Creating an experience based learning system

Implementing experience in our learning process and exploring the role of architecture in it.

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This thesis began by working in the field of Virtual Reality whilst also studying architecture. The combination of giving people experiences whilst also studying for creating buildings was an interesting combination. Through the work in VR, I experienced the effects of the environment on the behaviour of the person experiencing. At the same time I was learning how to build buildings and how to look at building from an architectural perspective. A perspective that learns to build beautiful integrated buildings that supply a comfortable indoor space which satisfies most people. This contradiction of creating virtual, very specific, spaces and more general comfort in architecture was and still is very interesting to me. This contradiction, the lack of experience in most architectural design processes and the lack of experience in our learning process started the thought process which led to this paper.

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Introduction

"We **experience** experiences to become *experienced*"

Humans are animals that have become the most dominant animal on earth. Through time we have adapted from living in small groups of hunter gatherers to a species that can live together with millions of others in one city. Of Course this didn't happen in one day, just like Rome wasn't built in one day, but during the ages we have learned to live with many people at the same time. conveying our knowledge and experience to the next generations which then would apply and improve upon it. This passing of knowledge and experience is the focus of this thesis.

For ages we have learned from books, manuscripts, scrolls, conversations, stories and in the recent years new digital mediums like radio, videos, audiobooks and podcasts. These tools convey the experiences of other people and their knowledge gained, however I believe that we should invest more into gaining the "real" experiences from which we can deduce our own knowledge. As so to become experienced through our own experiences.

This has now become more feasible than ever with new tools and realities at our disposal. The increase in computational power in computers allows us to simulate very realistic experiences.Tools like virtual reality(VR) and augmented reality(AR) allow us to enter these experiences and truly be in them/interact with them. These tools are still in their starting phase, but already show very promising results.
VR and AR allow us to have experiences which conventional tools can not convey. For example, we can experience what it is like to fly in space, experience a volcano erupting while standing on the edge of the volcano or handle and inspect ancient pottery. Having these experiences will give us another layer to our learning process. And allow us to have the real(also sometimes very dangerous) experiences and learn from them and/or get inspired. This thesis will explore the use of digital experiences in our learning process, a framework for experience based learning will be made and we will explore the role (digital)architecture will play in experience based learning. To answer this the following research question will be answered:

How can we create a new experience based learning system and how to create (digital)architecture for it?

The first part of the thesis focuses on why experiences are important and why we need real experiences. The sub-question being:

Why is experience important for our learning process and how do we experience?

This question will be answered by dividing it in smaller questions. The relevance of experiences and of being experienced will be reflected on our history and a case will be made of why we need to again focus on gaining real experiences(instead of learning from other people's

experiences). After explaining the relevance of experience and what role it plays in today's society(and what role experience will play in the future) we will look into present-day advances in theories about how we experience. This knowledge will prepare us for the second part of the thesis which will answer the following sub-question:

What is experience based learning?

This question seems relatively simple, but as obscure as the word experience is as obscure is the term experience based learning. In this chapter, the definition of experience based learning that is used in this master thesis will be explained. In this sub-question the process of experience based learning will be explained and what the role of new tools like virtual reality(VR) and augmented reality(AR) will have in this new form of learning.

Lastly we will explore what the role of architecture will be in this form of learning. This will be done through answering the sub-question:

What role does architecture play in our learning experience?

In this chapter architecture will be explored as the medium at which the experience plays. Both digital and actual architecture will be seen as the mediator of the experience. During this exploration we will look at the influence of the architecture on the content, context and conditions of the experience(process). This will be done by doing literature research and explorations using what-if situations.

Experience

Why is experience important for our learning process?

Experience in a historical perspective

Humans and their numbers

Through time humans have learned how to work together with thousands of people on the same goal. The human species is not faster than a cheetah nor stronger than a bear, but still we are more numerous and more successful in increasing the number of our species than both. Humans are weaker than most animals but still have grown in some of the most hazardous biomes on earth. From the savannah to the poles. But how did we survive and prosper?

Most of our success comes from the fact that we are able to coöperate together with others of our species and even with other species at times. But for most humans it is difficult to work, live and share with people we have never met. Robin Dunbar has researched the size of our social network(people we can recognize) and concluded that we can have a social group of around 150 people. But how do we now live in relative harmony with millions of people in a single city?

Tribes

At the start of the neolithic age the main reason for people to live together was the strength of numbers. When a farm was attacked by marauders(or wild animals) the other villagers would help the farm to fend them off and the same was expected from the farm when it happened to others.
Most of these villages and tribes were devoted to satisfying one god or multiple deities. These gods(religions) gave the people of the village common goals and rules to live by.The religions came with both rewards(going to heaven for example) and punishments(going to hell). These rewards and punishments allowed groups larger than 150 people to live together because they were working for the same cause and also knowing the stake of misbehaving.

When we look at the 21st century 16 % of us humans do not believe in god anymore, which is equal to 1.1 billion people. These people don't have a common religious goal, but they are capable of working together.

Humanism

In the 21st century a movement called humanism shares a new way of how to look at what we can and can't do. Humanism says that we humans are the center of our own perception and that human experience gives meaning to the world. This does not mean that humans rule the world and decide what needs to be done, but it means that we decide for ourselves what we

think is good or wrong based on what we have experienced. For example, we do not punch others for no reason because we know(from experiencing it ourselves) that punching can hurt. Another example, we do not steal because we know(or can imagine) how terrible it is to lose something that is important to us. In the past, religion told us to not steal or we would go to hell, but now with more and more people not believing in a god some fall back to our previous experiences to “know” whether something is right or wrong.

This way of thinking is not completely new, but it has become more prevalent in the 21th century. With advertisements like “reis jezelf rijk”(travel yourself rich) or the question after you have done something mean to someone else: How would you have liked it if I did that to you?

As shown in our history we are shaped by the experiences that we have had in our past. But what is the future of experiences in our society? This will be illustrated in three situations which show why experiencing is even more important for a functioning society in the 21th century.

> In the 21th century we are promoting that everyone is an unique individual and allowing everyone to express themselves in any way they want. In this free society a lot of different groups of people will meet each other. Each with different values. Some will find new friends with similar interests, but many will find that they don't understand other groups. How would it be if they could experience the story of the others?
>
> A large part of studying in the 21th century is reading and learning from our collective knowledge. This can be done by reading books, listening to a lecture, watching documentaries etc. These types of learning allow us to learn from masters in their subject (e.g. ancient philosophers). But why can’t we learn the knowledge in the situation it happens?
>
> Computer advancements show us that computers are better at handling raw information. Computers can compute thousands of formulas in seconds. So why is a large part of our education still focussed on learning facts? What if our education would prepare us better to deduce the key features of the context and what actions need to be taken from the situation itself?

These examples show specific use cases of learning by experiencing. In the next part of this chapter we will explore new theories about how we experience and what experiences are.

The experience - The narrative and the experiencing self

What is experience, How do we experience and what do we remember?

Experience is an obscure word. We use the word in different contexts and the word experience means something different in each. We talk about experience as a process, a product and as an attribute(Saugstad, 2012, p. 14). When experience is used as a process then the word is used as a way of learning. E.g. training, habits and former actions that guide new actions. When we use experience as a product it can describe a culture's collective memory, on scientific knowledge and empirical facts, or it could be the individual's personal accumulated knowledge(Saugstad, 2012, p. 14). And lastly we use experience as an attribute. Which often described someone as experienced in life, his/her social status, how skilled the person is etc.

This thesis will focus on the giving of the experience(process) to give the person experience(the attribute). The product of this process is to make someone experienced(in something), therefore we will also briefly touch on the subject that will be taught.

How do we experience?
Daniel Kahneman, 2002 Nobel prize winner in economics, researched what most call "I", "me" or "myself". He researched patients going through a painful medical procedure and asked them to rate their level of pain from 1 to 10. During the research their levels of pain might have looked like this:

minute	0	1	2	3	4	5	6	7
Pain level	1	4	8	6	8	3	8	6

Figure 1: levels of pain during experiment.

From this patient he would have gotten a total pain level around: 7.5. He discovered that he could estimate the total level of pain by taking the peak levels of pain and the end pain. In this experiment this would look like this: (8+8+8+6)/4. Doctors were interested in what would happen if they would try to reduce the peaks of pain of the patient. But due to the nature of the procedure this would mean that the procedure would take longer(increasing the time of experiencing pain). From this procedure Kahneman got a list of pain levels looking something like figure 2.

minute	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pain level	1	4	3	6	3	6	3	6	2	1	3	6	3	3	5

Figure 2: levels of pain during a slower procedure.

Even though this experiment lasted twice as long, the patient would rate this procedure with a lower score than the patient with a short procedure with higher pain peaks. With this experiment and other experiments, Daniel Kahneman concluded that there are two parts to “I”. One being the experiencing self and the other the narrative self. The first being the “I”, who is here and now, called the experiencing self . The other being the one that tells the story afterwards. He/she would make a story of the different experiences gained through the experiment, this part of “I” Kahneman called the narrative self.

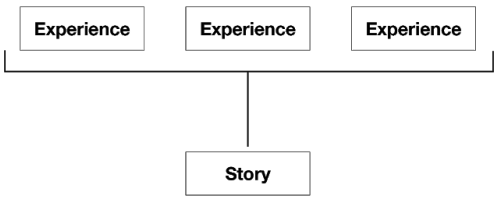

Figure 3: experiences form a story, source: own image.

This in turn can influence the actions taken in new situations and lead to different stories which will lead to different experiences from these stories. Leading to a cascading effect of experiences good or bad. See figure 4(figure below)

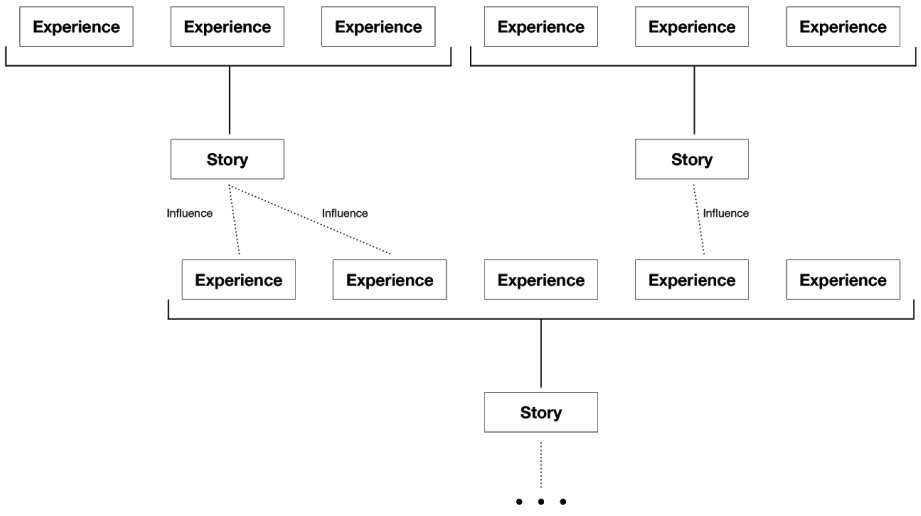

Figure 4: an experience can influence the actions of the next story ,Source: own image.

These experiences can together form a story of what has happened. E.g. a person who has had a bad experience with fire could lead to them being more nervous next time they handle fire and might cause them to drop a candle(action) leading to another bad experience(a large fire). Which in the end leads up to another bad story leading to new bad actions etc.

Pacing

A very important part of creating an experience is the amount of information that is conveyed. This is important, because we humans cannot process endless amounts of data. Therefore the data that we receive needs to be controlled if possible, otherwise we would miss important information. Controlling the amount of data is called pacing. When we don't control the amount of information that we can consume we can get fatigued. This type of fatigue is called DAF(Direct attention Fatigue)(Bell, Greene, & Fisher, 2001). We start to get DAF when we strongly focus on any given task for a long time. Some focussed tasks will tire us more quickly than others, but in the end all of them drain our direct attention capabilities. This fatigue can clearly be experienced during a long museum visit. In the beginning of this visit everything is clear and focussing doesn't take too much effort. Near the end of the visit it will become harder to focus on the art. Tunnelvision, a decreased perception and decreased cognitive capabilities are some of the symptoms of DAF(sometimes also referred to as museum fatigue).

This type of fatigue can be decreased/delayed by pacing the experience(s) and decreasing the information given at any time during the experience. But even if the information stream is controlled the participant can still become fatigued. To decrease the amount of fatigue we can make environments that help us restore our direct attention span. These spaces are called Restorative environments. These restorative environments have been described by Bell, Greene, en Fisher (2001, pp. 1–3) as having the following characteristics:

1. Being away, or something other than your normal environment.
2. Extent, or providing an experience that is extended in time and space.
3. Fascination, or being interesting and engaging.
4. Compatibility, or the ability for the environment to support what you intend to do.

These restorative environments are different for everyone. For some people a cafe where they can talk about their weekend can be a restorative environment, while for others a walk around the building can be what they need. To help many people to restore their direct attention span many types of engaging activities need to be facilitated. Combining these restorative spaces with learning spaces(direct attention spaces) will allow people to focus longer and increase the effectiveness of the learning experiences.

Sum-up

We humans are built on experiences. We have experiences and learn to express ourselves through the tools that have been taught to us by the people that have been closest to us and have interacted with. They give us the tools which will teach us how to express ourselves.
The experiences that we have together form a story that we will take with us into the future. But not everything that we experience will go into this story. The peaks(and throughs), as Daniel Kahnemann, called them will together form the biggest part of the story. The things that caught our attention and stood out.
These stories will become the collective story of our lives and represent the experiences that we had and will influence our actions in the future.

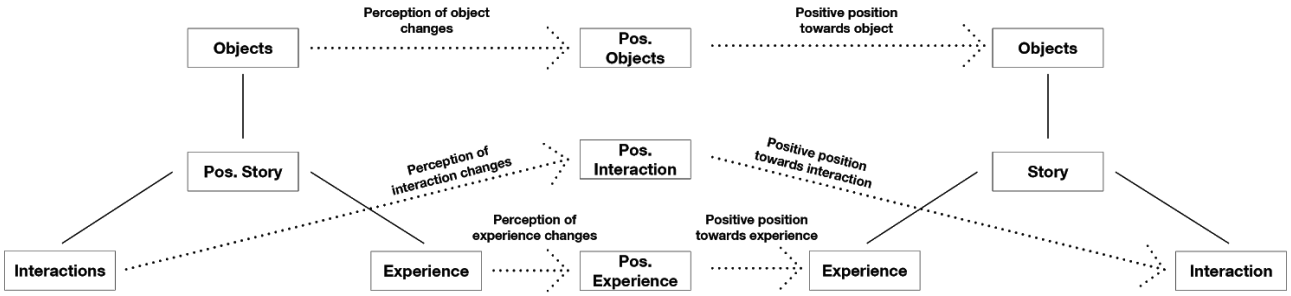

Figure 5: a positive experience can change future experiences ,Source: own image.

But this reasoning could let us to believe that we need many interesting moments for the experience to become as efficient as possible. But too many peaks of information in a short period of time will cause the experience to become less effective. Therefore the information in an experience should be paced in processable chunks. Inevitably the learner will become fatigued of focussing on a subject for a long time. To decrease the fatigue of the learner restorative environments(e.g. A cafe, a lounge, a park, comfortable chairs etc.) will need to be incorporated into/near any learning environments.

The next chapter will introduce how to use these experiences and the concept of “I” by Daniel Kahneman in our present day society. This chapter will be focussed on education/learning.

Experience in education

What is experience based education?

It is important to understand two words before we start with experience in education, these words being: Experience and knowledge. These words can be best understood by quoting a paragraph of Saugstad(2012) that in turn looks at an example of Aristotle:

> *There are two reasons why we act incorrectly: partly we can be mistaken with regard to the knowledge we have, which is the knowledge of the general, or we can be mistaken with regard to the knowledge we apply, which is the knowledge of the particular knowledge. In the following quote from the Nicomachean Ethics, Aristotle claims that the person who only has experience (i.e. knowledge of the particular conditions) can have more success in practical life than the person who only has general knowledge. 'This is why men who are ignorant of general principles are sometimes more successful in action that others who knows them: for instance, if a man knows that light meat is easily digested and therefore wholesome, but does not know what kinds of meat is light, he will not be so likely to restore you to health as a man who merely knows that chicken is wholesome; and in other matters men of experience are more successful than theorists' - (Saugstad, 2012, p. 10)*

The example given clearly favors the man of experience over the man of knowledge. This is because the man of experience can actually apply the knowledge. Whilst the man of knowledge only knows but cannot act. Saugstad(2012) continues with the comparison of the knowledgeable and the experienced man, but also introduces a new type of man that combines the two. The man of practical experience. The man who knows the why and knows how to act. He who knows what meat is white and also knows that white meat is more wholesome.

How do experience and knowledge represent themselves in contemporary learning?

Knowledge

The most we learn at schools (but also museums, libraries etc.) are deduced versions of the raw experience and supply us with knowledge about a certain experience(a subject, situation, a location etc.). Artists very beautifully describe their view/interpretation of an experience in creative ways. Videos describe the general premise of a topic and can be seen as an introductory gateway to a topic. Stories tell the experience of a specific person during the experience. Libraries supply us with one of our oldest mediums: books. Books (often)describe very specific topics and its intricate details and allow us to understand the topic at our own pace.

Experience

To become an experienced man we can go out and work on a project, do a workshop or apply for a job that will teach us the experience. This complies with the second characteristic of experience by aristotle. He implies that the body and soul are interdependent, and that this indicates a close connection between human, activity, human cognition and human character. This leads to the importance of getting the right experiences by performing the right actions. For example, during a woodworking workshop, the student can learn to become a good woodworker by doing the actions a professional woodworker does.

Process

Often during this process of gaining the knowledge and/or the experience we use active reflection. Or as can be seen in figure 6 drawn by kolb(1983), a cycle between different phases in the reflection process.

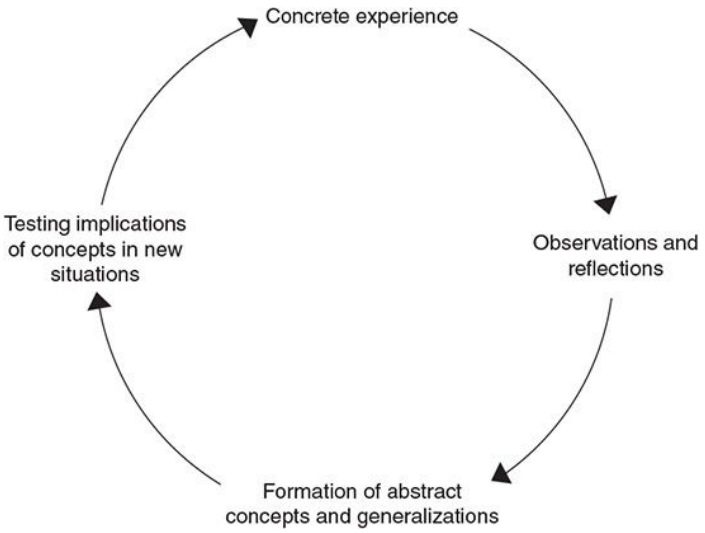

Figure 6, The Lewinian Experiential Learning Model. Source: Kolb, 1983, ch. 2.

This process often repeated to come to a conceptual overview that cohers with the experience being experienced, see figure 7.

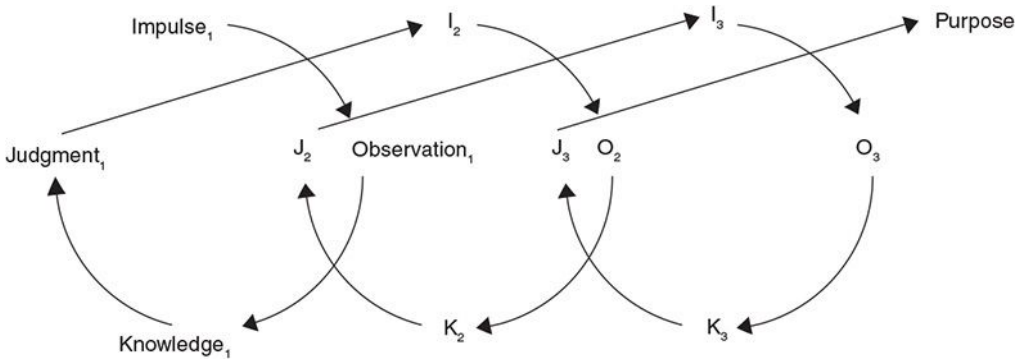

Figure 7, Dewey's Model of Experiential Learning. Source: Kolb, 1983, ch. 2.

Types of experience based education

Experience based education has been used in multiple ways in the past. The most common is the approach of using practical experience in the education process. For example, giving a mechanical engineer student the possibility to assemble a car (or parts of it). This approach is one of the most common, but certainly not the only way of approaching experience in education.

There are three versions of the experience and experience-based learning. The culture-based version, the science-based version and the motivation-based version (Saugstad,2012).

> The culture-based version is closely related to practice, training, habituation and customs. The knowledge is taught through these practices is part of the cultures collective- and useful knowledge. The focal point of this type of learning is on the importance of becoming experienced through the ways of the culture.
>
> In the science-based version, experience is related to induction and experience-based knowledge is associated with objective scientific knowledge. The educational focal point is on inductive learning and 'the importance of getting educational experiences'.
>
> Finally the motivation-based version is related to the individual biography and their social backgrounds. This type of experience based learning also relates to the dewey-inspired understanding of reflection through experience(see figure 7(dewey's model). Motivation based knowledge is often associated with pragmatic and useful knowledge. The focal point of this type of learning is on the needs of the individual, his/her inclination and/or social background.

All the types of experience based education rely on experiencing the right experiences. A good experience being specified by the type of experience based education. For the culture-based version this means to repeat the actions multiple times until they become natural(experienced) and have conveyed the cultural knowledge. For science based versions the approach of the student is most important and the knowledge induced from the experience. For motivation-based experience learning the reflection during the experience and after the experience are the most important aspects.

The different types of experience based learning experiences do not necessarily exclude each other. E.g. If an experience is "made" for culture based learning it could also be used as an science-based experience, because the main difference is how the experience is used. The science based version could deduct from the experience whilst the culture-based could still "make" someone experienced.

The steps in learning

The learning process uses multiple steps to come to full understanding of what is to be learned. The Bloom's Taxonomy of learning is one of the most famous and widely used figures by all kinds of teachers to research and learn teaching. The figure lists multiple ways of learning and categorizes them according to increasing difficulty. The two dimensions along the axis are the knowledge dimension and the cognitive process dimension. Along these axes the actions of learning are ranked according to the level of the thinking/learning skill required to do the action.

Figure 8: A Model of Learning Objectives–based on A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives, Source: https://www.celt.iastate.edu/wp-content/uploads/2015/09/RevisedBloomsHandout-1.pdf

Figure 8 will be used as the foundation for describing the actions in the learning process and will be used as a reference for the level of thinking, e.g. the level of the skill, required to do this type of learning. The objective of most learning programs is to advance the skill level to be able to do "higher" actions. For example, architects start by analysing different parts of a building to be able to design their own buildings.

Digital tools in experience based learning

What role do digital tools play in experience based learning?

Why is "digital" important for our experience based learning?

The importance of the digital world for education is determined by what the digital world allows us to do and experience. To understand what the digital world will add to our learning we first need to understand what the digital world and the actual world are(two common terms for the different worlds) and why is the digital important now? And not 10 years ago when the digital world also existed?

First, the actual world and the digital world. The actual world is the physical world that we know and we live our lives in. The digital world being the world that we interact with everyday through the computer screen, mouse, touch screen or any other input device. The interaction that we have with the digital world is very limited and requires facilities(facilitators) to be a gateway into this digital world and allow us to communicate with it. This interaction is illustrated in figure 9.

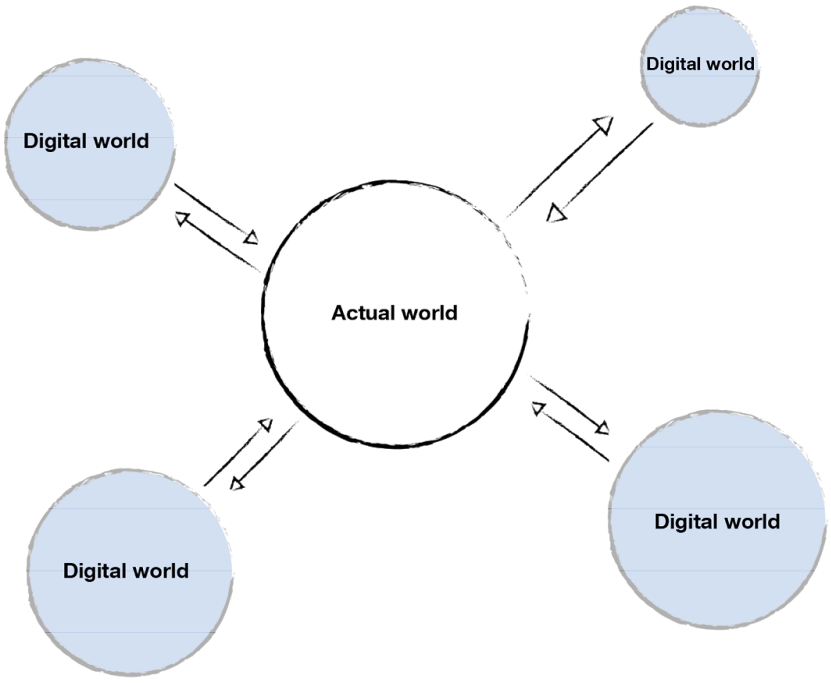

Figure 9: The separated digital world from the actual world, source: own image

But this way of interaction with the digital world has changed. New tools allow us to interact with the digital world in new ways. Phones(or glasses) allow us to project digital "assets"(name of objects in the digital world) into the actual world. While other tools allow us to travel to the digital world. In essence these two examples, travelling to the digital world and showing the digital world in the actual, are VR and AR. AR, augmented reality, adds a digital layer to our perception and allows us to see assets, data etc. in our actual world. When we talk about VR (virtual reality) we (mostly) use a HMD(head mounted display), a type of glasses that will only show the digital

world while also allowing us to freely move in said space. Both of these types of interaction with the virtual space alter our experience. AR altering our experience of the actual space(adding or removing parts of the actual world) and VR giving us new experiences in a virtual world(realistic/non-realistic, historical/fantasy). This new type of interaction is conceptually drawn in figure 10. The blue spaces being where we will interact with the digital world, whether them being in our actual world(AR) or in the digital world(VR).

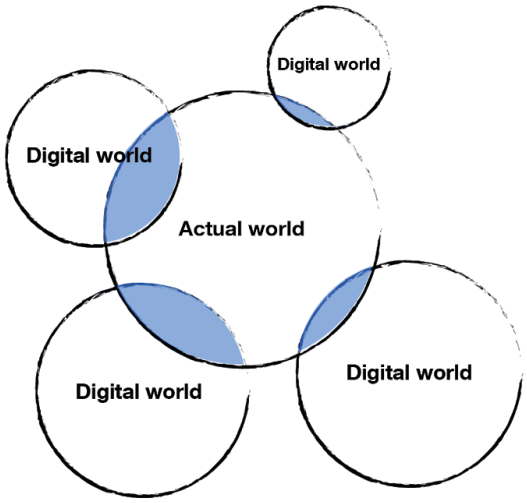

Figure 10: The intertwined digital world from the actual world, source: own image.

The main strengths of AR and VR are the possibility to be fully immersive and being very clear communication tools. But just like older teaching tools (like books, video etc.) AR and VR have their own strengths and weaknesses. The place of VR/AR will be explored in the next chapter.

XR is part of architecture

XR(VR and AR) is part of the architecture and the tool of the future architect. With access to VR and AR architects no longer do we need to guess how their building looks or imagine(possibly wrongly) how it will become. Architects can finally test hypotheses without the need to build the building first and quickly make 1:1 scale models of their building fully experiencing every aspect(layout, light, color, openness etc.) of the building.

These digital tools are not only part of our experience, but also go as far as being architecture. Future generations of architects will be able to design with AR in mind which will give them even more possibilities(think of ever changing stone facades, color changing stones, adding digital only assets etc.)

The place of digital tools in the experience-based learning process

“I never teach my pupils, I only attempt to provide the conditions in which they can learn.”

- Albert Einstein

AR and VR will add new possibilities to our learning experience as described in the previous chapter, but VR/AR is not the ultimate media which makes videos or books unnecessary. Each medium has their own strengths and weaknesses. For convenience we will group all of the different media by purpose and at which stage of learning they are the most effective. The two original stages are the gaining of broad knowledge and deep knowledge. Broad knowledge describes the knowledge at the surface of a subject. For example, the knowledge that water molecules attract each. Deep knowledge would be the knowledge of exactly why the water molecules attract each other.

Let’s say you have never really seen or experienced this cohesion of water, this would make the learning process of both the broad- and deep knowledge more difficult to understand. This is where experiencing comes in and new tools like VR/AR. In figure 11 the different characteristics of the main tools within the three types of learning phases are shown.

Experience AR/VR	**Broad knowledge** Video/discussion/lecture	**Deep knowledge** Books/create
- Immersive - Own speed - Allows exploration - Stimulate exploration - Move, interact - No limits/restrictions - Active learning - Get intrigued - inspire	- Linear experience(video) - Talk, discuss, share - Find specific interest - Clear overview of subject - Narrative by director - Fast knowledge	- Vast knowledge - At own speed - Very specific knowledge - Gradually builds up knowledge

Figure 11: characteristics of different tools in education ,Source: own image.

Different roads in experience based learning

The characteristics of the different steps in education(experience, broad knowledge, deep knowledge) foretell that in almost every journey of learning multiple ways of learning will be done during the process. The multiple ways of learning and their different characteristics allow for multiple routes to take during the learning process(108 when 4 steps are taken). This shows that we cannot create a space for every different route, but we don't need to. Spaces can be built to be able to adapt to multiple types of experiences. For example a space can be built for active experiencing, but also used for gaining broad knowledge during a lecture. Requirements for this space would be, enough space and the possibility to adapt. Other steps like the deep knowledge stage would benefit more from a permanent and more specific space shaped to their need. Like a quiet space to read a book.

Below multiple routes are shown. These routes are limited to 4 steps to limit the amount of possibilities. Most likely some of the steps(or the whole cycle) will be repeated to achieve the greatest effect.

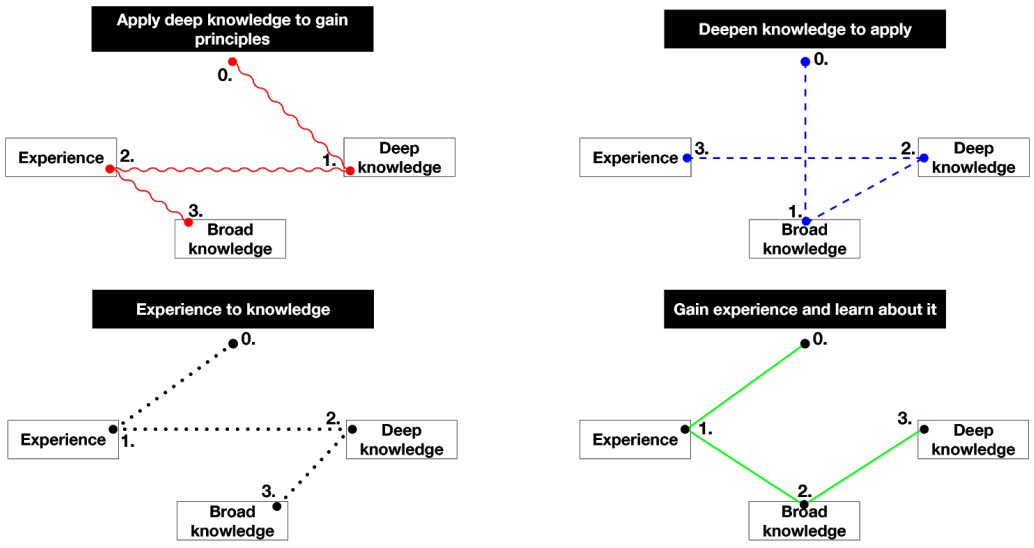

Figure 12: different roads of learning ,Source: own image.

As can be seen above, the learning can be done in any order. For example the order experience → broad knowledge → deep knowledge. This order can be used to guide someone through an experience which the person should know to (easier) understand the broad knowledge to eventually be interested in/understand the deep knowledge. Another scenario could be to peak someone's interest into this specific scenario/scene. The user might have a positive(interested) or negative(not interested) reaction to the experience and could use this experience to broaden their knowledge of the experience(or a specific object/process/part in the experience). This could lead to a fascination into a specific part of the experience which will

trigger the person to learn broad knowledge about the subject. Eventually the fascination could stimulate the person to learn the deep knowledge or gain new deep knowledge.

Another added benefit to using the digital tools is that they give the possibility to revisit the experience and allow for learning at someone's own pace. As described by Routledge(2016) the amount of information that we can take in at any given day/time is limited. Therefore we need to be able to have moments of reflection and time to process. These moments of reflection are not shown in the figure, but are nonetheless a very important part of the learning experience.

Below some of the "roads of knowledge" are explained in more detail. These are different possibilities for allowing experiences to be part of the learning process.

Spark fascination into knowledge

experience→ video→book
Children will be shown a volcano erupting(the experience). This might trigger their interest in volcanoes, lava, pyroclastic waves, clouds, heat, earth and /or the climate. After this experience the children will be given the opportunity to learn more about the general topic(videos for example) and they will be guided/supported in their search for the deeper knowledge (e.g. how can it be that stone can behave like a liquid).

Gain experience using knowledge

video/book→experience
In this example people will first learn how to change a circuit board(broad knowledge), what you should and shouldn't do while working with circuit boards(broad knowledge) and a detailed understanding of how a circuit board works(deep knowledge). After gaining the knowledge the people will practice how to work with1 circuit boards and will experience working with circuit boards.

Start with deep knowledge and learn a practical use for it

Deep knowledge→basic knowledge→experience
You already have the knowledge but now you need to get a practical use for what you have experienced/learned. Going from deep knowledge to expanding your base knowledge to experiencing your own use case.

Provide knowledge in new ways

experience/book/video
Learn a kid who has problems with sitting still(the cause) new words(He is behind on learning new words due to the lack of focus and excess energy). This kid can learn new words by moving virtual words and learn whilst also moving around.

Role of (digital) architecture in the process of learning

How can architecture enhance the learning experience?

> *"There is no doubt whatever about the influence of architecture and structure upon human character and action. We make our buildings and afterwards they make us. They regulate the course of our lives."*
> - Winston Churchill, 1924

As Churchill stated the architecture around us is shaped by us, but also shapes our actions. The role of architecture on the person has been researched many times and empirical research has shown the effects colors, light intensity, amount of space, organisation, shapes, scale and many other factors have on people. Even now we don't fully comprehend all the effects architecture has on the people living in it, but many aspects of architecture like the organisation of a room, the need for daylight, the positive effects of green are already proven and used.

As noted above, many aspects exist which influence how we work and live in our buildings. Below some of the major aspects will be explained and highlighted to be used in the what-if situations at the end of this research paper.

Position and focal point

If we have two choices A and B then architecture does not make us choose option A, but it does influence our thinking process and our actions. For example, the layout of the room influences the role we take in a conversation. Below are three kinds of layouts we know and use during our spoken moment of sharing. These layouts tell the people in the room whether they are participating(allowed to talk) in a discussion, listening to a monologue or part of a group(side) in a discussion. The layout (sub)consciously influences the audience and their actions.

In these examples two factors play a major role in defining what a normal action is. The factors being: position of the speaker vs the public and the focal point of the group.

Figure 13, Three examples of spaces where the participants have different positions in the experience. On the left the DelMar theater, middle house of commons, right a small discussion group.

The position of the speaker shows the relation between the speaker(s) and the public. In the left example of image 1, the speaker is elevated. This elevation creates a (social) barrier, for the people who are not elevated, to speak. The focal point of this organisation is on the speaker and thus makes the speaker an even larger point of importance.
The two opposite tribunes, as in the house of commons, is a type of organisation which creates two sides in a group with a focal point in the middle. The split into two groups insinuate that the discussion is between two groups with different opinions.
The final example is an organization with the focal point in the middle of the group and no elevated platform. In this organisation everyone is equal and an open type of discussion is promoted.

In short, the layout of the people in the room tells the people whether they are in a discussion or listening to a monologue. But the layout can also change the approach the participants have to the experience. A discussion group will function better when everyone can see each other and everyone is equal. A speech will work better if one person is the focus point.

Visibility and light
Light together with the organization of a space strongly influences how we act/react to phenomena around us. The organisation of the space, for example a theater with a raised stage, gives a focal point and implies that we are supposed to be observers. The bright lights focussed on the actor strengthen this relationship. When the lights of the rest of the room come on we know that we again can take action, e.g. clap, shout, cheer or discuss.

This example of the effects of the organisation of space and the strengthening effect of light show the influence that our perceived space has on our actions and reactions. The influence the architecture has shows how much we can use architectural aspects to shape our actions and enhance the learning experience by using fitting architecture. . In the next chapter an exploration about how (digital) architecture can be used to improve/guide our learning experience is done based on what-if experiments(see appendix).

Digital side note

The digital architecture, the architecture of the space in a digital environment or augmented actual environment, does not restrict itself to the laws of nature(only to the laws of computing power). This allows the architect of the real space to use impossible objects, but also allows the virtual architect to create architecture which is precisely tuned to what the person going through the experience needs.

What are the requirements of the Experience based learning experience

The parameters

In this chapter the factors of a learning experience from the previous chapters will be combined to form a framework with which the experiences will be evaluated. In the previous chapters three contradictions(but not excluding contradictions) which are part of the learning process were found and explored:

Active - passive
Experience - knowledge
Deep knowledge - broad knowledge

These are some, but not all, of the factors which describe the learning experience. To better describe the experience three other factors have been included in this experiment:

Together - alone
Guided - self-taught
Conceptual - factual

These parameters are not binary. For example, the experiences described can be done alone or completely together, but it's also possible to do the experience partially together. A full list of the parameters and a short description is shown below:

Together - alone
: Does the student do the experience together with others or alone?

Guided - self-taught
: Will the student be guided through the experience through media and/or others? Or will the student be learning on their own?

Active - passive
: Will the student be actively partaking in the experience of will the student be observing?

Conceptual - factual
: Is the knowledge/experience gained conceptual or factual?

Experience - knowledge
: Will the experience teach the student how to do something(experience) or why something is happening(knowledge)?

Deep knowledge - broad knowledge
: Is the knowledge very specific for this situation(deep knowledge) or more common and widely applicable knowledge(broad knowledge)?

The experiences

These characteristics have been used on three very different experiences(see appendix 1). These what-if situations have been analysed to see what kind of effects the parameters have on the architecture of the experience and the requirements of the architecture around the space. An expansive explanation and reasoning of how the specifics of the experience came to be can be seen in appendix 1. The three visualistations and their characteristics of the experiences can be seen below.

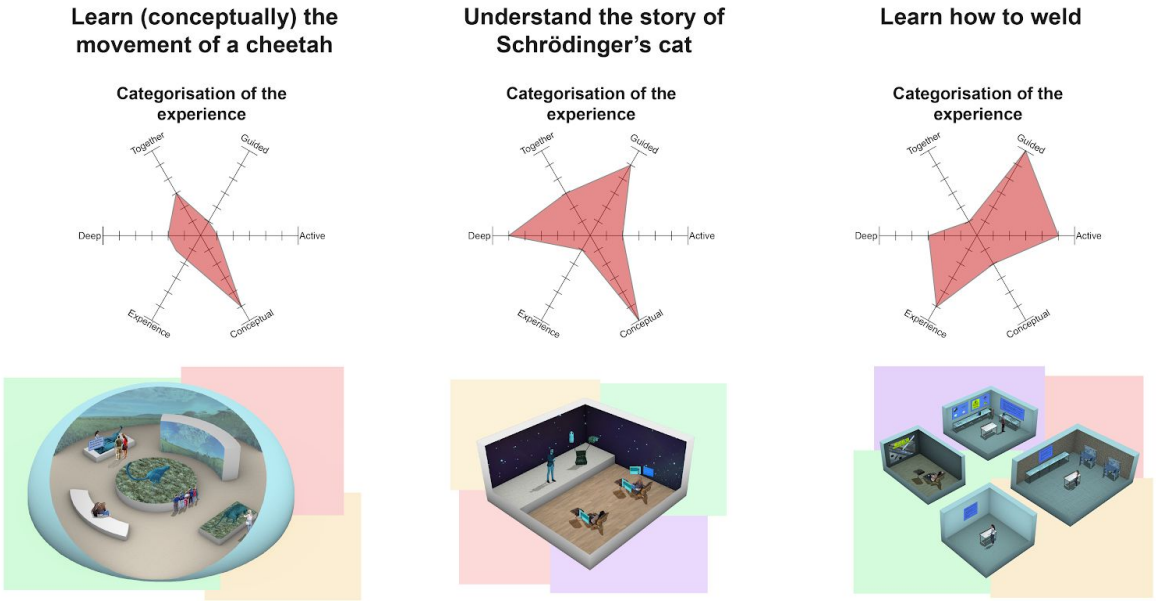

Figure 14: three what-if experiences created for learning what a learning experience environment consists of. Source: own image

Digital sidenote

Important to note is that in these experiences both digital and virtual objects have been used. This was done to be able to explore what digital assets in a real world could be used for, but also to be able to create experiences that are highly effective and not restricted. The blue objects are digital assets in a real space. This would presume that AR goggles would be used. The same experiences can also be done in a completely virtual environment(VR).

The first experience was to learn a group of students, or a student alone, how a cheetah moves. This experience focussed on gaining knowledge and by passively observing. The focus point of the room is in the middle where the student can see an elevated stage where a cheetah is running and reacting to his/her surroundings. The student was not able to view the cheetah from close, this was to convey conceptual knowledge of how the cheetah runs.

The second experience is designed to make people understand a very conceptual theory/story, namely the story of Schrödinger's cat. Here the student is put in a relaxed position with a

speaker(a digital version of Schrödinger). Schrödinger will explain the story of his cat going into a box, supported with a digital version of the story, and will ask the students wether the cat is alive or dead(or both). During this experience the student will placed lower than the speaker on a stage to convey the unspoken message of: you are listening to someone. In this experience the students can listen to the story multiple times and also to multiple versions. The students will also be able to read with the story and use other media during the experience(e.g. Short videos, audio, books, documentaries).

The third experience is about learning how to weld. This experience is more practical and will teach the student experience(how to do something). During this experience the students will go through a series of smaller rooms which will focus on a specific part of the experience. The first room will give the knowledge of what the student will need to do. In this experience the student will be seated and watching a video which will give a short overview(broad knowledge) of welding. In the second room the student will learn about the objects she will use and find in a workshop. In the third room the student will be (virtually) welding and guided on how to weld. This will be done in a realistic workshop environment and thus preparing the student for how a real workshop looks and feels. In the last room the student will review the different welds he/she has made and by doing so(with other examples and a guide) will learn to recognise a good weld.

Reflection on the experiences and their parameters

In this part of the chapter the different experiences will be evaluated by how the characteristics influenced the type of space.

Together-alone
The effect of this parameter on the experience was mostly related to space and seating space. The more people in the experience would mean a bigger space. This aspect of the experience together with other aspects will lead to certain arrangements of objects, for example tables, in a room. A guided experience with multiple people would mean that the experience is viewable for multiple people and a focal point(e.g. raised stage) for a teacher.

Guided - self-taught
In some of the experiences the focus of the experience was for the student to learn by themselves(cheetah experience) and in other experiences the student was guided through the experience with the knowledge of others in different forms(other people explaining, video, tekst etc). This parameter was translated mostly into the shape of the rooms and the direction of the rooms.
In case of the cheetah the focal point is on the center of the room, this is done by creating a circular room. In the Schrödinger's cat experience the focus was on the stage with the teacher. Therefore a more rectangular room was chosen with a clear elevated stage to draw the students attention and also insinuates that the person is a more knowledgeable person on this subject. In a guided experience in which the students will be taught something more practical a different approach is needed to conveying the knowledge/experience. In this approach the student would benefit from an open area that allows the student to see what the teacher is doing from all sides.

In a self-taught experience the setup of the environment is largely dependent on other characteristics. An active experience(how to do it) self taught experience will require space for the student to do the experience, but a passive version would only require a small space to go through the experience.

> **Digital side note**
>
> The power of the digital tools is that they can completely alter the vision and hearing of the students. This however, does not mean that this should be done. The student will be voluntarily participating in the experience and thus the student should not be forced to look in a certain direction. But the student can be nudged to look in certain directions through clever design(a focussed light, bright colors etc.). The second argument here is that an experience feels more immersive when more senses are engaged at the same time. Even unreal experiences like, a cartoon styled experience, a medieval village or a spaceship can be immersive. However, a negative feedback loop would quickly remove the immersion of the experience. Examples of a negative sensory feedback loop are:

trying to touch something that isn't there(no tactile feedback), a slowed video feed(delayed visual feedback) or audio and video being out of sync.

Active-passive

This dictates mostly how the participant interacts with the experience. In the digital world interactions can be disabled. However this will break the immersion of the experience (more about this can be read in my theory thesis: realism of the virtual reality, see appendix 4) . The main factor that breaks the immersive experience is the creation of an impossible moment(also called a negative sensory feedback).

The student can be influenced to be active by regulating whether it is possible to easily interact with the experience. For a student to be actively participating in an experience the space needs to be able to facilitate the student to be part of the experience and come close or influence the experience. For the architecture this means that the student should be able to approach the subject and any barriers physical or digital should be avoided. At the same time the position of the objects respective to the user influence how the user behaves. A good example of this is to place objects at hip level(easily reachable. Other architectural measures to stimulate activity are widely researched and terms like nudging, active living environment and the effect on color on our behavior are examples of this.

In case the goal of the experience is to (forcefully) experience the experience passively then the architecture of the space would need to create barriers(both psychological and physical). For example, architecture could stimulate passive behaviour and prevent people from going against the goal of the experience by using: Raised stages, a dimly lit room, a closed off subject(an art piece in a glass cube). These examples of natural architectural "barriers" can nudge the participant to live through the experience passively.

Conceptual-factual

In most cases a conceptual or factual learning experience translates to how the experience and subject is presented. This aspect of the experience is part of what the student is supposed to learn. For example, either the student needs to know the hard facts of how a cheetah walks(muscle a moves then muscle b) or the more conceptual approach(his left leg lifts and moves forward).

This characteristic of the experience described what the required(or visible) detail level of the experience level should be. This detail level is focussed on the senses that are used to experience the experience. This could be handled by using abstract models. Also architectural tools can be used like light level, forcefully creating distance from a subject(by creating barriers), obstructions in a space(limiting view) etc.

Experience-knowledge
Whether an experience is knowledge- or experience focussed dictates the kind of actions that the student will take. In short the question is: Will the student learn how to do or know why it happens?

This characteristic is hard to express in an architectural statement. The effect that this characteristic has on the experience is often combined with other characteristics. For example, a purely experience (how to do it) focussed learning experience will teach the student how to weld. In this case the experience(learn how to do it) aspect gives the space the requirement of enough space for a person to weld, but whether this should be a small room for welding or a large classroom for multiple people will be dictated by the together-alone characteristic.

Broad knowledge - deep knowledge
The broad or deep knowledge characteristic of the experience is even harder to define in an architectural expression. Broad knowledge is knowledge more broadly applicable(and often easier to understand) the deep knowledge often requires prior knowledge and makes an experience very specific.
A deep knowledge focused experience is often(but not always) focussed on one very specific part of a field and requires a certain situation and environment. This also requires the room to meet those particular requirements. E.g an experience showing how tidal waves move requires a context(ocean or large mass of water) for the student to be able to interpret the reason why the movement of the wave started and how it flows afterwards.

A broad knowledge focussed experience requires a room which is not specific to one particular situation/event/subject. The knowledge is applicable to multiple situations and would be interpreted wrongly if the experience would only be shown in one overly detailed particular situation. Therefore a broad knowledge experience would be conveyed better with multiple versions of the same concept in multiple situations or one abstract visualisation.

The difference between a broad knowledge room and a deep knowledge room can be seen if you compare the welding experience with the schrödinger experience. The Schrödinger experience is a more general room with no particular architectural features. Therefore the room gives no context to the knowledge. The welding experience(especially room 3 where the student has to weld) is designed to look like an environment in which the student will be welding. This will subconsciously teach the student where this deep experience is applied.

Conclusion

What can be concluded from making the what-if experiences is that the way the characteristics of the experience express themselves is often a mix of multiple characteristics. Each characteristic influences the experience, but combinations of characteristics dictate how the characteristics express themselves. Therefore it is important to completely understand what kind of experience is made and what the student is supposed to be taught. By doing this, for example creating what-if experiences, a more complete and fitting experience environment can be created. For example, a guided, experience focussed, conceptual experience could be a guided workshop to build a roman arch. But a guided, knowledge, conceptual experience could be a movie with commentaries.

Reflection

The making of these experiences did not necessarily teach me knowledge that is easy to explain. You could say that I have learned myself how to do it and also gained knowledge of what different design decisions can do for the experience. As can be seen in the previous chapter the exploration of the characteristics leaves some sometimes vague and almost always interdependent answers. This made it hard to explain but also very interesting knowledge for the design of the building in the second part of the graduation process.
This research made me think in a different way about how we can use our environment to create a symbiosis between the environment and the experience.

For me personally the part about how we learn/experience and what our mind needs was eye-opening. The knowledge of what we remember clarifies and engages me in daily life to understand more about what engages me and others in their daily lives. This knowledge combined with learning about the limited processing power and the need of restorative spaces/time helped me during the process to take (and validate) having regular breaks.

During the process I also discovered that a lot can be gained and learned through reading, watching videos, discussing with others and sketching. But the use of new technologies to experience the real model is something that really expanded the design process. By experiencing the building that looked good on the drawings felt different and wrong. But at the same time the new building (that felt good while experiencing it in VR) felt wrong and looked strange on paper. This raises the interesting question of whether a building should look/feel better on paper or while experiencing in VR(which are both very subjective).

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Images

Appendix 1 - What-if Situations

Case study 1 - Learning the conceptual movement of the cheetah

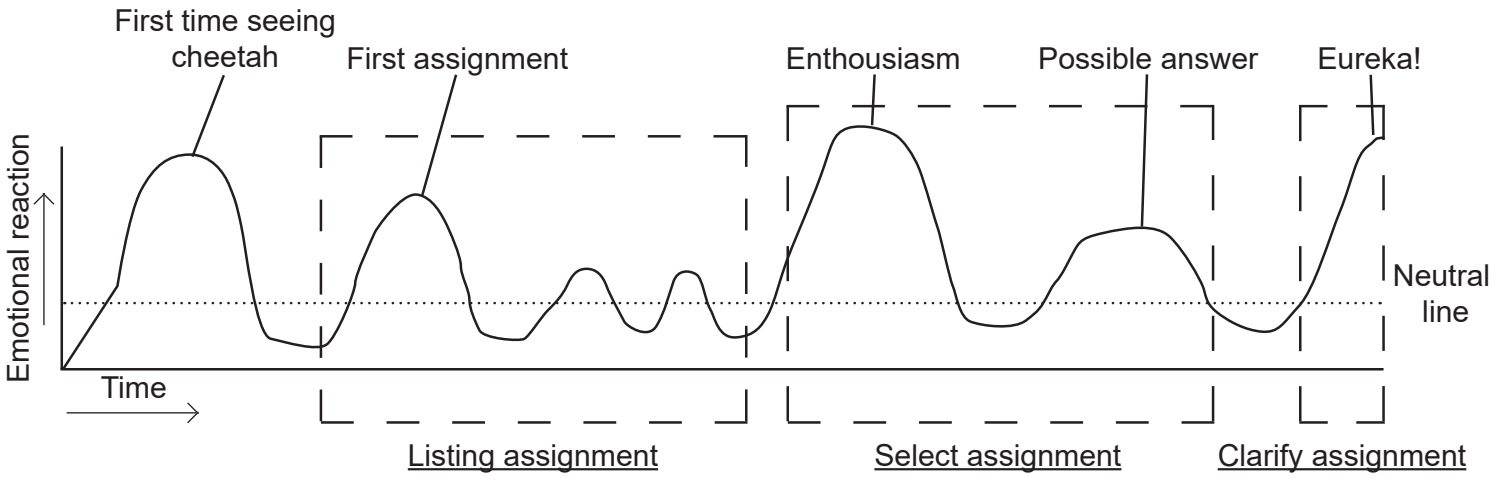
Description of the context

The student wants to learn about the movement of the cheetah. The student doesn't know anything about the cheetah, it's movement or it's anatomy.

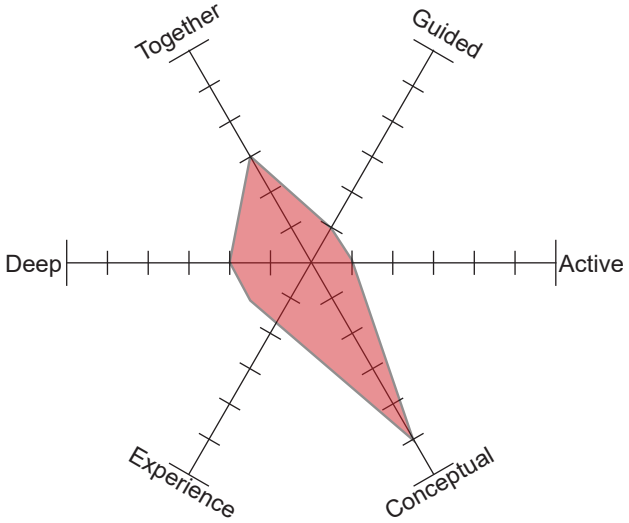
The assignments in this experience will be to: list, select and clarify.

Description of the way of learning

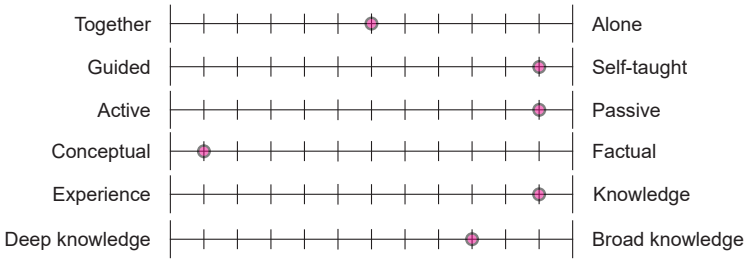
The student will be taught the movement rhythm, the joints and the reaction of the cheetah to its environment based on a virtual version of the cheetah in its natural habitat. Through observation, the student will gain a conceptual understanding of how the cheetah moves.



Categorisation of the experience



This diagram shows to what characteristic the experience belongs most to on 6 different criteria(as seen below)



Together - Alone

The student can do this experience both together and alone

Guided - self-taught

The student will be learning how the cheetah walks by him-/ herself. The student will have the raw experience of a cat walking

Active - passive

The student will be passively observing the cheetah in the room. he/she will not interact with it.

Factual - conceptual

At first the students will learn the joints(factual) this basic knowledge will help him/her with understanding how a cheetah walks

Experience - knowledge

The student will learn the knowledge of how a cat walks

Deep knowledge - broad knowledge

The knowledge gained will be a basic understanding of how the big cat walks.

Case study 1 - Learning the conceptual movement of the cheetah

Generalisation of the experience

The cheetah experience can be described by the following characteristics: together or alone, self-taught, passive, conceptual, knowledge, broad knowledge(see image 2). These characteristics make the design of the experience as seen in image 4.

The main activities of the experience are to list, select, and clarify. This is mostly done by observing the cheetah in its daily activities.
To be able to list what is happening the student needs to have a place to see all the things happening. In this case, a digital model of the cheetah doing the actions repeatedly. To facilitate this the experience will have a place to sit and observe.

The select action is done to analyze what part of the list is necessary for the movement of the cheetah. To do this the student needs to be able to go deeper into what some particular muscles/joints/bones do. For this use, a more detailed model is placed in the experience(top left). The select action benefits from being able to do a quick research on the specific topic as to know what is important and what to select from the list.

The clarify action is the final step in the process. In this step, the student will learn from observing the selection(the important parts of the movement) and will try to understand how the cheetah moves. In this step, the student would benefit from testing the hypothesis. As such the student will able to slow down/pause/repeat the running digital cheetah. At the same time, the stage on the bottom right will facilitate an active exploration of the movement of the cheetah by allowing the student to interact with the cheetah.

Assignment	Knowledge dimension	Cognitive dimension	Actions
List	Factual	Remember	Anotate, repeat
Select	Factual	Analyse	Repeat, observe, isolate
Clarify	Conceptual	Understand	Explain, test, write down

Case study 1 - Learning the conceptual movement of the cheetah

The requirements

For the optimal architecture to be found the experience first needs to be described, the six categories explained and the list of requirements made.

The experience requirements	The architectural requirements
Together - Alone The student can do this assignment both together and alone, for this learning experience it does not matter.	The room needs to be able to be closed and also allow for enough space for multiple people to be in the same room without hindering each other.
Guided - self-taught The student needs to teach him/herself, therefore, the student needs to be able to focus and needs to have the most realistic experience	The room will be composed of a mix between virtual and actual objects allowing as many senses as possible to be engaged(mainly sight and touch)
Active - passive The student will be passively observing the cheetah and needs to be able to do this without too much distraction. Also for this experience, the students would benefit from some distance between them and the cheetah. As to observe the concept of the movement and not the detail of the walking.	The student will be passively observing and will benefit from not seeing distractions from others and/or sounds from others. Therefore the overall lighting of the room should be low. Also, the student will not be able to walk close enough to the cheetah to see the details
Factual - conceptual The students need to learn the concept of how the cheetah walks, for this the students need detail, but not too much as to distract them.	The room needs to have sufficient lighting and a focus on the subject(the cheetah walking). The cheetah needs to have light, but not too much because the small details are not important and will only clutter the learning experience.
Experience - knowledge The student will gain knowledge and need to be able to record the knowledge.	The room and seatings need enough lighting for drawing, writing, and photo’s/video’s
Deep knowledge - broad knowledge The knowledge gained is broad, due to this the student might gain more questions than are answered. Therefore the possibility to be able to pursue these questions should be provided.	Provide the possibility to pursue the questions. For example, a bookshop, discussion room, etc.

Case study 1 - Learning the conceptual movement of the cheetah

The experience

The experience consists of the people in the room observing the cheetah moving. The cheetah models are situated in their natural habitat and move according to the habitat. The observer can sit behind the cheetah and see what the cheetah is doing on a virtual screen. This way the students can see what the cheetah sees and how it's movements react to the surroundings.

In the middle of the room, a cheetah is shown running at top speed(120 km/h) which can be slowed down(slow motion) for the students to be able to see the movement of the cheetah. The stage around the cheetah prevents the students from coming too close, this is because this is an experience focussed on the conceptual movement not the precise movement of the cheetah. On the side, two other digital cheetah's are presented doing other activities(moving a cadaver and following a trail). These will allow the students to go more in-depth into the movement of the cheetah.

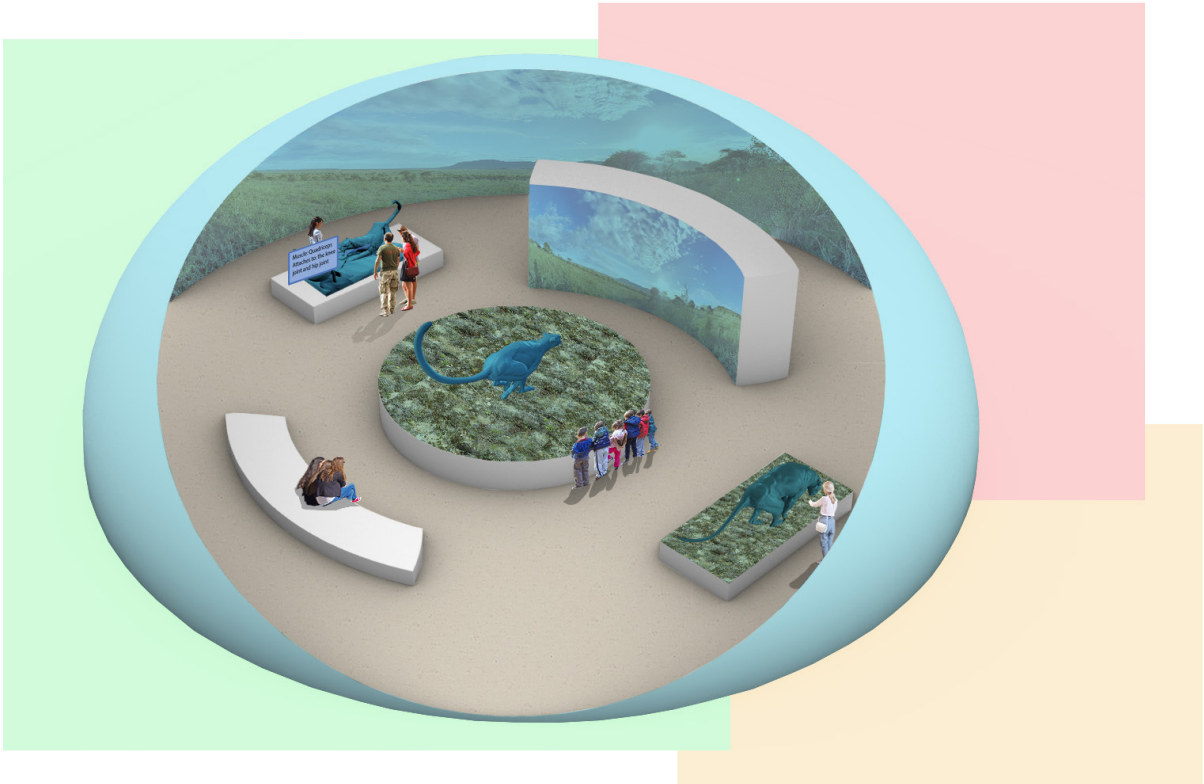


Image 4: The conceptual cheetah experience room

Image 5: A cheetah tugging a rope with an explanation of what the what the muscle is and where it is attached to the joints.

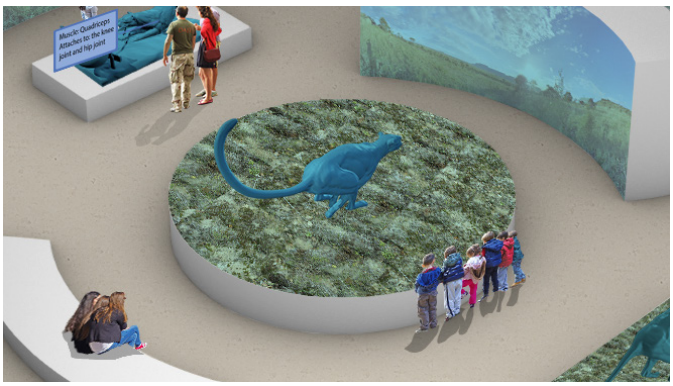


Image 6: A cheetah in full sprint, seeable from all sides.

Case study 1 - Learning the conceptual movement of the cheetah

Anatomy of the experience

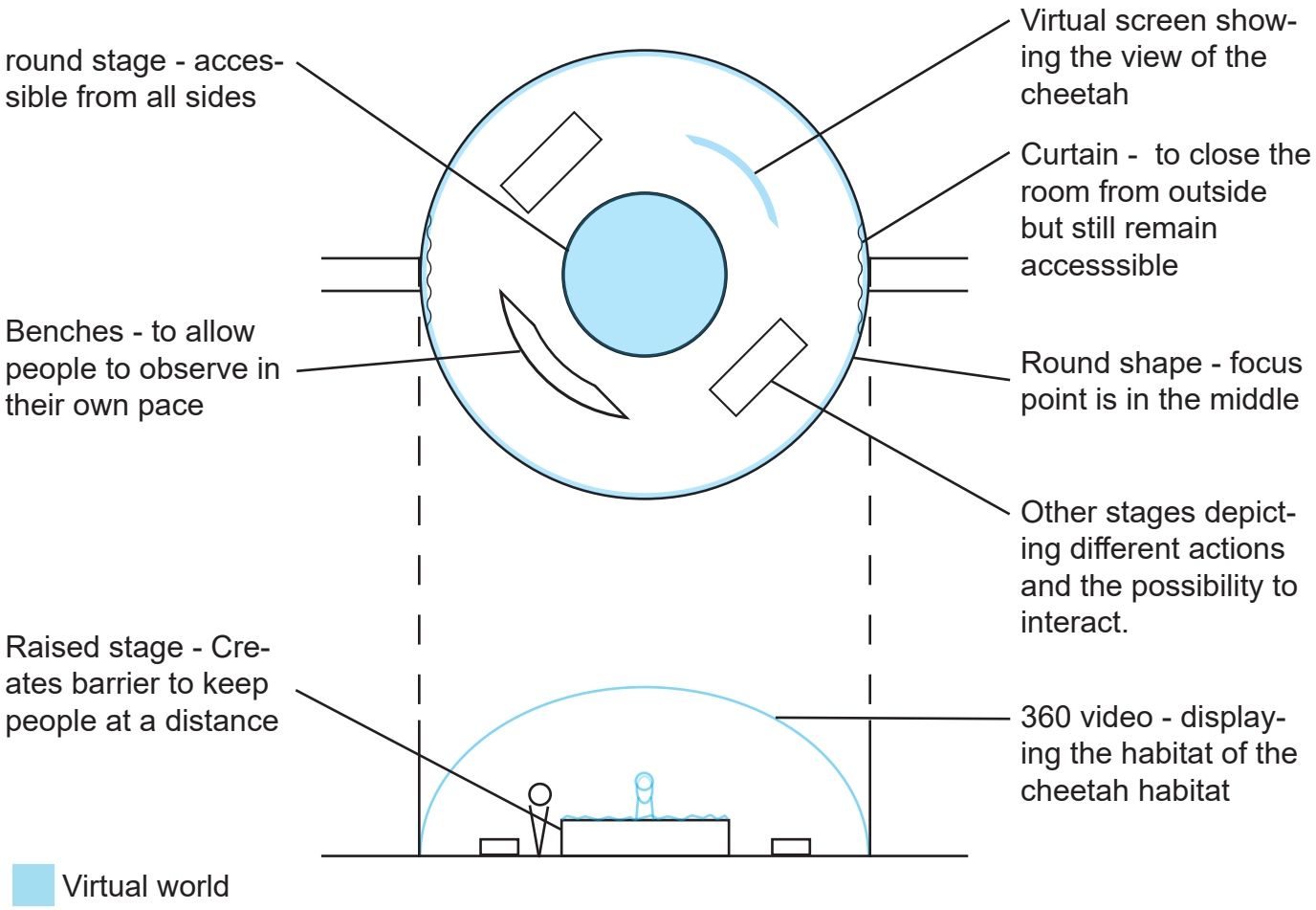


Image 7: The anatomy of the mixed reality learning experience

What-if the experience was active

For the students to be actively investigating the conceptual movement of the cheetah the student should be able to interact with the cheetah. For example, the student would be able to attach muscles to bones and try to mimic the muscle structure of a real cheetah.

Architectural needs..

To facilitate this the students would need to be able to get close to the virtual cheetah and interact with it. Therefore the stage would be smaller and multiple in the same room(to facilitate more people or different assignments).

What-if the focus is deep knowledge

To be able to fully comprehend the deep knowledge the students would need to be able to retreat to a place where they can work undisturbed at their own pace.

Archtectural needs..

The room would be divided into multiple smaller rooms which would all have their virtual cheetah and an optimal environment for learning from different media(books, video, and VR).

Case study 2 - explaining with schrödinger's cat

Description of the context

The goal of this experience is to explain the schrödinger's cat experiment.

The assignments in this experience will be to: to summarize, clarify and to reflect.

Description of the way of learning

The student will be taught what the schrödinger's cat experiment entails and what it is meant to show. the experiment tells how an object can "have" two opposite characteristics. To learn this the students will first summarise the situation, then clarifying and finally reflect on the experiment.

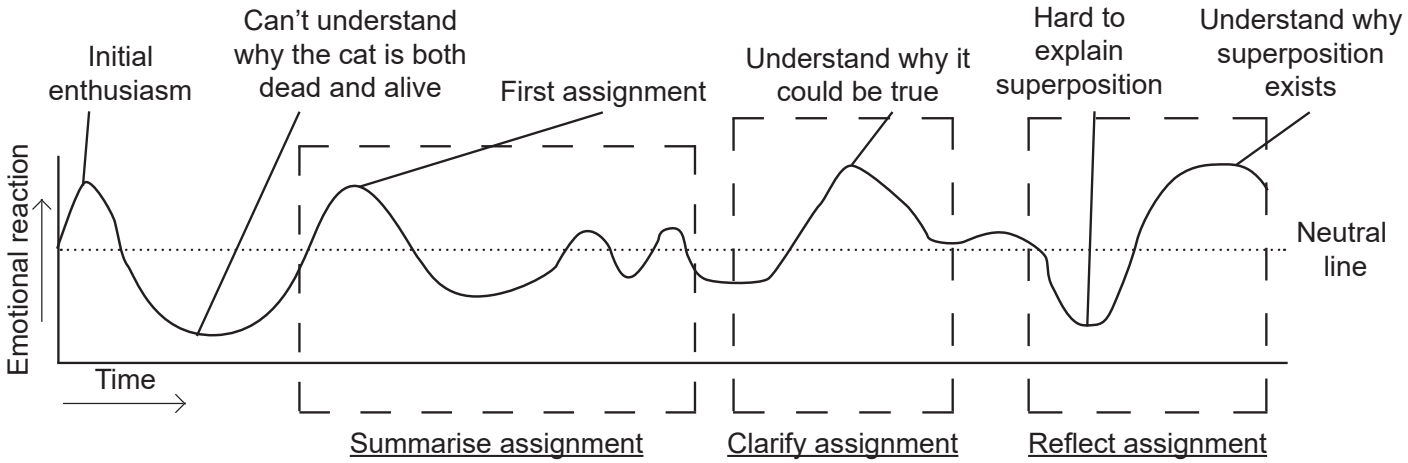
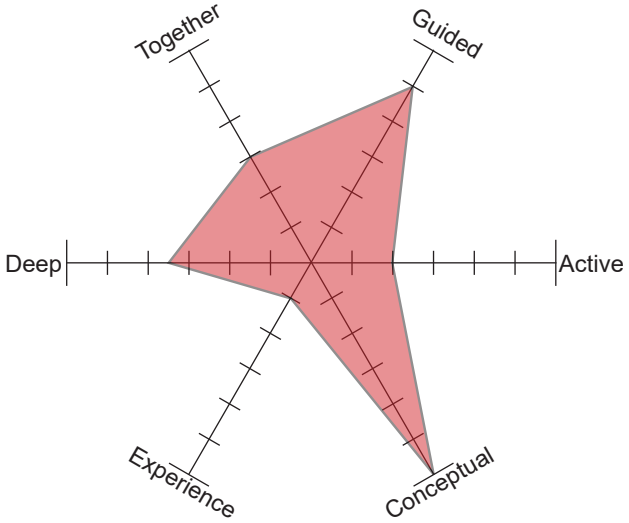


Image 1: The Schrödinger's cat actions timeline. Source: own image.

Categorisation of the experience



This diagram shows to what characteristic the experience belongs most to on 6 different criteria(as seen below)

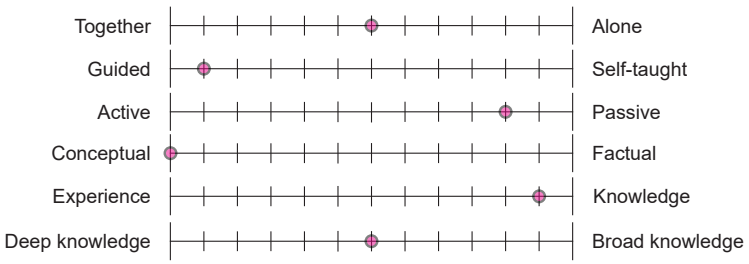


Image 2: The Schrödinger's cat categorisation of the experience in a radar graph and linear graph. Source: own image.

Together - Alone

This experience can be done both together and alone.

Guided - self-taught

To learn (the very abstract notion of) how a cat can be both dead and alive the student would benefit from being guided in the right direction.

Active - passive

During the experience, the participants will mostly be thinking, not actively participating.

Factual - conceptual

The knowledge gained is very conceptual.

Experience - knowledge

Understanding the story of Schrödingers cat´s gives knowledge and does not give practical experience.

Deep knowledge - broad knowledge

The knowledge is both deep and broad, because it is not specific and also only applicable to very few things.

Case study 2 - explaining superposition with schrödinger’s cat

Generalisation of the experience

The schrödinger’s cat experience can be described by the following characteristics: Together or alone, guided, passive, conceptual, knowledge, broad and deep knowledge(see image 2). These characteristics make an experience design as can be seen in image 4.

The first activity in the experience is to hear the story about schrödinger’s cat. The story is as follows:

Schrödinger stated that if you place a cat and something that could kill the cat (e.g. radioactive material) in a box and sealed it, you would not know if the cat was dead or alive until you opened the box. Common knowledge would say that the cat is either dead or alive. But in quantum physics, a state exists in which a thing can be both. This is called superposition. In the case of the cat, the cat can be both dead and alive.

After hearing the experiment the student will summarise what the Schrödinger’s cat experiment is. This will help the student understand the whole spectrum of the experiment and its different aspects. The focus of this part of the experiment is to understand what is happening, without having to explain why. This can be done by talking about it with others, repeating the story, writing it down, drawings etc.

The second step of the experience will be to clarify why Schrödinger states that the cat can be both dead and alive. During this step, the student will again repeat the story and isolate the parts that are difficult. To understand these parts the student can discuss the isolated parts with others or look up different examples on the internet.

The final step in the experiment is the verification of whether the student fully understands the Schrödingers cat experiment. In this step, the student will explain what the experiment entails. This can be done by discussing or answering questions

Assignment	Knowledge dimension	Cognitive dimension	Actions
Summarise	Factual	Understand	Anotate, repeat, ask
Clarify	Procedural	Remember	Repeat, isolate, discuss
Reflect	Metacognitive	Evaluate	Discuss, explain,

Image 3: The Schrödinger’s cat experience assignments, knowledge- and cognitive domains and their respective actions. Source: own image.

Case study 2 - explaining superposition with schrödinger's cat

The requirements

For the optimal architecture to be found the experience first needs to be described, the six categories explained and the list of requirements made.

The experience requirements	The architectural requirements
Together - Alone This experience can be done both together and alone.	The experience space needs to be able to accommodate a small group of people to be able to discuss the Schrödinger's cat experiment.
Guided - self-taught The student(s) will need to have access to the guide (virtual schrödinger) and also communicate with the guide. The student will need to be able to annotate what is being told.	To think, the student will need to be able to create a place where he/she can concentrate. The experience space should be able to accommodate the personal(concentration) wishes of the user(s).
Active - passive The student will be mostly passively participating(thinking/processing in their mind). To do this the person needs to be able to have enough space and the possibility to exclude others from their perception.	The experience space should allow the student to exclude everything from their perception if needed, but at the same time allow for discussion to take place.
Factual - conceptual The knowledge gained is very conceptual. Therefore the student needs to be able to store the information using the methods they prefer. Whether this is through audio, writing video, drawings, etc.	The knowledge gained is very conceptual. Therefore the student needs to be able to store the information using the methods they prefer. Whether this is through audio, writing video, drawings, etc.
Experience - knowledge The Schrödinger's cats experience is focussed on knowledge. The knowledge is very conceptual and would benefit from multiple types of explanations (short and long versions of the story, video's, animations, metaphors, analogies, etc.)	The room and seatings need good lighting for drawing, writing, and photo's/video's
Deep knowledge - broad knowledge The knowledge is both deep and broad, because it is not specific and only applicable to very few subjects.	Provide the possibility to pursue the questions. For example, a bookshop, discussion room, access to the internet etc.

Case study 2 - explaining superposition with schrödinger's cat

The experience

The experience consists of the student(s) being in a room which will have a representation of the cat in the box. The story will be explained by schrödinger itself. Schrödinger will be positioned on a stage for him to be visible to everyone. This will make Schrödinger the center of attention. The stage will stimulate passive behavior(listening) of the student. The room has multiple comfortable seating places.

The story will start with the cat going into the box together with the radioactive material. After one minute, Schrödinger will start to explain that by using common knowledge the cat is now either dead or alive, but that in Quantum physics the cat can be considered both dead and alive, this is called superposition. During this explanation, the students will see a digital representation of the whole story(cat moving into the box, etc.) Digital diagrams of the concept will show a conceptual version of what is happening. During the explanation, the students will have the possibility to read along with what schrödinger is saying. Afterward, the students will have the possibility to re-listen and re-read what has been said. To accommodate different kinds of students, the students will also have the possibility to reach other sources(internet etc.) which explain the principle in a slightly different way.

Image 4: The Schrödinger's cat experience room. Source: own image.

Image 5: the speaker will be accompanied by a real(digital) version of the story and also a conceptual (digital) representation Source: own image.

Image 6: The students will have multiple versions across different media(written, video, VR, audio) at their disposal. Source: own image.

Case study 2 - explaining superposition with schrödinger's cat

Anatomy of the experience

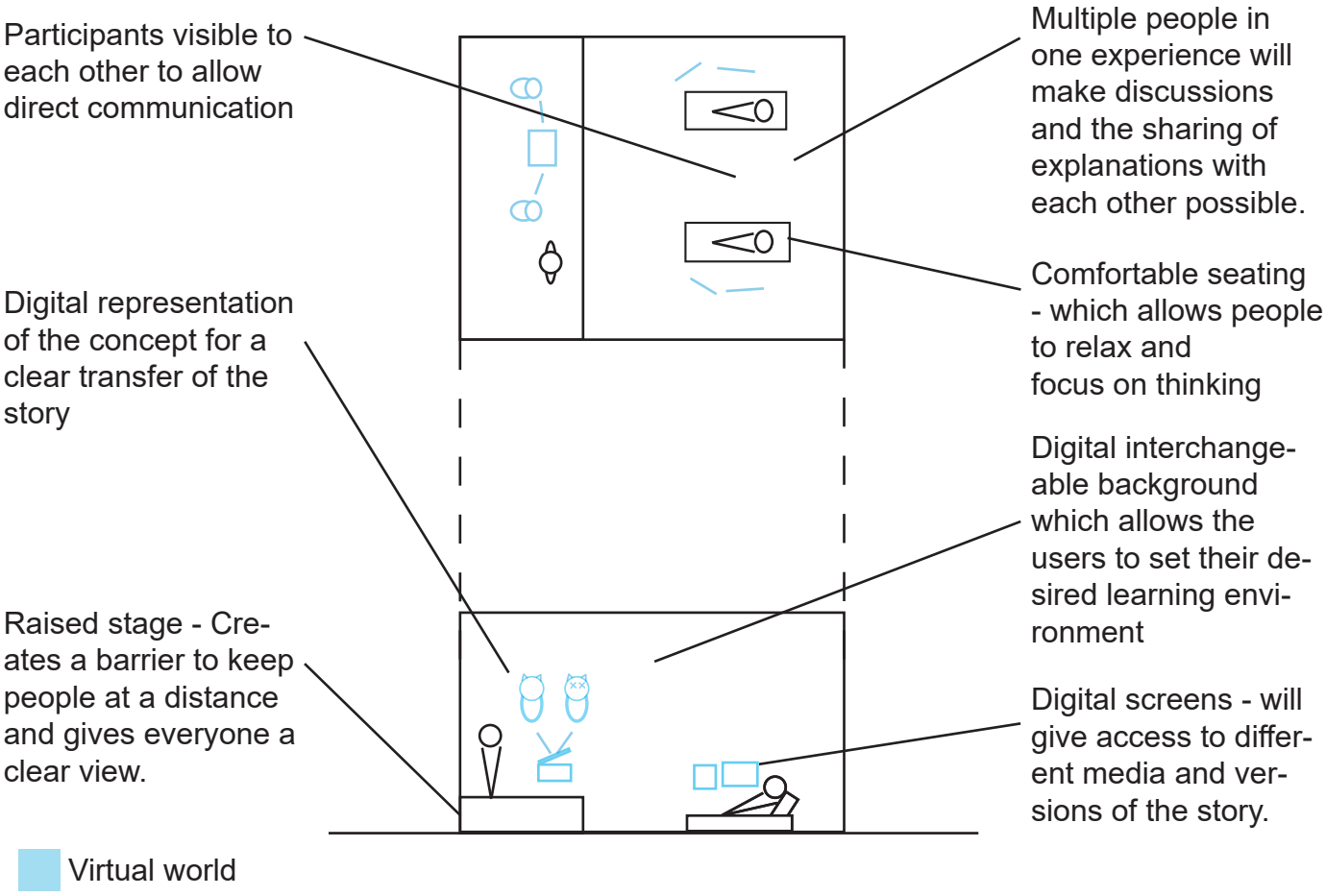


Image 7: The anatomy of the mixed reality learning experience. Source: own image.

What-if the experience was self-taught

For the students to be teaching themselves the concept of superposition the student would need to have a workspace where they could interact with the concept of the cat and other examples of superposition.

Architectural needs..

The experience space would need to be able to facilitate interaction with the experiments. The experience space would need to be bigger to accommodate multiple experiments.

What-if the focus is deep knowledge

For the student to understand the deep knowledge he/she would need to be able to understand what exactly happens with superposition and in what situations this would be useful. Therefore the room(or rooms) would need to have multiple examples(e.g. installations) of real use cases of superposition. Also, these examples should have a detailed description of what is happening, how and why.

Archtectural needs..

The architecture should give enough space and also create optimal environmental features(e.g. lighting, the height of the example, distance from example, etc.) for the student to be able to see and understand what is happening.

Case study 3 - Learning how to weld

Description of the context

The goal of this experience is to for the student to learn how to weld. This also contains the student knowing when a weld is good/bad and what to change to make when a weld is bad.
The assignments in this experience will be to: to list, clarify, carry out and to reflect.

Description of the way of learning

The student will be taught how to weld. The experience will start with providing information about how welding works, the equipment required and the procedur. The second part of the experiment will be a test to see if the student remembers the information given. Thirdly the student will be able to practice and finally the student will be taugh how to evaluate his/her welds.

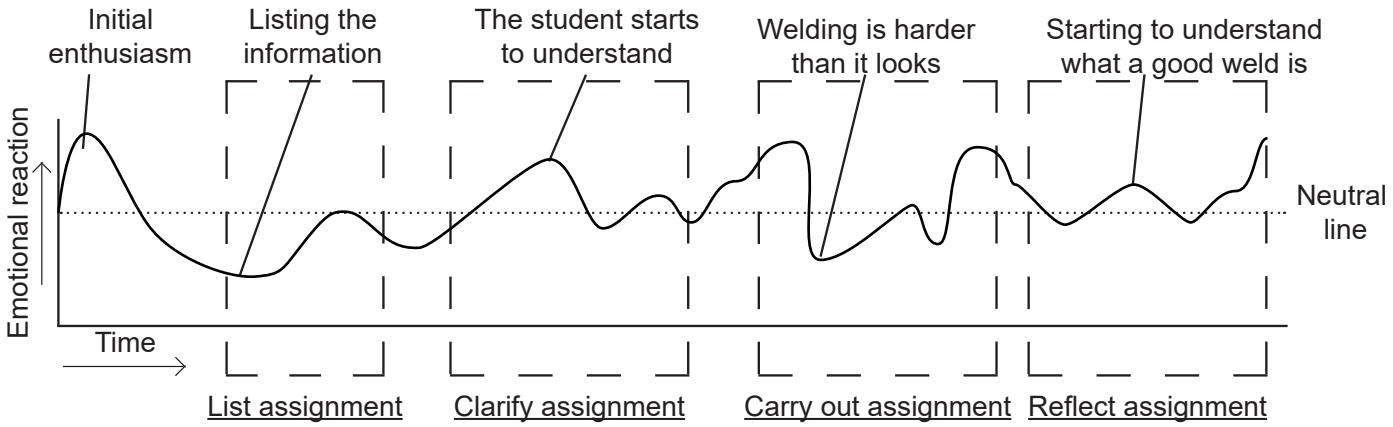
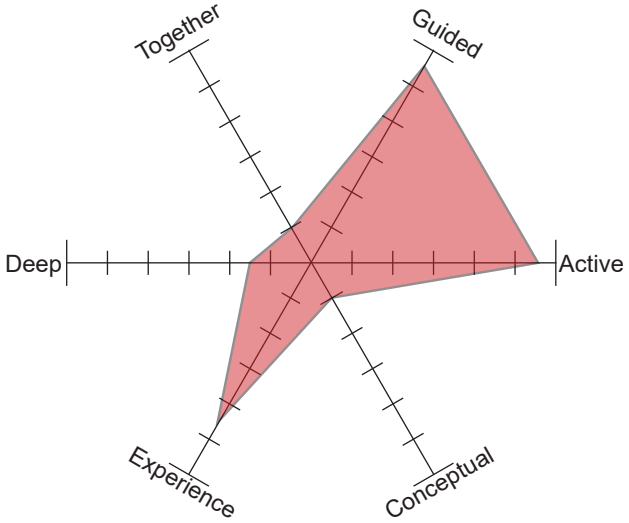


Image 1: The Swelding experience actions timeline. Source: own image.

Categorisation of the experience



This diagram shows to what characteristic the experience belongs most to on 6 different criteria(as seen below)

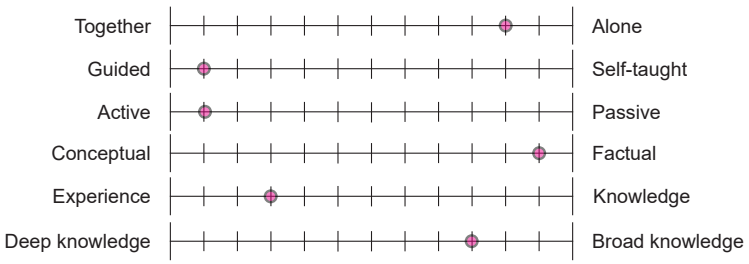


Image 2: The welding experience categorisation in a radar graph and linear graph. Source: own image.

Together - Alone

The experience(learning how to weld) needs to be done mostly alone, because the student itself needs to do it to learn welding.

Guided - self-taught

Years of experience will teach the student how to weld. Otherwise learning how to weld would take a lifetime.

Active - passive

This experience starts with learning facts and safety measure, but the core of the experience is focussed on learning how to weld.

Factual - conceptual

The knowledge gained is very practical and factual.

Experience - knowledge

This experience gives the student basic knowledge and practical experience in how a weld should be done.

Deep knowledge - broad knowledge

The knowledge is mostly broad, as this experience learns the basics of welding to a student who has never welded before.

Case study 3 - Learning how to weld

Generalisation of the experience

The schrödinger's cat experience can be described by the following characteristics: done alone, guided, active, factual, experience and broad knowledge(see image 2). These characteristics make an experience design as can be seen in image 4.

The first activity in the experience is to understand the basics of welding. There are three main types of welding. TIG, MIG and stick. To make this explanation simpeler we will focus on stick welding. During these steps the student will be in an virtual version of the working environment.

The first step of the experience is to go through some information that is important to operate a welding machine. This will go through the components, safety measures, basics of welding and the steps of making a weld.

The second step is to start memorising the important information. The experience is digital and thus safe to make mistakes, but this also allows the experience to be heavily regulated in what you can do at any given time. Therefore the steps that need to be taken are explained through audio, video and shown in a list on a poster. Also in this step the student will be shown(and can experience him/herself) what happens when certain steps are skipped or done wrong. E.g. not wearing safety gear during will make the student (virtually) blind.

The third step for the student is to do the welding. The welding will be done virtually and live guidance will be applied. The student will know what he/she is doing wrong, for example moving the rod too slow, having the rod too close to the metal etc.

When the student has enough experience of how to do the welding, he/she will move onto the next step and start reflecting on the welds that have been made by him/her and others. This will help to understand what a good weld is and learn to see what went wrong.

Assignment	Knowledge dimension	Cognitive dimension	Actions
List	Factual	Remember	Anotate, repeat
Clarify	Procedural	Understand	Explain, isolate, discuss
Carry out	Procedural	Apply	Do
Judge	Procedural	Evaluate	Review, describe, explain

Image 3: The welding experience assignments, knowledge- and cognitive domains and their respective actions. Source: own image.

Case study 3 - Learning how to weld

The requirements

For the optimal architecture to be found the experience first needs to be described, the six categories explained and the list of requirements made.

The experience requirements	The architectural requirements
Together - Alone The experience will be done mostly alone. Some guidance might be needed during the process, but the information given in the experience should provide most of the knowledge that is needed.	The experience needs to be able to facilitate one person and at most two(with a guide). The working space needs to be accesssible from multiple sides as to be able to work and spectate at the same time.
Guided - self-taught The student(s) will need to have access to the guide and information material. The student will need to be able to annotate what is being told.	The space needs to be focussed on what the guide is telling the student. Therefore, the space needs to be directional to the center of the experience.
Active - passive The student will be actively partaking in the experience. The experience needs enough space for the student to be fully enveloped in the experience and believe that he/she is actually doing the experience	The experience space should have enough space for the student to not be constricted. At the same time for the student to be
Factual - conceptual The information gained is mostly factual. The experience will need to be able to show this information in a clear and easily understandable way. Also the student should be able to review this information at any time during the experience.	The space needs to be brightly lit for the students to be able to see the actions that need to be done.
Experience - knowledge The welding experience is focussed on gaining actual experience. To be able to convey the experience the students need to be able to be fully immersed and 1 to 1 transaction of actions in the actual to the virtual space.	The experience room should provide a mix between actual and virtual objects which allow the student to be fully immersed in the experience. Major objects like tables, walls, should be both in the actual and virtual world. This allows for more senses to be engaged and an more immersive experience.
Deep knowledge - broad knowledge The knowledg gained is mostly broad knowledge. To convey this knowledge the knowledge should be explained in a clear way and conceptual.	Provide the possibility to pursue the questions. For example, a bookshop, discussion room, access to the internet etc.

Case study 3 - Learning how to weld

The experience

The experience consists of multiple steps. The steps in this experience benefit from separation and therefore will be separate rooms.
The first part of the process is for the student to get the basic knowledge of welding. In this first step, the student will learn the very basic knowledge of the process of welding, the equipment, the actions needed to be done, etc. This step will take place in a small room with very little distractions. The room will feature a large screen and a comfortable seat.

The second step in the learning experience will be a room filled with more detailed information about the different parts of welding. The equipment can be looked at, handled, and explained. In this room, the student will also learn about the dangers and the things that shouldn't be done.

The third room is focussed on carrying out the action(welding). With the knowledge of the previous rooms, the student will be able to start the process. The student is not expected to make a good weld but will gain tips during the digital welding process. This room will be a virtual version of a real workshop. This way the student will learn how the environment of a welder generally looks and prepare him/her for their future.
The final room will be a clearly lit room with very few features. This room is used to inspect the welds done by the student him/herself. The room will have guidance information on how to see whether a weld was too slow/fast.

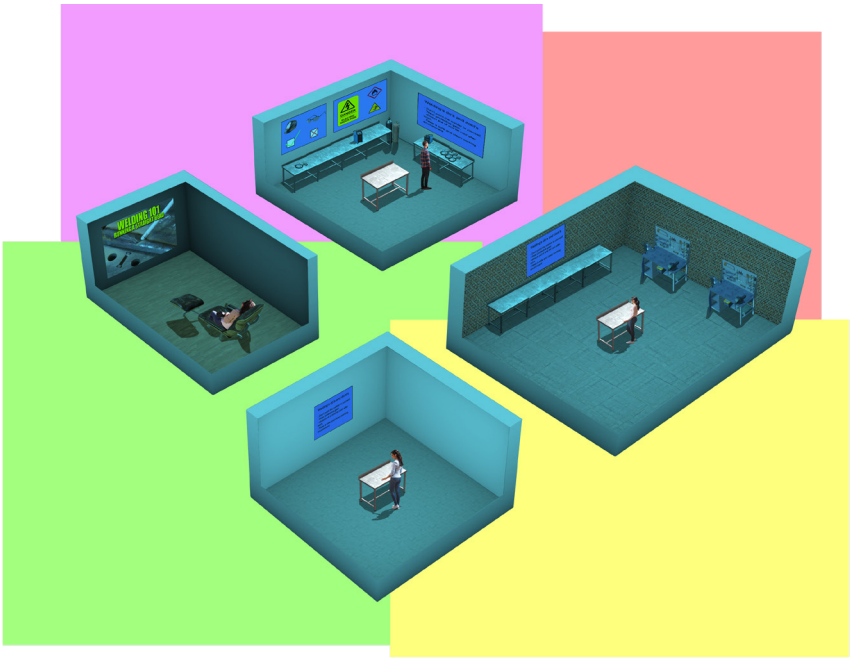


Image 4: The welding experience room. Source: own image.

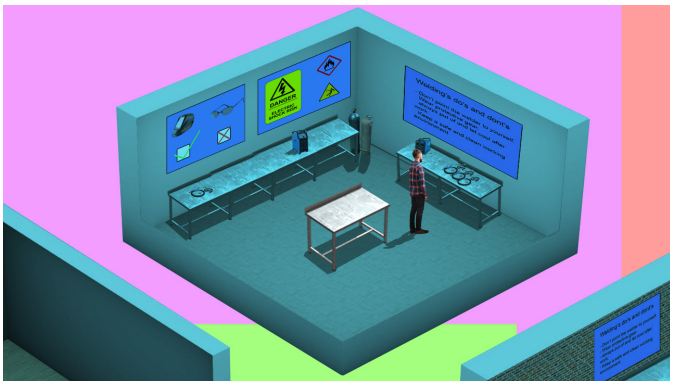


Image 5: the speaker will be accompanied by a real(digital) version of the story and also a conceptual (digital) representation Source: own image.

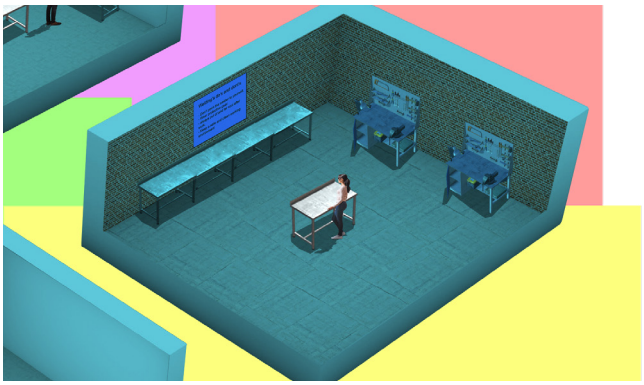


Image 6: The students will have multiple versions across different media(written, video, VR, audio) at their disposal. Source: own image.

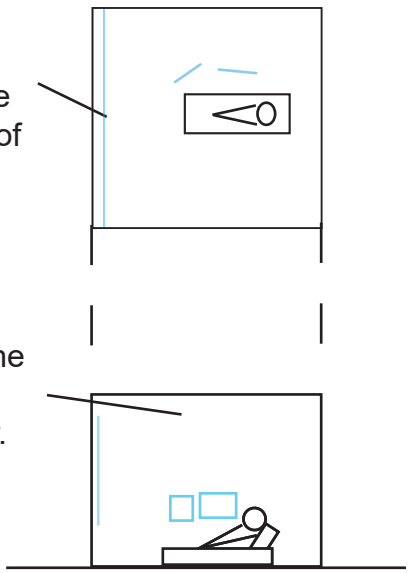
Case study 3 - Learning how to weld

Anatomy of the experience

Room 1 - gain broad knowledge

Big digital screen - This screen will convey most of the broad knowledge of welding through videos

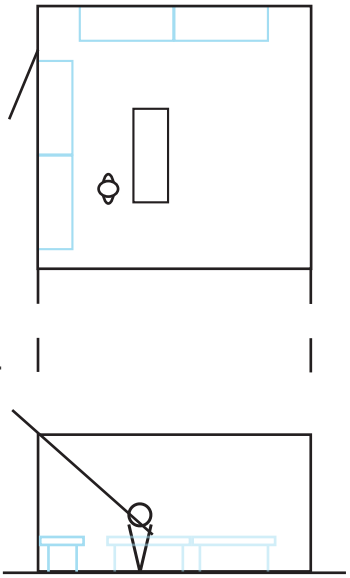
Single person in the room to be able to concentrate better.



Room 2 - Clarify the actions and objects

Single person in the room to be able to concentrate better.

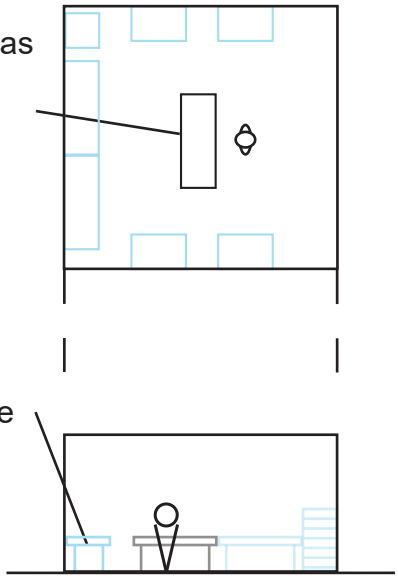
Multiple tables showing the different objects used during welding



Room 3 - Carry out the action(welding)

Table in the center as the focus point and workstation of the learning process

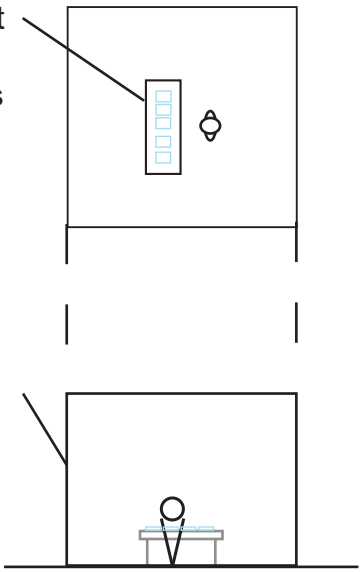
A fully decorated digital version of the workshop to add more immersion



Room 4 - evaluate multiple weld examples

A table with different digitial examples of good and bad welds

Single person in the room without any decorations or distraction.



Virtual world

Image 7: The anatomy of the mixed reality learning experience. Source: own image.

Case study 3 - Learning how to weld

What-if the experience was self-taught

If the experience was self-taught the experience wouldn't be divided into different steps. The students would be able to experiment with the welding tools without any information.

Architectural needs..

The experience space wouldn't be divided into multiple rooms. The experience would only be one single experimentation room.

What-if the focus of the experience was knowledge

If the experience was focussed on knowledge the students would not learn to do the physical welding actions. This would mean that the students would need to describe how to weld.

Archtectural needs..

The architecture should give enough space and also create optimal environmental features(e.g. lighting, the height of the example, distance from example, etc.) This is needed because the students will need to record the experience and their description of how the welding process goed.

Appendix 2 - Enhancing the experience with architecture, by Jeroen Boots

Enhancing the experience with architecture

> *“There is no doubt whatever about the influence of architecture and structure upon human character and action. We make our buildings and afterwards they make us. They regulate the course of our lives.”*

- Winston Churchill, addressing the English Architectural Association, 1924

Churchill mentioned this in this speech but also during other speeches in his lifetime. He acknowledges the role architecture has on us people. Architecture is said to influence people in multiple ways and is being used to set the scene for the activity that will be done in the room. Different topics have been researched throughout history to research the influence factors have on the people using the room.

Examples of this are the effect of color on the perceptions of people, the mood and the behaviour people have. Another example of this being Color and psychological functioning: A review of theoretical and empirical work(2015). In recent years we also see research in the environmental factors on patients in hospital environments and the well known (unconfirmed?) effect of green on the patients healing process.

In the paper (de Paiva & Jedon, 2019, p. 569) the authors aim to describe and analyse the results of previous work and propose a way of organisation. They propose that a way of organising the effects of architecture could be by using the exposure and effect of architecture on people. The authors have chosen to start with organising the results from different fields of study(e.g. Psychology, neurosciences and architecture) by using the filters: Exposure and Effect.

the word exposure is chosen, instead of words like “occupation” or “interaction”, because the person can be both active and passive when using exposure. The person can be exposed to the effects of the architecture whether both when he is passively reading or when he is engaging with the architecture(playing soccer in a gym).
The word “effect” has been chosen because this does not say whether there is a positive or negative relation between the person and the architecture. This is partly chosen, because effectors(objects/things that trigger an effect) can be either interpreted negatively or positively depending on the receiver(e.g. Mood, mental state, receptiveness etc.) In figure X the different combinations of exposure and effects are shown.

exposure	effect
Short	Short
Short	Long
Long*	Short*
Long	Long

Figure 13: Relationships between exposure and effect,Source: de Paiva & Jedon(2019)
* This situation is not researched by de Paiva & Jedon, because it could be seen as a short term exposure at the time of the effect occurring.

Short-exposure, short-effect
The short exposure is an immediate reaction that is not enduring(de Paiva & Jedon, 2019). An example of this is when a treat is perceived, at this time the body will react to this threat. During this time the body is preparing to go into a fight or a flight state. These effects can last for a few seconds, until the danger has passed or could remain for a short amount of time after the exposure(a couple of hours). During this time noticable changes can happen: increase in breathing, perspiration, increased heartbeat. But also un-noticeable changes like increase in stress, increase in blood pressure. Another example is becoming happy after smelling the smell of your favorite ice cream. During this time you noticeably become happier and unnoticeable and start to relax more.

Long-exposure, long-effect
When someone is exposed to something for a long time this could have a large effect(noticeable and unnoticable). These effects/changes can be removed, but often take a long time. Long-exposure, long-effect could manifest in two (not necessarily independent) ways: repetitive exposure or continuous exposure.
An example of a continuous long-exposure is living in an healthy living environment which promotes physical movement and provides a healthy climate could make the inhabitant do more healthy actions. Like taking the stairs instead of the lift.
An example of repetitive long-exposure is visiting a place multiple times to learn the floorplan of the building. Eventually creating the understanding of the building and allowing for easier wayfinding inside of a building. This is what is often needed to do when living/working in a highly repetitive/monotone building like a hospital.

Short exposure, long-effect
A short-exposure, long-effect is something that happens quickly but has a great effect on the person. Often with this situation a stimulus is experienced which is so strong that repetition of long exposure is not needed to have a long term effect. Examples of this are a trauma or visiting your favorite building. Often during these moments very strong emotions are experienced creating long lasting memories.

exposure	effect	example
Short	Short	Scare of something
Short	Long	Traumatic experience, Seeing park Güel by Antonio Gaudí or seeing Sagrada familia
Long	Long	Living in an (un)healthy living environment

Figure 14: Relationships between exposure and effect with examples,Source: de Paiva & Jedon(2019)

In their study de Paiva & Jedon(2019) propose that the exposure is independent of how they are exposed. In the next figure I introduced two activities/passivity of the person affected, which I believe are crucial to be able to explain proposed categorization of de Paiva & Jedon and categorization use it in practice. With active people being affected first has to take action for the effect to happen. With passive the person will be affected without having done any action related to the effect. For example, a person opening a door or putting off the light is active. A person sitting in a chair and the light goes off is a passive situation.

Active/Passive	Exposure	Effect	Example
Active	Short	Short	Walking around a dark corner(raised heartbeat, transpiration etc.)
Active	Short	Long	Walking into the segrada familia
Active	Long	Long	Living in a house which teaches good habits, like exercise and stimulates to take breaks.
Passive	Short	Short	Experience the lights in a room going off(excitement, fear etc.)
Passive	Short	Long	Experience a building crashing down
Passive	Long	Long	Living in an (un)healthy house

Figure 15: The relationships between active/passive exposure and it's effect,Source: own image, based on Paiva & Jedon(2019).

With this new categorisation in place we could take a look at the specific characteristics of the environment itself. What makes the place active/passive and what is the desired effect of the space.

Appendix 3 - A reflection on: “”The Ethics of Authenticity” by Charles Taylor is an important book” by Luca silipo

A reflection on: “”The Ethics of Authenticity” by Charles Taylor is an important book” by Luca silipo

In the more and more fragmentation of our world we grow towards a world which promotes authenticity and individualism. Everyone is themself and we shouldn’t work up to grow into someone someone else wants us to be. But we need to grow to be who we want to be. This in its purest form does not subject itself to any external (or higher) authority. The growth of oneself should come from within and center around themself. Often shutting out or becoming unaware of greater issues or concerns that transcend the self, be they religious, political or historical. This can clearly be seen with the outbreak of the corona virus and the large groups of people going outside on sunday because they need a break and not taking into account that a pandemic is going on.

Charles Taylor talks about the way people act in his book “The ethics of authenticity”. He introduces manner and matter. Manner being “the self-referential language in which we express our identity” and matter “the self-referential meanings in which we define our identity.” These two concepts help show where the modern society which promotes individualism has its flaws. As previously discussed in the last paragraph the modern society promotes authenticity and individualism and the growth comes from oneself. We slowly learn throughout our lifetime our interests/hobbies/loves and hates. This is referenced to what we think we like based on what we know and understand. Important is to note that we base what we like/our position/our opinion/our “taste” on our experience/knowledge.

Taylor continues on the Matter and manner and expresses the difference between individual manner and individualistic matter. The first being an individual, being yourself, and not a copy/abstraction of something. The latter being the narcissus, the self focussed individual with no conditional strings attached to outside/others. Taylor’s mission is to save authenticity from being the narcissus and to convince the (soon to be) narcissus to embrace/know the broader, shared meaning and urge us to be participants of a social sustainable community.

In his book Taylor also introduces dualism. One person teaches you how to express and you grow with other people. You learn how to express yourself by the people who are close to you.

> *dialogism’. Our existence is unavoidably dialogical because of two facts: somebody else (“significant others”) have taught us the language (of words but also of art) through which we define our identity, and some goods in life are accessible only in conjunction with another person. - Trilling, 2005*

Appendix 4 - Theory thesis: The realism of the virtual reality by Jeroen Boots

The realism of the virtual reality

The dawn of the digital age and the role of the architect in it

AR2AT030 Architectural theory thesis
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Abstract – This thesis explores the coming of a new age, the digital age. In this age, the digital will come to the actual world. The research question of this thesis is: What is the digital age and will the architect play a role in it? This question will be answered in sub-questions. The first being: what is the digital age? In which we learn that the digital, actual, real and possible are very closely related to each other but are a bit different. And we will learn how we can separate the different virtual realities. In chapter 3, the criteria for the digital world to be perceived as the actual world will be researched. In this chapter and chapter 4 three main aspects of the virtual world to be perceived as real come forth from the research: control, synchronous information and sensory input. Also, the importance of immersion will be explained and what the immersion of the system used to access the digital world can do for the feeling of 'being there'.
In the final chapter, the architect will be compared to present-day digital world designers(environmental artists/game designers). In this comparison prospects of how digital worlds will be designed in the future will also be taken into account. From this I conclude that the architect could be the designer of the digital worlds in the future, but not at present-day. Because the architect does not have the required skills which are needed for digital world design. But does have experience in designing our actual world. In the future when interacting and translating ideas to the digital world can be done in ways more native to the architect, then it is possible for the architect to become the designer of our digital worlds.

Keywords – Virtual reality, VR, Augmented reality, AR, Mixed reality, MR, The architect's role, criteria of presence, presence, Immersion, A new age, Realism, Rule-based design, virtual worlds, world design, digital world design, game design

1. Introduction

This thesis came forth from a quote by Maurice Conti in his TED talk 2017. He said:

"I think we are at the dawn of a new age in human history. There have been four major historical eras defined by the way we work. The hunter-gatherer age lasted several million years. The agricultural age lasted several thousand years. The industrial age lasted a couple of centuries. The information age lasted a few decades. And now today we are on the cusp of our next great era as a species: Welcome to the Augmented Age."
- Maurice Conti at TED (2017)

Maurice Conti believes that we are at the dawn of a new age. The augmented age. In his TED talk, he talked about how the human perception, thinking and physical labor will be enhanced by the collaboration between AI and humans. Which I translate as the age in which the digital comes to interact with the real world. But I believe that a part of this world will go to the digital world and that we are not moving towards an augmented age, but to the digital age in which the Augmented & Virtual realities will become part of our world and we become part of theirs.

What is the digital age and will the architect play a role in it?

I call it the digital age because the digital is becoming more present in our everyday lives. Almost all buildings are drawn first in a virtual environment and even assessed in a virtual environment before being built in the real world. Every year, in the gaming industry new worlds are created for the player to roam around. These worlds have been growing in size exponentially. The biggest known (non-infinite, non-generated) virtual world is the size of Delaware(5.130 km^2). While the worlds are becoming bigger, the realism in terms of graphics, physics and AI(the people in the world which are not humans, also called NPCs, Non-Player Characters) are becoming more advanced with each game. For example, NPCs have fully animated jobs for every day of the year.
It will not be long until the virtual world will be almost as realistic as our actual world in terms of graphics.
Up until now, the virtual has only been on a flat screen. With the arrival of augmented(AR), virtual(VR) and mixed reality glasses the virtual has made its first step into the real world and the virtual age has started. Because the digital world will be the center point of this thesis we will first explore the terms digital, virtual, actual, possible and real. Then we will focus on how humans perceive and finally, we will delve into the criteria which need to be met for the digital to be perceived as an actual world. This will be explored in the following the sub-question:

what are the criteria for the virtual to be perceived as a real world?

To illustrate how long the idea of a non- existent world exists, a world made by us humans (our brains), we need to go back to the ancient Greeks. The

Greek philosophers started to explore the idea of a world constructed only in our minds, or rather constructed by our minds. This metaphysical philosophy is called Idealism. Idealism believes that reality, or reality as we experience it, is fundamentally mental, mentally constructed. The reality is immaterial, constructed by our own brains. Idealism asserts that the primacy of consciousness is the origin and prerequisite of the material. The idealists believe that the mind existed before the material and the material came forth from the mind

Whether or not one agrees with Idealism, it is an interesting notion. And now this ideology is very close to becoming real.

Soon a new world can, and most likely will, be created around us which is fundamentally constructed by us, our minds. And is non-existent without the use of technology. But exist in the same space as we do. Just like atoms and molecules do. The new worlds are the augmented world(s) and the Virtual world(s).

The two are often confused with each other. The augmented being a world that adds a layer on top of the existing. And the virtual world is visually completely separated from the existing. Present-day, a new reality is now explored which is mixed reality(MR). In this reality, the virtual assets can be interacted with and the assets may one day interact with the actual world.

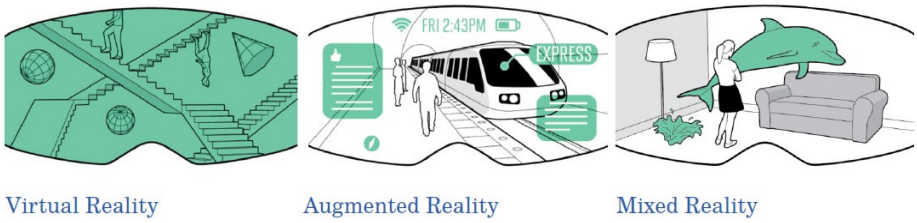

Figure 1 - AR VR MR, Source: Op de Beek (2018).

These new worlds open up a whole new world of possibilities. The new virtual environments can be used to simulate different hypothesis on a large crowd of people. And the Augmented world can declutter the real world from information. But since these new worlds don't exist yet, who will make these new worlds? This will be researched in the third sub-question. To narrow the scope of the question the architect will be taken as a case study. Leading to the following sub-question:

Who will design the new world? will it be a descendent of the architect?

This sub-question will be researched by using the research of the previous chapter about the virtual worlds and this will be compared to how the virtual worlds of today(mostly games) are created. By comparing these two we learn which skills are needed to design the virtual world. Then we will compare these skills with the skills of the architect to validate whether the hypothesis of the architect being the future designer of the virtual worlds is right.

2. What is the digital?

2.1 What is the digital age?

As introduced before, the digital age will bring two new elements to our society. the augmented and the virtual world. In most of the research(especially before the 2000s) no distinction was made between virtual and augmented reality. Therefore some of the researchers(like Deleuze) only talk about the virtual, but the theories also apply to the augmented reality.

In 1966, Deleuze made a very clear distinction between real, possible, virtual and actual. He described them as constructs. He made a distinction between Real constructs and possible constructs. The first being either actual(physical objects we can touch) or Virtual (virtual assistants like Siri or Alexa that are nowhere in actuality, but are nonetheless real and can be interacted with). And possible constructs, which can be everything. But these constructs do not (yet) exist(Shivaro, 2007). In this distinction, Deleuze introduces us into the complex distinction between actual(physical or virtual) or possible(also physical or virtual).

The differentiation of the actual and possible constructs are still too broad for the research but make a good foundation for the discussion of the actual realities that are now and the possible realities that will be created in the coming years. Whereas Deleuze talked about objects, the distinction between the actual and the virtual(and augmented) is also very useful for the definition of the virtual and the real reality:

> ***The real reality*** *being the physical world we can touch and we can interact with.*
>
> ***The virtual reality*** *being the world that we can interact with but doesn't physically exist.*

In figure 2 Farshid et al. (2018) explain and categorize the different realities. They divide the realities into two categories which they call the actual reality continuum and the Virtual Reality Continuum. The Actual Reality Continuum being the physical world, the same as described by Deleuze. Virtual Reality Continuum being the virtual world, non-physical world.

To be precise, the part of the Virtual Reality Continuum being focussed on in this thesis will be the Augmented Virtuality. The Augmented Virtuality refers to a virtual representation of a possible world. This world can be realistic or completely fictional(Farshid et al, 2018). In this world elements(furniture, or people) of the real world can be introduced.

The other realities do not fully allow the designer to alter every aspect of the virtual environment. Except for the Virtuality, but this is defined as a completely different world wherein no actual elements are present. Which means that there are no real constructs, people or digital representations of actual constructs.
The other realities could be described as virtual overlays over the existing(Augmented reality), a 3D representation of the existing(Virtual reality) or virtual elements are added to the real world(Mixed reality).In figure 2 a more complete description of the realities can be seen.

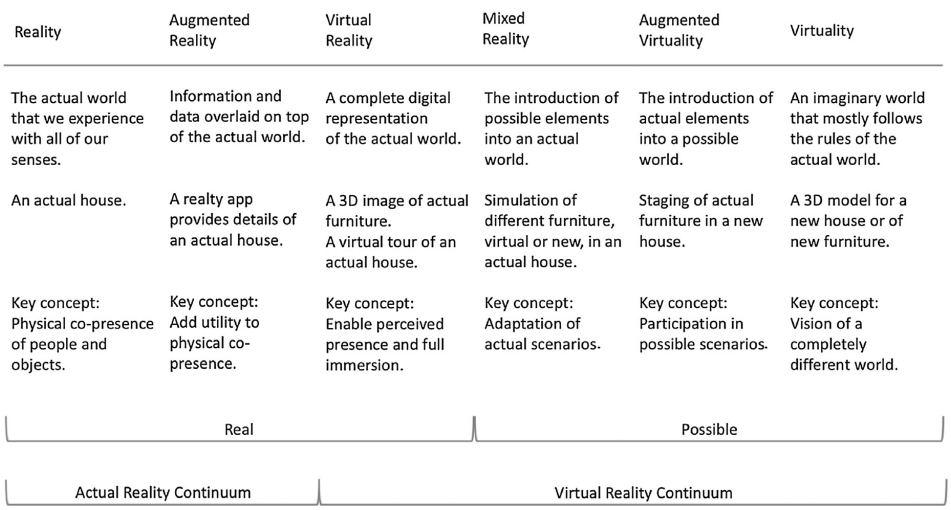

Figure 2. The actual reality/Virtual Reality Continuum, Source: Farshid et al. (2018).

Important to note with the virtual reality continuum realities is that they are not actual, but can have effects on the actual world. For example, when a house is redecorated different possibilities can be tried in the virtual world as a digital representation. Eventually, the setup in the virtual representation can have an effect on the actual setup of the furniture.

The types of realities in the virtual reality continuum that deal with possibilities have significant generative potential. Because possible realities, for example a new layout for furniture in a house, can be tried without moving all the actual furniture. Or the effects of a tall building in the middle of a city can be simulated. This plasticity allows the realities of the possible

Realities to be used not only for architecture but also for rapid prototyping, simulations, product design, psychology and much more.

So in short, The digital is the age in which the Virtual world and the augmented world will be coming to everyday life. Where both the augmented and virtual will be a world on their own, but not necessarily separate from the actual world.

3. What are the criteria for the virtual world to be perceived as the actual world?

3.1 'Feeling real' and 'being there'

There is a difference between 'feeling real' and the feeling of 'being there'. Something feeling real is mostly tied to natural laws and visual quality. But when the user is in a possible world where some things don't seem possible, the user often loses the feeling of the virtual world being real.
The difference between 'feeling real' and 'being there' is that the feeling of being there is independent of whether it is real or not. One could feel like he is in a fictional setting or the medieval ages even though that is not possible.

As an example, when I guide people through Virtual Reality the people almost always say: "this feels so realistic" or "it's almost as if it is real". Which means that they are aware that this is not the actual world they are in, but a virtual world. After a while, and some almost instantly, tend to forget that there are objects in the real world and walk and bump into them. And thus forgetting their surroundings because they are 'there' and not here. Most of the times this happens when certain emotions are present like being excited, being angry or interested.

In this chapter I will give a short introduction of how people perceive their surroundings. This is a general description because everyone is different and the field of how people perceive is another paper on itself. But by introducing some theories of this field of study we can get a sense of how people process the world around them. After this, the feeling of 'being there', presence, will be unraveled. This will be done together, with the closely tied word, immersion.

3.2 Perception

The definition perception. This definition is not as easy to describe as there are multiple strong and legitimate opinions about the way we perceive things. The general definition of perception is:

"become aware or conscious of (something); come to realize or understand."
- Merriam-Webster dictionary, 2019

In 2010, Bernstein and Douglas A. split the processes of perception into two aspects:

1. Processing the sensory input, which turns the low-level information to higher-level information (e.g., extracts shapes for object recognition);
2. Processing which is connected with a person's concepts and expectations (or knowledge), restorative and selective mechanisms (such as attention) that influence perception.

Bernstein and Douglas a. divided perception into receiving the information(input) and processing this low-level information into higher-level information. For example, extracting shapes out of what is seen. Which will then be used for object recognition.

In 'Action in Perception' by Alva Noë he talks about the minimal metaphysical condition for perceptual experience (i.e., the minimal supervenience base). The metaphysical condition in this context referring to the reality beyond what is perceptible to the senses.

This can be illustrated with the example given by Alva Noë about a tomato. When seeing a tomato, with your eyes, you only see the front of the tomato. But in the mind, an image of the whole tomato is formed. This part of the tomato is not part of the sensory input but is present in the experience.

Another example is when someone enters a room with graffiti on the wall. When you see the graffiti and you find it offensive a reaction will sprout. But what if it's the same wall and you don't know the language. Then it will most likely not invoke a reaction. Even though the sensory inputs are the same.

When we evaluate this with virtual elements, we can see that by adding recognizable elements which invoke reactions we can stimulate feelings. Which will increase the feeling of presence, but this will be explained further on in this thesis.

Alva Noë also proposes the enactive view. He believes that even if the evolutionary and immediate past is fixed. There still is something outside of the brain that needs to be fixed in order to determine the phenomenal character of experience now. He suggests that it is the activity of the body(Block, 2005). He also mentions that, even if the perception is often related to the moving of the body, perceiving is not always an activity and certainly not always related to movement.

3.3 Presence

Perceiving is how we see the world around us. But presence is the feeling of 'being there'. In this chapter, presence will be explored and related to how we perceive things.

But why is perceiving important for the virtual reality experience?
It is because I believe that the level of experiencing something as real has three levels. The levels being:

Seeing	-	Experiencing	-	Presence
(passive)		(passive/active)		(Active)

Figure 3: levels of experiencing, source: own image.

Seeing is the act of viewing something from a distance but without invoking a reaction.

The act of experiencing can be active or passive, but invoking a reaction from the person experiencing it. This means that the experience is lived through, but the user does not feel like he is there. An example of this would be a medieval theme park you experience the medieval times, but at the same time, there is a very real distance between the medieval times and you. You know that you are in a park in the 21st century.

The last and final step of experiencing is Presence. Cummings and Bailenson (2015) described in their journal the difference between presence and immersion and how the final psychological step for the feeling of "being there" is presence. In the case of a Virtual world, this level of experiencing would mean that it is too hard to differentiate the (possible) virtual constructs from the actual constructs. The user feels like he is fully engaged in the world and forgets that he is in the physical world and thus he will be present in the virtual and not just experiencing it.

Cummings and Bailenson (2015) make a clear separation between presence 'being there' and immersion. These two are often used as synonyms. A clear description is made by Slater and Wilbur(1997). They describe that presence is a function of the user's psychology and immersion being the technological aspect. Immersion being the quality of the virtual environment and also the capabilities of the system (graphical power or the amount of sensory input).
Cummings & Bailenson (2015) conclude that Immersion facilitates the psychological presence of being there. This distinction between the psychological and the technical will be used in this thesis as the separation between the psychological and the technological advancements that could be made to make the virtual experience more immersive.

The formation of presence

Cummings and Bailenson (2015) condensed the process of building the feeling of 'being there', presence, to a two-step process:

> First, the user must draw upon spatial cues to perceive the mediated environment as a plausible space.
>
> Second, the user must also then experience his or herself as being located within that perceived space. Only then is spatial presence achieved.

The first step is related to how we perceive things and the second about where we are. the two steps of Bernstein and Douglas A. explained that before one can perceive he needs to gather information about his surroundings and process this low-level information to a higher level. After this, this information can be used to see if the mediated environment is a plausible space.

The second step is then related to experiencing the space. As described in the previous chapter, Alva Noë proposed that even the evolutionary past and the immediate past are not all that form the experience. But also the body (movements) are part of experiencing the space and a spatial. When the evolutionary past, immediate past and the body (movements) align a spatial presence is achieved.

3.4 Immersion

The evolutionary past and the immediate past are both parts of the psychology of the user. How the person moves is defined by the user. But how (well) the body movements are translated to the virtual and how well how the user is capable of interacting with the virtual are part of the immersion of the virtual. Slater, M., & Wilbur, S. (1997) suggest that display and interactive capabilities are essential in evaluating the immersiveness of the system. The display and interactive abilities of the virtual, support the sensorimotor contingencies by which user actions lead to meaningful changes in the environment or user perception.
According to Slater, these user contingencies strengthen the presence of being there. Slater also states that the extent to which the environment offers events beyond the user's control strengthens the sense of the environment being actual.

4. What are the criteria for the virtual world to be perceived as the actual world?

As described in the previous chapter we perceive things in two steps. First collecting low-level information. The second step is making this low-level information into high-level information(shapes, objects, etc.). Now we see.

When we add another level of depth to the interaction between us and our surrounding we start to experience the surrounding. For example, we can interact with the surrounding or move in it.

If we would like to stimulate the feeling of 'being there' we need to add more. As described in the previous chapter the interaction(Slater, M., & Wilbur, S. (1997)) between the virtual and the user increases the immersiveness of the system and the immersiveness of the system helps with the feeling of 'being there'.

In this chapter, the criteria for the virtual world to be perceived as the actual world will be explored.

> *The ultimate representational system would allow the observer to interact "naturally" with objects and other individuals within a simulated environment or "world," an experience indistinguishable from "normal reality,"*
>
> - Cummings and Bailenson (2015)

4.1 Control

In the research of Wei et al.(2019), called: 'Effects of virtual reality on theme park visitors' experience and behaviors: A presence perspective', Wei did conclusive research about what gave the users the feeling of 'being there'. In the research Wei interviewed people that have been on an actual roller coaster while wearing a head mounted display(HMD). The results (fig 3) shows that the biggest factor influencing the presence was being in control. Wei et al. (2019) concluded:

> *"the feeling of being in control of the VR environment contributes the most to one's sense of being there virtually"*
>
> - Wei et al (2019)

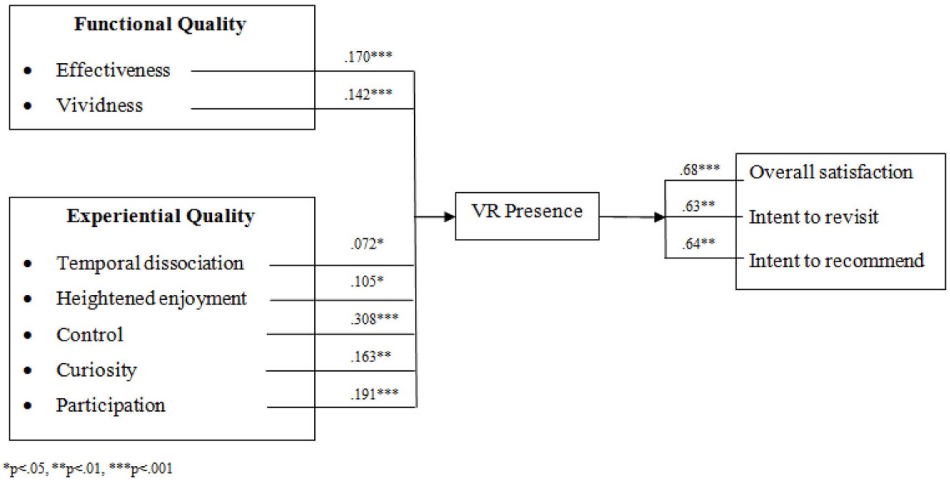

Figure 3: repression results, Source: Wei et al. (2019).

4.2 Immersiveness

Commings and Bailenson (2015) quote Wilbur (1997) in his paper where they sum up how a system could be more immersive. And possibly shut people out of physical reality.

His first point is to make high fidelity simulation through multiple sensory modalities. He basically says that by creating very realistic simulations that stimulates multiple senses the system would be perceived more immersive. His second point is that the more precise the physical movements of the user are translated to the virtual. The more immersive the system is.
His third point is that when the user follows a plot/narrative inside the virtual environment then the experience is more immersive. This is compared to when the plot or story is explained from outside the virtual environment. For example, a system could be made more immersive by letting someone inside the virtual environments tell the assignment instead of a physical person standing next to him/her.
These three points allow the user to be more psychologically engaged in the virtual environment.

By the standards that have been explained up until now, we can conclude that a more immersive system allows the psychological counterpart, presence, to be easier achieved. From this we can conclude that by having the best possible hardware, the highest refresh rate, the finest tracking devices, the best sound, all senses engaged, the best graphics and realistic control over the virtual environment would allow the user to get the most spatial cues and thus leading to a greater likelihood that the user perceives the spatial cues and sees himself located in it(Cummings and Bailenson, 2015).

It is important to note that having the best setup will improve the chances of the user perceiving the spatial clues. But the best setup does not mean that he will perceive them. And also due to the high-speed improvements being made in equipment(for example in head mounted displays) would lead to the constant renewal of the system. And the constant renewal would prove to be very expensive.

To go back to fig 3, the most effective element of the VR rollercoaster experience for the presence was the feeling of control. At some point, the head mounted displays(HMD) will be good enough and the improvements in graphical performance will be minimal to neglectable. In the next chapter, I will discuss some of the equipment that makes it possible to have the most immersive system possible as of March 2019.

The most important factors that will be taken into account are:

- Being in control
  - movement
  - Interactions
- The five senses
  - smell
  - sound
  - touch
  - Taste
  - sight

4.2.1 How immersive can the system be as of May 2019

In this chapter, I will sum up the options for what is possible for an immersive system as of May 2019. The options already exist and are meant as an example to show how the senses could be stimulated and give a preview of what could happen in the future.

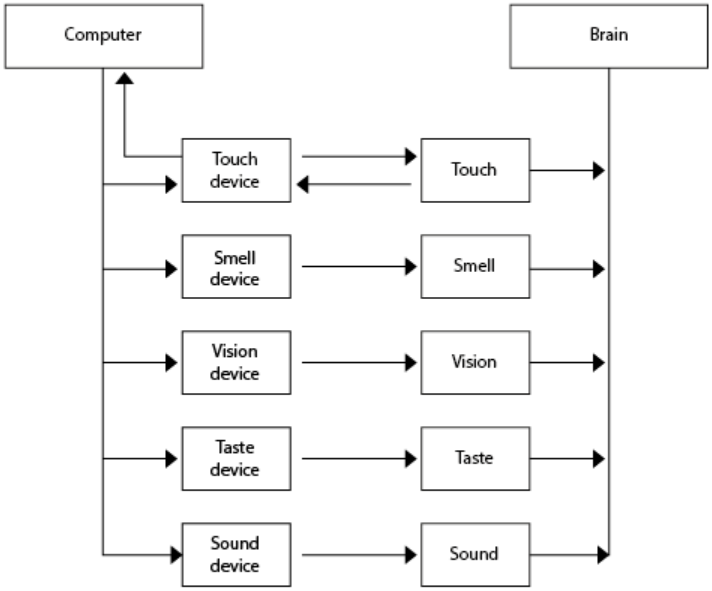

figure 4, the senses system. Source: own image

Touch

For the sense of touching, there are products already in existence. One of the examples is haptic suits. They can apply pressure, heat or coolness to specific parts of the body. These suits cover the body except the hands. The hands need real-time feedback to use while the hand is gripping something. But also for the hands, a device is made. These are called haptic gloves. Some of these gloves are bulkier and can restrict the hand when it wants to move. For example, when holding a virtual(solid) object it stops the fingers from moving. Others are more subtle giving small electric feedback for when the hand touches something. Leaving it up to the user to stop closing their hands.

Figure 6: Teslasuit - haptic suit, Source: Teslasuit, n.d.

Smell

It is already possible to create smells if you add an additional device to HMD's. An example, is the Feelreal Mask. Which has specific smell sets for different scenarios. The Feelreal Mask will release perfume that is

specifically made for an environment which the user walks in. For example a pine-wood forest smell pack can be bought for when the user wants to walk through a virtual forest and also smell the forest.

Figure 7: Feelreal VR mask, Source: Feelreal, n.d.

Sight

The VR headsets that are out now do not yet have the capability to have a high enough resolution to be seen as a sharp image. This is because of the technology of the screen and the cables that have to transport the data to the screen inside an HMD. Another big factor is the strength of the computer that needs to power the two screens. As of May 2019, no consumer desktops (especially the graphics cards) can power two very high-resolution screens with high refresh rates.

Taste

It is already possible to induce a taste by sending small electric non-evasive currents directly to the taste buds and by doing so emulating the sense of taste in our mouths. An example prototype of this is the Vocktail. A cocktail glass that makes water taste salty, bitter and sour. But as of today no HMD compatible devices exist.

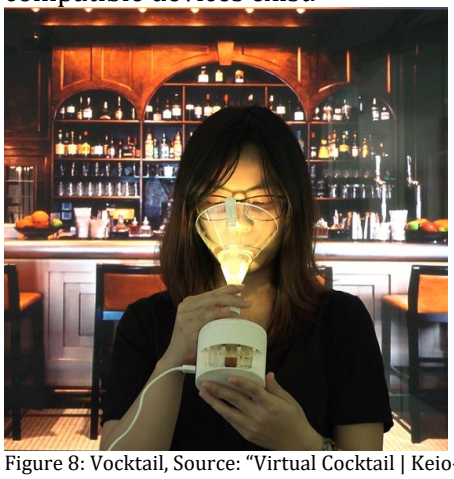

Figure 8: Vocktail, Source: "Virtual Cocktail | Keio-NUS CUTE Center," n.d.

Sound

It is already possible to create realistic sounds which can be used for the virtual world. By using 3D sounds a sense of location can be created and could help the user with developing more spatial cues. It is possible to dimm the sounds when it comes from something far away and intensify when the user moves closer.

4.3 Bodily ownership

In a recent study (Van Lit, 2018) redid the rubber hand experiment but this time with a virtual rubber hand. The rubber hand in VR would be touched(in VR) and at the same time, the real hand would be touched. With this and other experiments, he tried to research whether the feeling of bodily ownership could be achieved in VR. He concluded from this experiment that the visual feedback through the HMD has a significant positive effect on the illusion of the virtual hand being their own hand. What is interesting in this research is that the synchronous active movement(the movement of the virtual hands when the real hands were being moved) did not significantly increase the illusion of the rubber hand.

This can be supported by a real-life example. If someone has a wrench in their hands and he moves this, then he does not feel like the wrench is part of his body. In the case that when the wrench touches a wall and you can feel on the wrench where it is touching the wall as if the wrench is part of your body. Then it is possible that mind would see the wrench as a part of the body.

In the paper, they speculate about why the synchronous active movement does not significantly increase the sense of ownership. In "Over my fake body: body ownership illusions for studying the multisensory basis of own-body perception"(K. Kilteni, A. Maselli, K. P. Kording, and M. Slater, 2015) this is described in one sentence:

"the bodily self-image is a result of the brain's processes which integrate multiple sensory cues (visual, tactile and propriocepsis) into the perception of one's own body. "

Our body knows where it is. This is called propriocepsis. Propriocepsis can be described as being the awareness of the position and movement of the body.
In the rubber experiment done by Van Lit(2018) the visual perception showed to be of bigger importance than the proprioceptive information. He also refers to the rubber band experiment and research done by Kammers, De Vignemont, Verhagen, and Dijkerman (2009). In their rubber hand experiment, the visual and proprioceptive feedback were not synchronized. Because the visual and the propriocepsis information was not the same the proprioceptive information updated the location of the hand to the real location instead of the location of the rubber hand. Thus leading to a degenerative effect on the rubber hand illusion and leading to a decrease in the sense of the rubber hand being part of the body.

4.4 Future prospects

From the previous chapters a common theme should become clear when talking about adding senses to the experience. All of the senses need to be added by adding device(s). Which may or may not need to be refilled. Also as stated before all of these devices could in total become very expensive.

A more science fictional approach for creating an immersive system is by using direct brain stimulation. This means that the brain and the computer are talking directly to each other by electric waves. The computer will provide the environmental data for the body to react to. For example, a virtual field where the users can walk through. The brain will send the actions (electricity) the body needs to take to walk through the field to the rest of the body. This information (the electricity) will be intercepted/read by the computer and translated to movement of the virtual body.

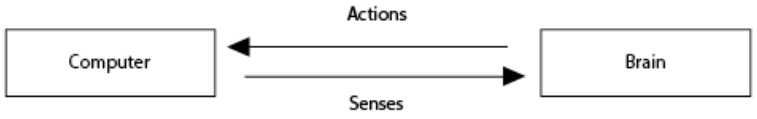

Figure 9, the direct brain stimulation system. Source: own image

Whereas the system, we use now, relies on devices to convey the virtual senses to the physical body. With direct brain stimulation, the brain and the computer will talk directly to each other.
A technique that could be used is called EEG(electroencephalography). Electroencephalography is a method to measure the electrical activity generated by the brain. The computer can, by reading the electrical activity, translate the information and move accordingly.
Even Though this technology is still far away, it has already proven that it could work. Successful experiments have made it possible to move remote body parts(the tail of a mouse) by letting a human think about moving the tail.

5. Why the architect?

5.1 What does the architect do?

This is a question that has troubled architects of all ages and especially in modern times. In modern times the role of the architect has been changing at a very fast pace and many try to re-define the role of the architect. Therefore answering this question is not simple. But with the help of the report of Sigler et al. (2003), Hunch, a very general description will be created for the use in this thesis. In the report Sigler(2003) asked renowned architects 6 simple questions about their profession. The first question, and the most important question for this thesis, is: "What is the architect in today's society?".
Below a few of the answers of the architects are collected to show how different the opinions are and how contrasting the approaches in architecture can be.

> *"We architects are people with a vision of the possibilities and potentials of space and craftsmanship, defining the processes of their realization. Space is defined, it's physical and phenomenological contexts created, constructed, and experienced."*
>
> - Rudy Uytenhaak, Uytenhaak architecten + partners (Sigler, 2003, pp. 453-454)

> *"In an age in which people communicate through various media in non-physical spaces, it is the architect's responsibility to make actual space for physical and direct communication between people."*
>
> - Kazuyo Sejima, SANAA (Sigler, 2003, pp. 407)

> *Otto Wagner: " A happy combination of idealism and realism".*
> *Peter Wilson: "It does not matter what one is called, the effect of what one does is what matters".*
>
> - Wilson & Wagner (Sigler, 2003, pp. 503)

> *"one cannot make architecture; one can only build. We are interested in architecture that can be physically experienced; that is why we have to build. Perhaps what we build can become architecture, but that can only be judged afterwards. "*
>
> - Felix Claus & Kees Kaan (Sigler, 2003, pp. 139)

What can be deduced from the answers of these architects is that the architect works with the space and tries to create an experience and/or a space that facilitate the user. By looking at this description of the architect, the architect could be taken as a possible candidate for the design of our virtual worlds.

The second reason why the architect is a candidate for the design of our virtual space is the experience the architect has gathered in the centuries of

designing our surroundings. No other profession has such a long history of designing our space and experiences as the architect.

In this part of the thesis, the term architect will encompass urban planners, interior designers and architects. This is for convenience and because all of these kinds of architects mostly focus on one scale in our actual world, but often go out of their scale and design in other scales.

Before we can decide whether the architect or a descendant of the architect will design the new digital world. We first need to understand how the architect designs, how the digital world is designed and how it probably will be designed in the future. By comparing how the architect designs and how digital worlds are designed we can conclude whether the architect is a possible candidate for the designer of the virtual world.

5.2 How does the architect design?

Architects often start designing by gathering information from the area that they design in. From this information they gain a feeling of the area and they will try to deduce from the information what the area needs. After this, the architect creates a concept/hypothesis for the project

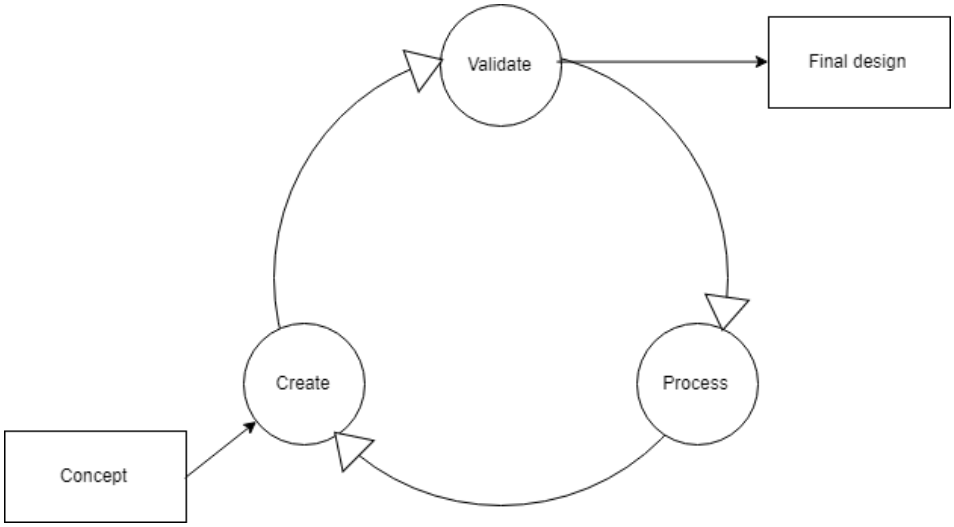

Figure 10: Design process of an architect, Source: own image.

Shown in figure 10 is the process of the architect. The architect usually starts with a design and keeps validating/iterating this design to the given assignment until it (at least) meets the requirements and is chosen as the final design.
The tools which the architects use are mostly visual. The architects use sketches, diagrams, drawings etc. to convey the message and concept of the design. During the design process, the architect uses models, 3D models, sketches, research and drawings to come to a design.
During and at the end of the process 3D modeling programs (For example, BIM, parametric modeling programs or modelling programs) are used. Architects use the programs to design and validate. At the end of the process, the drawings of the design can (often) be extracted from the program.

5.3 How is a digital world designed?

Making a virtual environment is a lot of work. In the gaming industry, for every game, a world is designed to fit the atmosphere of the story and the history of the world. In the last few decades, each asset(object) was placed by hand by a big team of environmental designers. But with the creation of large worlds, the manual placement of objects takes up a lot of time. For example, the designers have to place all the objects(from trash cans, lantern poles, cars and windows) in an area like new york. This would make the creation of a digital world a time consuming and expensive endeavor.

But the designers of the new digital worlds are approaching the design of the worlds in a smarter way. In the recent years in both the gaming environment and architecture a couple of new ways of designing have emerged. Names for these ways of design have been: data-driven design, parametric design, procedural design or designed by AI. What all of these types of creating/designing have in common is that the designer uses the power of the computer with their design. The designers use the computer to rapidly prototype or let the computer make the design based on the given rules.

This rule-based design is what is used by gaming industries while making the large digital worlds for games. Two recent games (in 2019) have been designed by using the rule-based design. The rules are applied to the world by the computer, but the rules were made by a human.

5.3.1 Rule-based design

Spiderman 2019

In Spiderman(2019) the programmers together with the environmental designer set-up a list of codes/rules from which the virtual world would be generated. In Spiderman, the game makers cleverly used the strength of the computers(making a lot of calculations based on rules) and humans(creative thinking, experience and imagination) to procedurally design the city of New York.

In the Spiderman game, a vector map was drawn with all the roads and alleys that would be present in the game. The different line weights and colors would be translated to how wide the roads will be and what kind of roads(pedestrians, cars, bicycle lanes). This map can be seen in figure 10.

Figure 11: vector map example spiderman, Source: (Houdini, 2019)

The events in the game are also generated by the computer. The events can take place in the world if all of the conditions are met. This means that the designer doesn't specify the place of the event and the event could take place at any moment in time at any given place.
In the same way, the population is generated. For example, if a construction site is nearby a bigger percentage of the people walking around will be construction workers.

Figure 12: Spiderman traffic and road structure, development footage. Source: Houdini, 2019

Far cry 5

Another great example of this rule based design is the nature in the game: far cry 5. In this game, a massive natural environment is created by a set of rules. The rules for nature in far cry 5 have been deducted from nature in the real world.
For example, a forest biome is created by a set of rules which define how far the trees stand from each other depending on the height of the trees and the kind of trees. Below an example of a ruleset which could have been used in Far cry 5 is shown(Houdini, 2018):

- Directly under a tree are no bushes.
- Under a tree, mushrooms can sprout.
- under a tree, roots can pop up, but not more than x meters away from a tree.
- If the vegetation is close to water, then use plants tend to live close to water.

From rule based to procedural design

With these rules that have been designed(given that they encompass all aspects and dont conflict) complete worlds are generated. But these world still require human input(the road and alleys map). The next step would be to design these rules and let the computer make the world. A good example of this is minecraft. The world is created by rules in chunks(parts) at a time, this can go on endlessly given that enough memory and computing power is provided.

Conclusion

These three examples of a world being generated by rules instead of by manual placement show that whole worlds can be generated by minimal input and with the possibility to iterate quickly. For both Far Cry 5 and Spiderman, the team could generate parts of the maps at any time. And the whole map would be (re-)generated every night with the new rules and manual adjustments. Minecraft shows that a world can be procedurally generated without the intervention of humans by providing a clear rule-set to a computer.

I believe that the future would be to let AI create the rules based on references, drawings and sketches. By allowing different kinds of inputs, rom rules and text to sketches and images. This way different artists/experts with different specialties can work together. While also allowing a more natural way of expressing their thoughts.

5.4 What does an immersive digital world need?

In chapter 2, 3 and 4, we tried to specify what the digital world was and how the mind can be tricked into believing that one is actually in the digital world and forget that their body is in the actual world. From these chapters, we can conclude that some factors are more important for the system to be as immersive as possible and for the mind to be tricked into being there(telepresence).

As described by Bernstein and Douglas(2010) the perception can be split into two steps: 1. processing sensory input into a higher level of information. 2. perception based on someone's knowledge, concepts or expectations.

The system needs to put input in as many senses as possible. The senses being smell, sight, touch, sound and taste. Also, the system needs to give the right information. As seen in the virtual rubber band experiment. If the information of one of the senses(sight) is not corresponding with other information(propriocepsis) then the user will start to see through the illusion created by the system and thus the immersion will decrease. possibly leading to the loss of the 'feeling of being' there.

Wei et al. (2019) concluded that the body needs to interact with the surrounding just like in the real world. The immersion will decrease if elements which can be controlled in the real world cannot be controlled in the virtual world.

About the importance of the graphic fidelity of HMD's no conclusive research has been done yet. As the graphic fidelity for HMD's is not on a level close enough to reality for the effect of the graphics to be tested. What I experienced when the users 'feeling of being there' is stimulated enough the graphics fidelity doesn't matter that much anymore and the user could feel like he/she was there even though the digital world was in a surrealistic style.

5.5 Is the architect a good candidate for designing the virtual worlds?

Most architects of today do not have the required practical skills to be the designers of the digital world. Present-day, the designing of the virtual world takes some insight into coding languages and have system thinking and optimization as a high priority. All of these are not skills which the average architect has.
What the architect does have is the experience. Experience in designing the environment is something which is not easily gained. The architect gains this through designing in the real world and through study. The architect mostly starts designing by creating a concept which is a simplified version and often based on a small number of conditions. This is also how games are designed and could easily be translated into a set of rules(rule-based design).
As was described in chapter 5.1 and 5.2 the architects are starting to use rule-based design more in their practice. In the future, the digital design will probably be less code based but more of a visual script. And if the designing of the virtual world does allow the architect to use their native ways of conveying their ideas, then the architect would be a very good candidate.
What is also very important is that the designing of the digital world will not be a one-man job. Within the world designing team(environmental artists), the architect will be having a design-oriented role for which the architect would be well fitted. The architect will be working with programmers and environmental artists to make our digital world. I think the architect's role will be designing the experience. The architect will (together with environmental engineers) translate the story/climate/history/people into a set of rules.
If the architect would learn how to translate their ideas to a rule-based design(rule-set), then the architect would be a perfect candidate for the designer of our digital worlds.
To conclude, will the architect be the designer of the digital worlds? Probably not in the near future, as a game designer is more qualified to make the digital worlds. But the architect could be a very good candidate for the future. This is because the skillset the average (present-day)architect has is insufficient. But the conceptual thinking, understanding of scale and form are very valuable in the design of the digital world.

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7.1 Images