14: Stroke setup of achieving the gestural lines.

The difference in the characters' texture will be achieved through drawing subtle however effective shadows to difference achieved a sense of depth in character. This was done to minimise the amount of detail and therefore making it easier to animating the character and such that one should not spend much time on drawing the different characters. However, creating characters that resemble pseudo-humans require some level of anatomic understanding [Kerlow 2009]. In the case of the twelve principles this could also be referred to as solid drawing, which refers to that an artist should good enough to draw the character from any angle [Thomson & Johnston 1995]. Therefore, to the design a convincing and correctly posed characters research on human anatomy was conducted. For the reference on drawing humans, Bammes' (1994) The Artist's Guide to Human Anatomy will be used.

For the design of the background the approach was to follow the aesthetic guidelines of the twelve principles with an emphasis on appeal. Furthermore as declared in the chapter [The Conceptual Storyboard, *chapter 6.1*] the design method will based on elements from Mis-en-scene. The term Mis-en-scene, which is French and refers to what one put in the scene, is the film director's or in the case of the LSG, the environment designers control over what appears in the scene [Bordwell & Thompson 2010]. In this thesis the reference to Mis-en-scene explicitly refers to the settings in regards to objects and props placed in the scene. Furthermore the design of the different environments follows the setup made in the

storyboard phase. Furthermore, the designs of the objects in the different sets will be designed for reuse in the other sets. See Figure 15

Figure 15: The design of the poison maker stage and the fortune-teller stage.

7.3 Setting up the character for Animation

For the simple animations of the different characters in the games a simple setup was designed. This setup was based on Jones et al. (2007) approach towards making a simple however efficient setup: This setup was build such that it would include the principle of "pose to pose" [Thomson & Johnston 1995] and the possibility of making a programmable setup. By programmable is mend that the characters animation will be made in small sections, which will be activated when needed through snippets of code. An example of this code snippet would be *"man.head.mouth.gotoAndPlay(1);"* This would then trigger the mouth and animate it to look as if the character is speaking. See Figure 16 for the design setup for a character.
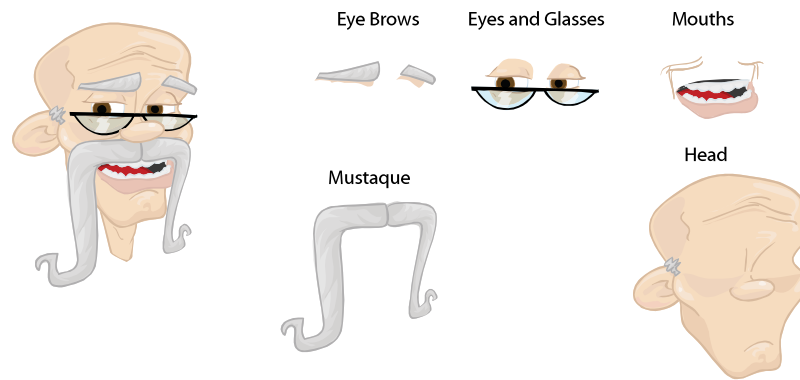
Figure 16: The animation setup of the Poison Maker's head.

7.4 *The design of the games*

The following section will focus on the development and setup of the LSGs. Since the subjects' interaction with the LSG is the key components of this master's thesis the focus will be on elements to support the chosen media and the interaction design.

As mentioned before the LSG is divided into three levels. In each of the three levels the focuses is on designing challenges based on one of the four LSDs. This was decided such that the focus could be on evaluating one LSD per game. Each level are based on three different methods of media and challenges, which are listed below.

- Rotating based game

- Drag and Drop based game

- Click based game

7.5 *The knife throwers game*

For the first level the overall challenges are developed based on Witkin's et al. (1977) rod and frame test method. The challenges of this game will be structures around rotating the knife thrower girl such that her head is placed in an upright position (illustrated in Figure 17). As with the test subjects of Witkin et al.'s rod and frame test the subjects will be tested for whether they either align the knife thrower girl (the rod) with the rotated rectangle with the red and gold stripes (the frame), or align the girl in an upright position. The design of the frame and rod is done such that both represent a rectangle. This is done to trick the subjects into aligning the lines of the rod with the lines of the frame, thus if the subjects do not align the two and placed the rod in around 0 degrees they would have the LSD Global.
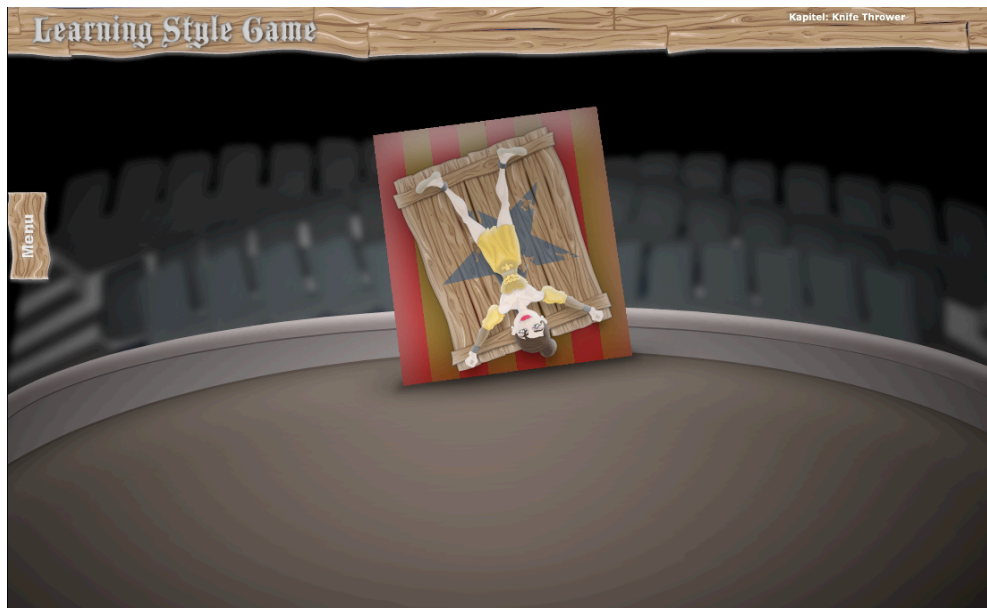
Figure 17: The knife thrower level

7.6 The Poison Maker game

The second level consists of two games which both tests for the *Processing* LSDs Visual/Verbal. These games both are designed as a drag and drop game. The challenge in this game is to, from the instructions given by the poison maker, drag and drop the correct bottles in to the pot. The first game focuses on the Visual LSD where the poison maker, without saying anything, will show which bottles the subjects have to drag and drop in to the pot (illustrated in Figure 18). The second game focuses on the Verbal LSD. In this game the poison maker will tell the subjects which bottles they have to drag and drop into the pot. The game design is based on Felder & Silverman's theory that people with the LSD Visual best learned through the use of pictures, diagrams and charts and people with the LSD Verbal best learned through spoken instructions and text.

Figure 18: Illustrating the game for the learning style dimension "Visual"

7.7 _The Fortune-Teller game_

The last level consists of two different games designed to incorporate the theory of the LSDs in focus. The first game focuses on testing the subjects within the LSD of _Perception_ hereunder Sensory and Intuitive. For this game it was decided to make a classic memory card game where the subjects will have to find two matching cards. The twist in this game is that instead of matching two identical images, the subjects have to match an image with text describing the image (This is illustrated in Figure 19).

Figure 19: Illustration of the memory card game.
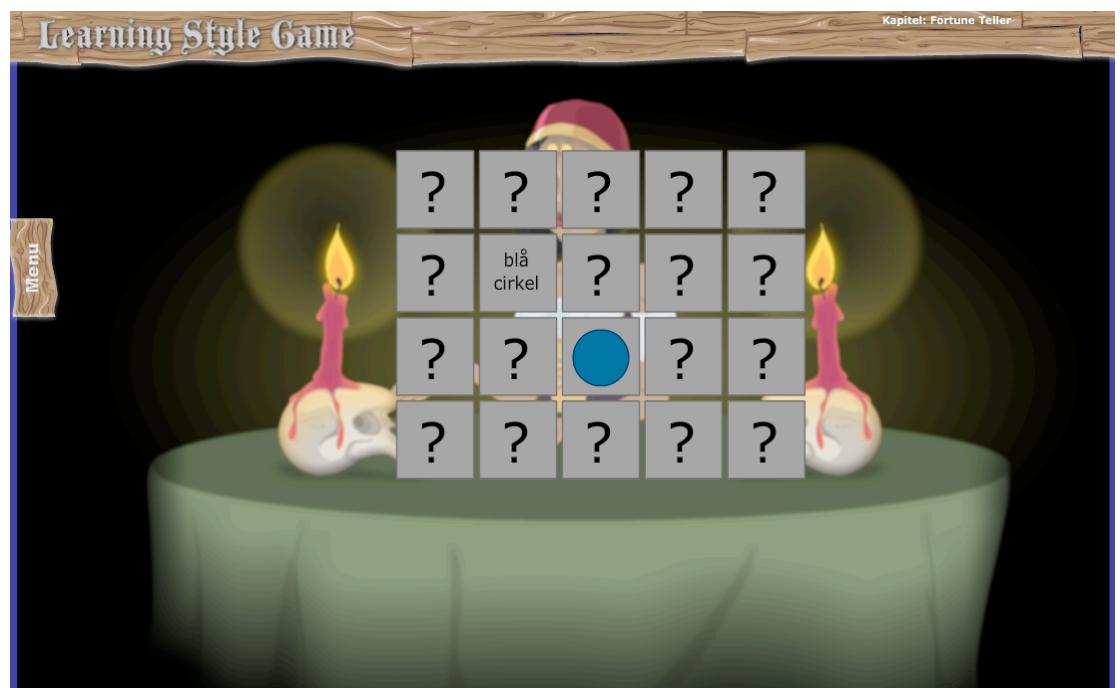
This game will be developed with the notion that people with the LSD Sensory will have a harder time with combining symbols and words and therefore will spend much more time on solving the game then People with the LSD Intuitive. However people with the LSD Intuitive might use more tries on solving the game because they do not mind making errors. The second game is as in the first level "The knife thrower game" designed to test the subjects for the LSDs Sequential and Global. This game is designed based on Witkin's et al. (1977) Embedded Figure Test (illustrated in Figure 20). The notion of this game is that people who aligned the knife thrower girl with the red and gold striped rectangle will struggle with finding the primitive figure in the complex figure.
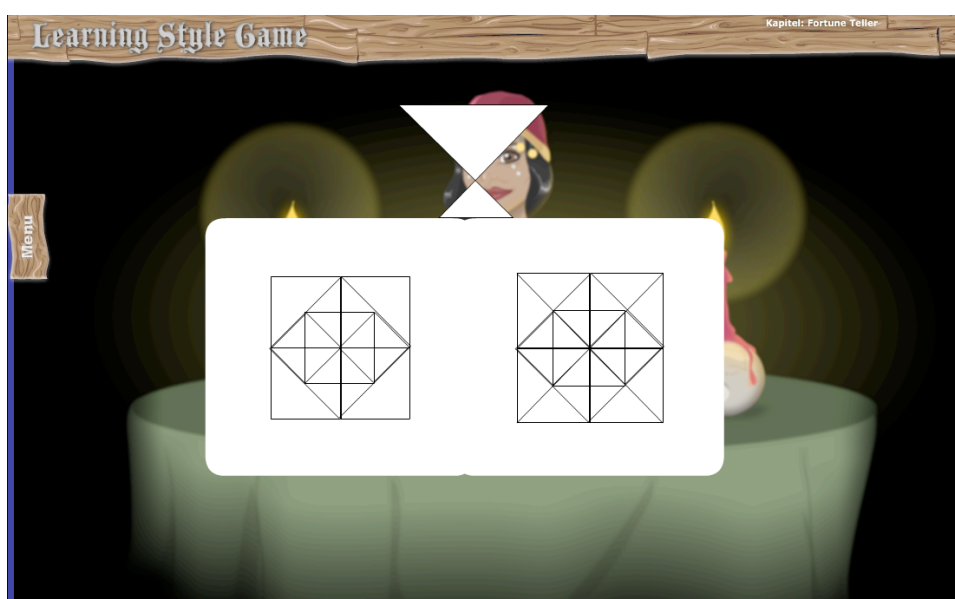
Figure 20: Illustration of the Embedded Figure Test game.

7.8 *The User Interface*

For the interaction with the game there will be made a menu in the left side of the game, which the subjects could use throughout the game (the menu is illustrated in Figure 21). This menu is introduced by the ringmaster of the carnival in the first scene of the game.

Figure 21: Illustration of the menu.

Furthermore, there is made an intro page where the users can enter the different levels through graphic elements, which represented the homes of the different characters in the game. Because, the game did not offer possibility of pausing or onscreen text the subjects will at the end of every instruction, be given the option of either seeing the instructions again or starting the game as illustrated in Figure 22.

Figure 22: Illustration showing the buttons for seeing the instructions again or playing the game

8 Implementation

This chapter will describe how the various design requirements have been implemented in the game. Furthermore, this chapter will walkthrough different methods used to accomplish the gathering of data, overall structure of the game, character animation, and the background setup,

The overall structure of the game is designed with an index file, which loads the different games. This structure is chosen based on a structure, which is used in Nykredit's e-learning department where the author of this masters thesis work as a student assistant. Therefore, the use of this already working framework was a natural pick. The structure of the Learning Style Game is illustrated in Figure 23.
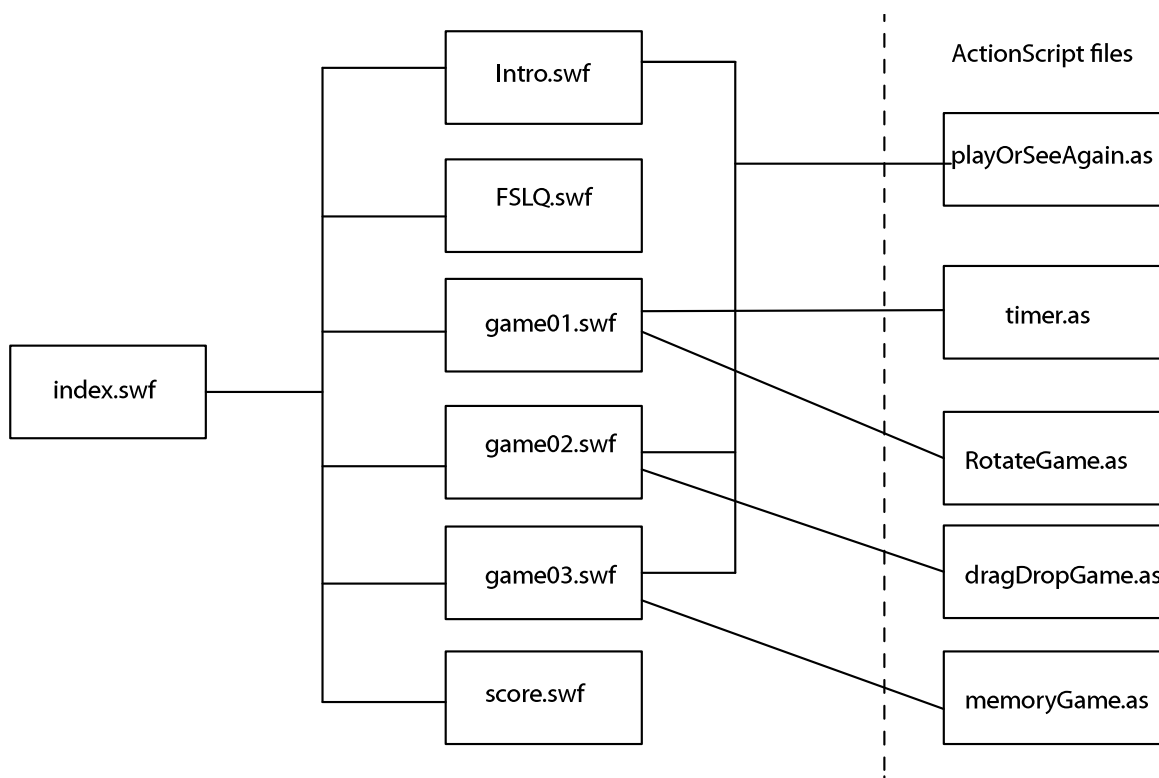
Figure 23: The structure of the Learning Style Game.

In this structure all the user interface elements are placed in the index.swf file. Furthermore, the score from the different games is gathered in the index.swf. This is done such that the other games can evaluate the data gathered in one of the other games i.e. if game01 needs to check whether a function in game03 has been set to true, the function in game01 only has to check a function in the index.swf. The separate swf files sends the value of a given variable to

the index.swf, which then sends the values to another swf. One can refer to the index.swf as the parent and the underling swf files as the children. Furthermore, separate ActionScript files will be made for all the code of the different games. This was done because many of the functions developed had to be used in other swf files e.g. the timer.as file and the playOrSeeAgain.as.

8.1 Witkin's Rod and Frame Test

The implementation of the rod and frame test game was fairly simple in its construct. The only thing the subjects had to do was rotate the knife thrower girl in to an upright position. However, the functionality of the game had to be based on the subjects using a mouse to interact with the knife thrower girl. Furthermore, the rotation of the knife thrower girl object should not be based on the angle of the mouse but on the knife thrower girl object. Therefore, the rotation function had to be designed such that it would calculate the angle from the centre of the mouse to the centre of the object (illustrated in Figure 24). Then this angle would be stored in a variable called oldRot. When the knife thrower girl object is rotated the function will constantly calculate the new angle of the mouse from the centre of the knife thrower object and subtract the variable oldRot from it, e.g. if the stored angle of oldRot is 57 degrees and the mouse rotates the object 120 degrees, then the rotation of the object would be 120-57 = 63 degrees. This angle would then be added to the original degree of the knife thrower object. For a closer look at the code please visit knifeThrower.fla [CD Appendix D.]
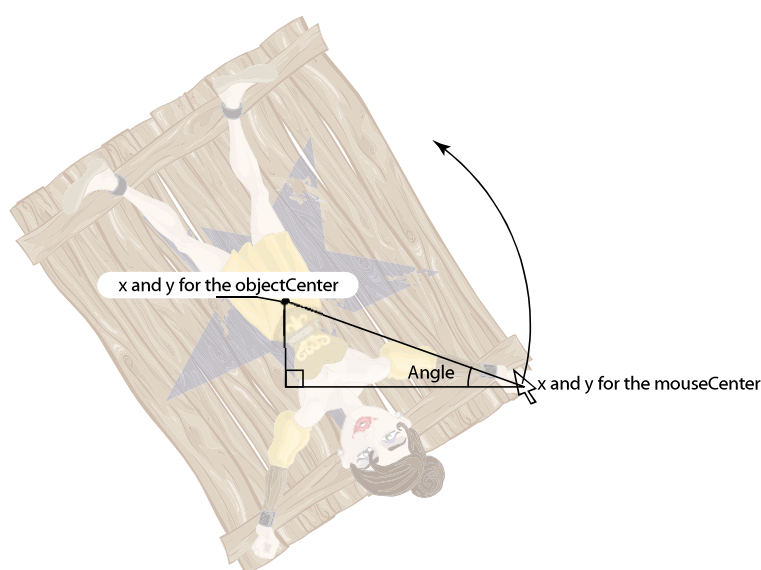
Figure 24: Illustration of the rotation functionality.

8.2 The Visual and Verbal games

The implementation of the instructional games for theevaluation of the LSDs Visual and Verbal will be done through animation and the use of a drag and drop setup. Because the drag and drop functionality had to be used in both the Visual and Verbal instructional game, one will have to create a function which will reset the bottles to their original position. To do this one needed to store the x and y positions and child indices[11] of the different bottles in an array. When the first game had finished the resetbottles() function would be executed, thus, resetting the game. Furthermore, at the end of each instruction the playOrSeeagain.as file was imported. The animation of the bottles diapering when dragged into the pot was programmed through using the TweenLite ActionScript library[12]. For the animation setup of poison maker there was used a very simple method with subtle animation. These animations were based on the definition from [Game and Visual Aesthetics, *chapter 3.4*] on character personality, i.e. automated blinking the moustache moving when the character talks. Furthermore, to avoid spending too much time on animation the character, in the visual game, the bottles where animated as well. This was done through using the Adobe Flash's build-in function tweening. (illustrated in Figure 25). The advantage of using this feature is that once that one bottle has been animated the motion of the animation can be copied onto the other bottles, hence animating much faster.
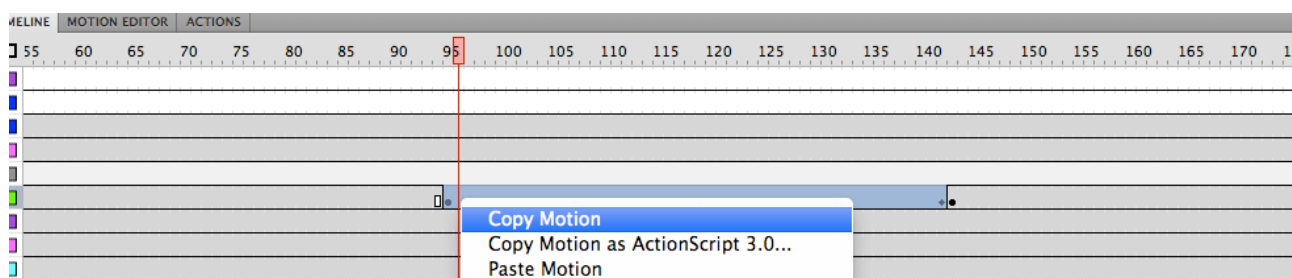
Figure 25: Illustrates how to copy the motion from Tween function:

The lip sync was done by first making three mouth positions and then animating through them when the character is speaking and stopping the animation the character stops

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[11] The child index refers to the layering of the objects. For more information see http://help.adobe.com/en_US/FlashPlatform/reference/actionscript/3/flash/display/DisplayObjectContainer.html#setChildIndex()

[12] http://www.greensock.com/tweenlite/

speaking, hence giving the illusion that it is the character who is speaking. Furthermore, elements such as smoke from the pot and the candlelight flame were animated in order to add appeal to the background.

8.3 The Sensory/Intuitive and Sequential/Global Games

The memory card game in the fortune-teller level was based on the concentration game from Feronato's (2011, p. 8-39) book "Flash Games by Example". The second game was developed based on the tools learned from designing the memory card game. The setup was very simple, and only had to evaluate whether the picked figure was correct or wrong. The animation of the fortune-teller was done in the same manner as the poison maker only with added breathing. The speak for all the character was made by using the iPhone microphone and then imported into a sound editing program.

8.4 Implementing Felder & Solomon LSI

In order to gathering the data of the Felder & Solomon learning style inventory there had to be setup at flash version of the questionnaire. This was done such that the learning style inventory data could be sent to the score.swf. The setup of the Felder & Solomon learning style inventory was somewhat complex because the questions and the driving code were located in separate files. However, for the subjects the user interface was fairly simple and somewhat uninspiring (illustrated in Figure 26).
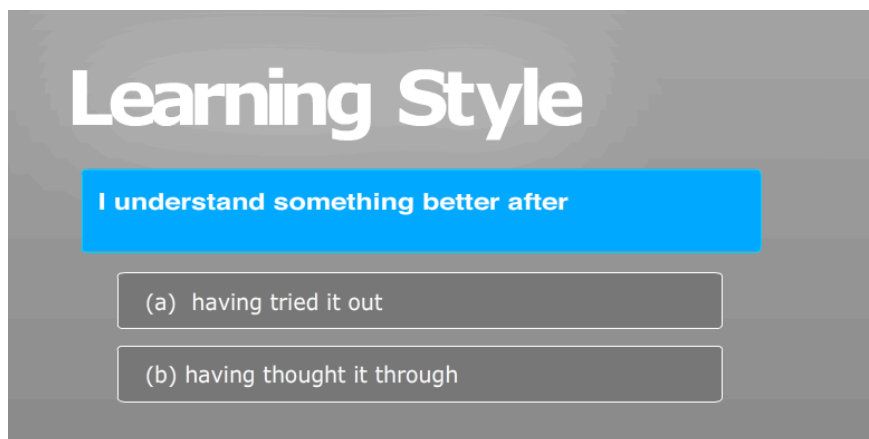
Figure 26: Illustration of the user interface of the Felder & Solomon learning style inventory.

The final stage of the learning style game was the score.swf file. This file was made to give the subjects a sense of accomplishment. Furthermore, the score.swf had another purpose namely

to gather the data from the subjects games. This was done by using the PNGEncoder[13] library developed for creating screenshot of the users desktop in an swf file. The score.swf would then take a snapshot of the subjects' data and store it, through use of a small PHP script, on the ftp server where the game is placed.

8.5 *Integrating the characters with the background*

The last thing, which will be done, is making the character and background look as if they are integrated into the same world. This is done through the use of the use of flash's filters. These filters include blur, drop shadow, glow, bevel and adjust colour. For the example of a setup that integrates the character into the background the knife thrower scene will be used. As can be seen in Figure 27 the knife thrower girl to the left look as if she belongs to the scene. Where if one compares her with the knife thrower girl to the right it is clear that this integration required some additional filters.

Figure 27: Knife thrower girl with and without added effects.

The girl in the right is somehow diapering into the red and gold striped rectangle behind her. In order to make the knife thrower girl "pop" and direct attention towards her one need to add some filters. This is done in a three-stage setup starting with the wood rectangle she is attached to. The wood rectangle's setup is very similar to how an object or a person of interest

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[13] https://github.com/mikechambers/as3corelib

is lid in a movie. The overall intention of adding the filters is to imitate the basic three point light setup from a film [Bordwell & Thompson 2010]. With the backlight being the white edge along the wood rectangle. Adding a drop shadow filter and giving it a white colour with the inner shadow button enabled achieve the illusion of a backlight. Furthermore, to create the illusion of the key light another drop shadow filter was added (see Figure 28 for the setup).
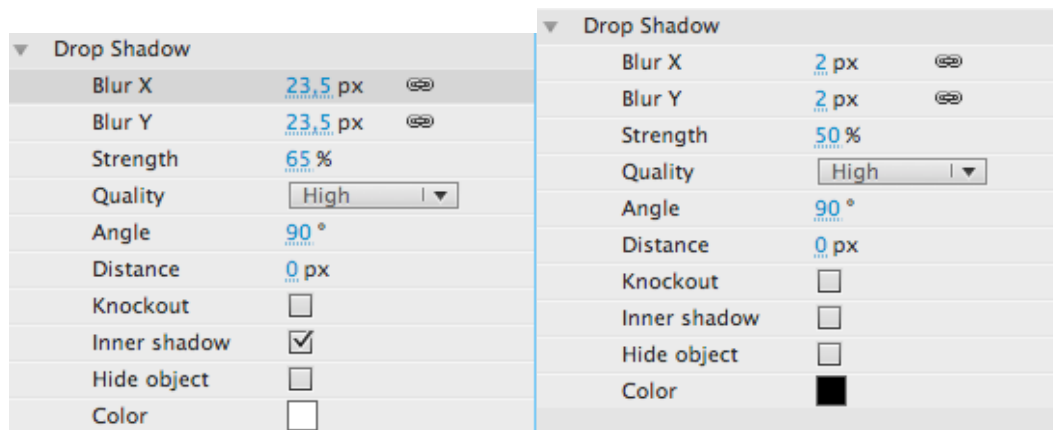
Figure 28: The filter that creates the backlight.

For the second stage setting up the light on the girl the same filters used on the wood rectangle were used. The third stage of lighting was to add another drop shadow to the combined wood and knife thrower girl object. This was done to add depth to the knife thrower object.

9 Results

The design of the test setup was inspired by Felder & Spurlin's reliability test as the subjective method and the LSG as the objective method. Though, the data from the learning style inventory could be invalid [stated in Evaluation of Adaptive Educational Hypermedia from 2000 - 2011, *chapter 2.4.3*] the evaluation of the learning style games still had to be based upon data from a well-tested method.

The learning style games were designed to test whether they could be used to evaluate the subjects' learning style dimension. The learning style game was developed such that people could play it online. This was done because most of the test subjects would be employees from the Nykredit's HR department who would have to participate in the experiment from their home computer. Furthermore, to gather more data the link for the learning style game was posted on Facebook. This was done because it was believed that the employees at Nykredit could be hindered in participating in the experiment because having other more important interests.

The subjects who took part in this experiment consisted of 23 people. The gender and age of the participants where not asked, because it was believed that this had no relevance for the scope of this thesis. However this would be asked in a future tested learning style game, which is able to evaluate the subjects learning style dimension. The purpose of the game was that one should be able to play it wherever one preferred it.

Looking at the results from the Felder & Silverman learning style inventory it can be seen that 17 out of 23 subjects had the learning style dimension "Active" from the bi-polar scale of Active/Reflective. For the representation of Sensory/Intuitive had 12 out of 23 the learning style dimension Sensory. For the Visual/Verbal 16 out of 23 samples had the learning style dimension Visual. Last had 15 of the 23 subjects the learning style dimension Global.

The first learning style game "The knife thrower game" was designed to evaluate the subjects' Sequential or Global learning style dimension. The test results were compared with results from the Felder & Solomon learning style inventory. The subjects where then sorted into two groups, one of Global and one of Sequential. The evaluation of the two groups was based on the hypothesis of Witkin et al. (1977) rod and frame test. The rod and frame test states that if the subjects would align the rod with the frame then they would have the cognitive style of

field dependent and field independent if they aligned upright. It was found in [Witkin Field Dependent /Field Independent styles, *chapter 2.3.3*] that Witkin's cognitive styles field dependent and field independent could be aligned with Felder & Silverman's learning style dimensions Sequential and Global. According to this hypothesis the subjects with the learning style dimension Sequential should have a tendency to align the rod with the frame. The test data showed that there is no significant difference between Sequential (M=(-2.6), SD=2.7) and Global (M=(-3.4), SD=2.25) conditions; t(7) = 0,2055, p=0,421 with a critical value of 1,894 (one tailed).
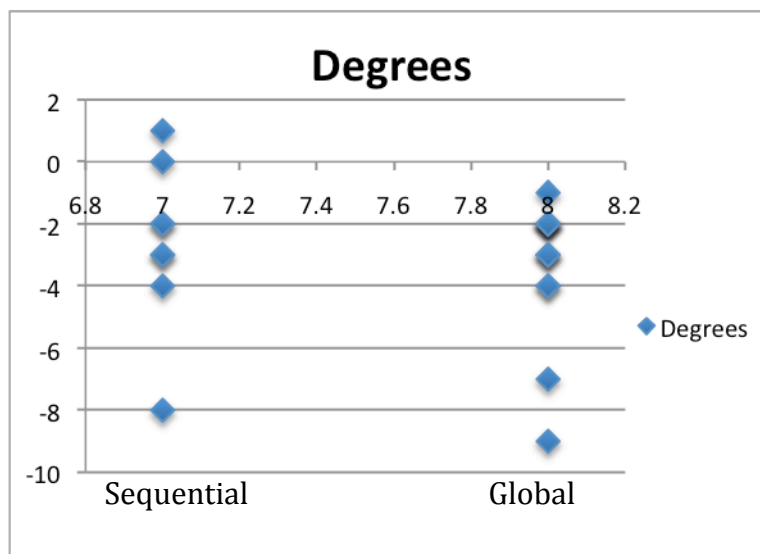
The second game "The poison maker part01" was designed to evaluate the subjects Visual and Verbal learning style dimensions. This game design was based on Felder & Silverman's hypothesis, which suggests that subjects with the learning style dimension Visual would remember better if the material were presented to them via graphs, symbols and diagrams. For this first part of the poison maker game the learning style Visual was the focus of evaluation. This was done through evaluating how many of the showed items they had correct. It was believed that this type of game would give an indication of the subjects learning styles. The test data showed that there is no significant difference between subjects with the learning style Visual (M=4.75, SD=0.45) and subjects with Verbal (M= 4.85, SD= 0.37) conditions; t(10) = 1,4907, p=0,084, with a critical value of 1,812 (one tailed).
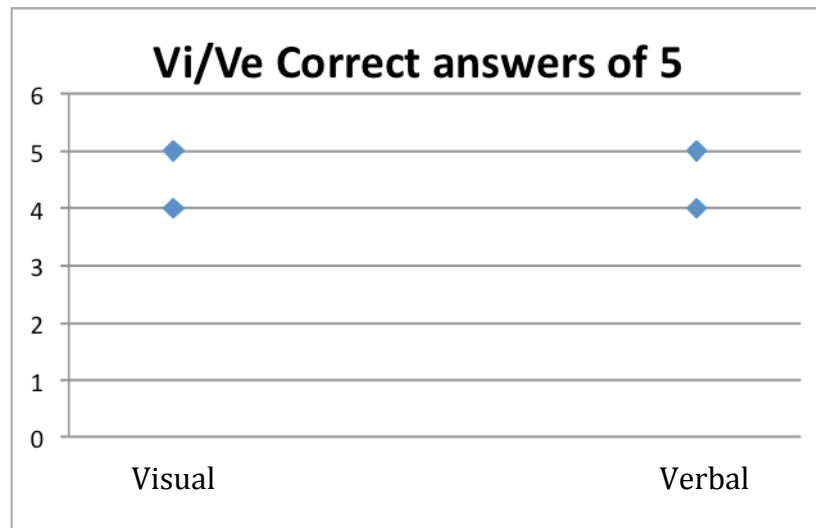
In the second part of the poison maker game the learning style dimension "Verbal" was evaluated. It was believed that subjects with the learning style dimension "Verbal", would do better than subjects with the learning style dimension "Visual" when the instructions were told and not showed. The data showed that there is some significant difference between Visual(M=4.7, SD= 0.21) and Verbal(M=5, SD=0) conditions; t(10)=1,936, p=0,047 with the critical value of 1,812 (one tailed).

The third game "Fortune-teller" first part of the game was evaluating the subjects' learning style dimensions "Sensory" and "Intuitive". This games design was based on Felder & Silverman's hypothesis that subjects with the learning style dimension "Sensory" would struggle with combining symbols and text, which would mean that they would spend more time on completing the game. The data showed that there is no significant difference between Sensory (M=99 SD=24) and Intuitive (M=100 SD=66) conditions; t(11)=0,223, p=0,413 with a critical value of 1,795 (one tailed).

Furthermore, the learning style dimensions "Active" and "Reflective" were evaluated in the first part of the fortune-teller game. It was believed that there would be a relationship between the amount tries the subject took to pair ten matching cards and the learning styles. According to Felder & Silverman subjects with the learning style dimension "Active" would less concern with how many mismatches they got because of their "try it out" mentality where subjects with the learning style dimension "Reflective" would have less mismatched pairs due to their reflective mentality. The data showed that there is no significant difference between

Active (M=27,6 SD=5,4) and Reflective (M=29 SD=13,3) conditions; t(5)= 0,356, p=0,367 with critical value of 2,01 (one tailed).

The second part of the Fortune-teller game was designed to evaluate the subjects learning style dimensions "Sequential" and "Global". The design of this game was based on Witkin's Embedded Figure Test. The Hypothesis of this game was that subjects with the learning style dimension "Sequential" would struggle with locating the embedded figure. The evaluation of this game was through time and corrects answers. The data showed that there for the time evaluation, is no significant difference between Sequential (M=151 SD=10,6) and Global (M=172 SD=8) condition t(12)=0,439, p=0,334 with critical value of 1,782 (one tailed). The data furthermore showed that there for the evaluation of correct answers is no significant difference between Sequential (M=7,3 SD=0,9) and Global (M=7,3 SD=2,2) conditions; t(16)=0,022, p=0,491 with a critical value of 1,745 (one tailed). Likewise, there is a weak significant correlation between the time data and number of correct answers, r = 0,416 n=23, p > 0,05.

 For an overview of the test results and calculation please see [CD Appendix E]

10 Discussion

If one looks at the collected data it is clear to see that the sample size was not large enough. However for the purpose of this thesis the gathered data was calculated as if it the sample size was large enough. It was believed that designing the game based on theory from Felder & Silverman's cognitive and learning style science and on Clark & Mayer's media science would show a significant difference in subjects' performance and thereby indicate learning style. However as can be seen in the results there were no significant difference in the scores and time spend between the either of the bi-polar dimensions. First of all one most note that the sample size was n=23 which meant that the representation of some of learning style dimensions was very low. For instance there were only 6 subjects out of 23 who had the learning style dimension "Reflective" which is far from enough to a measure any significant difference.

However there one of the games did show a weak significant difference, namely the poison maker game part 02. This game was designed to test peoples' verbal memory. However, because of the small sample size there were only 7 subjects with the LSDs Verbal. Looking at the results from the poison maker game part 01 it showed that there were no significant difference between subjects who had the LSD Visual and subjects who had the LSD Verbal. Furthermore the mean and standard deviation in both games suggests that the task of remembering five different objects was too easy.

In the perfect scenario the representation of each learning style dimension would be 30 or more. However this would demand a sample size of at lest 120 subjects and even in this scenario many of the subjects would probably have the same learning style model. Furthermore, Felder & Silverman (2005) mentioned that most people from the collage age and up had the learning style dimension Visual.

The game was as mentioned designed based on Clark & Mayer's (2002) theory on cognitive load. One of the suggestions when using animation and narratives was not to have onscreen text during instructions. Therefore, it was decided not to use onscreen text in the game. However, one of the recurring reports was that people would have liked to have the option of text because the instructions were too long and they had to revisit the instructions.

Another issue with the test was that the game sometimes froze and the subjects had to start from scratch playing the came games again. This issue was only reported two times and could be because of bad Internet connection. However, one of the requirement specifications should have been that the subject's scores should have been saved in a cookie in case of bad Internet connection or power failure.

Furthermore, the game, which should have represented Witkin et al.'s Embedded Figure Test, was not designed as the original test. In the original test the subjects were show the primitive figure for a short period and then the primitive figure was removed. The subjects then had to find the primitive figure in the complex figures, without being able to refer to the primitive figure. In the fortune-teller version of this game the subjects could compare the primitive figure to the complex figure, because the primitive figure was not removed. This could one of the reasons why the data did not show any significant difference.

However there was some positive feedback about the games. People found the games entertaining and suggested that it would be more fun to play a game which could elicit their LSD rather than having to fill out a LSI.

If the sample size had been lager and the results have been the same this could have been because of the reasons mentioned here. Because learning style inventory is designed to ask how people think they best prefer learning. Meaning that they might think that they have one learning style but due to their work environment and experience this is perhaps not the case. This draws out an important pitfall when analysing the data received from the test. While there might not be a correlation between the result of the self-reported questionnaire and the data from the LSG there might be a correlation between the tasks performances in the game and how engaging the subjects found the tasks. Therefore, in order to collecting this qualitative data the test method should have included a questionnaire which asked the subjects whether they found that the results from the LSI gave a correct picture of their LSDs.

11 Conclusion

In this I have looked at whether games can elicit subjects LSD through how they solve tasks in a game. I have looked at how a game can be designed to include theory from cognitive and learning style science. To achieve this a game environment based on e-learning elements was developed. The levels were designed to encapsulate the different theories connected to the LSD. The measures were done through a objective method in the form of the game environment. Furthermore the use of a subjective self-reported LSI was used as supporting data.

Though the results from the small sample size of 23 subjects suggest that games cannot be used to elicit the subjects LSD the author of this master's thesis is convents that it will be possible in the future. It is all a matter of the test setup. For the games in this master's thesis the complexity of the games setup was underestimated. It was believed that one could design a game, which would only focus on eliciting LSDs. However, the reason for the shattered results apart from the very small sample size could be that people do not use one learning style dimension when solving puzzles.

The final problem statement cannot be answered, indications from the results suggests that the games developed in this thesis are not capable of eliciting subjects LSDs. However, as stated the discussion this could be different if the sample had been lager. However a framework for designing LSGs still needs to be developed and other researcher from both the game industry and the cognitive and learning style field should as [Van Eck 2006] [Akbulut & Cardak] suggested work together in order to make a more entertaining LSI.

11.1 Future

The results showed that the traditional learning style inventory is still the best method to collect data about the subjects' learning style dimensions The results would indeed have been much different if the test had been conducted on more people. However, if the learning style game should be made possible in the future there is need for a more thorough observations via the use questionnaires gathering qualitative data perhaps on which games subjects with different learning style dimensions like and through it design the games. The field of cognitive and learning style science if filled with quantitative data, perhaps it is time to ask the users of the learning style inventories how they want to be tested?

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