MIXED REALITY CONCEPTUALIZATION AND PROTOTYPING

An approach to construct and visualize imagined concepts in 3D mixed reality environment.

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S2002523

Master thesis

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Acknowledgements

First, I would like to thank my company supervisor Arnold for insightful discussions and the opportunity, and Marith for the input and support during my research. Furthermore, thanks to all other colleagues at LEF which took time for me and contributed to my research.

Second, I want to thank my university supervisor Roy for constructive feedback and assistance during my graduation assignment.

Last, thanks to my friends who spent the time to review and give valuable feedback to the final report, as well as to my family for support during this period.

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Summary

LEF Future Center is part of the governmental company Rijkswaterstaat, which organises and facilitates creative design sessions for solving societal challenges. In the last years, the need for new transitional innovations increased to achieve social, environmental and economic sustainability. Therefore, FutureLAB was created to initiative, create and accelerate those by applying new approaches and technologies. This assignment contributes to the FutureLAB by researching suitable approaches and technologies to create and accelerate transitional innovations.

Analysis of the assignment design challenge identified the gap between the innovation, development and implementation operations, defined as the Implementation challenge. Due to that reason, numerous innovations generated by LEF and FutureLAB are never applied and implemented in the environment. The analysis identified the factors of not involving internal development team in the early design stage, lack of their communication, their different worldviews and incapability of understanding each other during the development process. This leads to the problem of not taking ownership that causes an Implementation challenge. This complex design challenge is divided into three parts by designing Experience framework, upon which further methodology research scope is defined.

The researched proposed developing a game methodology named Game the System, which supports users creating concepts and stimulates them to take ownership over produced concepts. By applying design case study, envisioned Game the System outcomes were designed to define the Game elements, which lead further research process. Upon the Game elements, Game the System concept and its requirements were created to define directions for the Game design.

The Game methodology is divided into three worlds, defining how the game is played, what are delivered value and meaning, and last, how is this connected to the design challenge in the real world. The elements of the three worlds are integrated into Game the System design, which offers a collaborative and fun approach to construct imagined concepts in a mixed reality environment to overcome the Implementation challenge. The methodology is supported by the Player journey map, which defines the player's actions and their touchpoints within the Game.

The Game methodology was demonstrated and applied to the interior design challenge of the FutureLAB. This enabled creating interior design concepts and capturing its images to communicate key concept information to the management team. Consequently, users took ownership of produced concepts and became more motivated to continue with the next development steps.

List of tables and figures

Abbreviations

GTS	Game the System
AR	Augmented reality
CTD	Connect-the-Dots
SMS	Sea-Mountain-Sun
PSM	Player switch mechanism
FFFC	Fishbowl facilitation for cooperation
CRM	Communication rewarding mechanism
MDM	Motivation driver mechanism
TOFT	Tankstation of the Future
NIHS	Not-invented-here syndrome

1.Introduction

The future of the world is a much-discussed topic. The exponential technological developments and increased human well-being worldwide on one hand, and declining stability in the world's ecosystems, on the other hand, offers rise to challenging design problems of urban and rural environments (Rosling, Rosling, & Rönnlund, 2018). Consequently, organizations and businesses are being affected by increased governmental regulations and pressures from the industries, as well as the demands of customers and users to be more sustainable. Due to the mentioned pressures and desires, organizations and businesses are expected to create economically feasible solutions corresponding to the market needs, technological developments and environmental concerns.

For that purpose, this assignment aims to develop a methodology to support organizations and businesses in the domain of infrastructure and urban planning to create desired concepts in the early-stage design process. Those solutions typically demonstrate complex system structures, which tackle numerous uncertainties. Those uncertainties arise due to involvement of multiple stakeholder groups and their perceptions, as well as different domains and environments of application implementation.

To apply the methodology to a real-world case, the graduation assignment was proposed to the LEF Future Center by Master graduate Sergej Zavrnik from the University of Twente. The graduation assignment started on the 2nd of September 2019 and finished on 1st of July 2020.

1.1 The aim of the assignment

This assignment aims to develop a methodology, which bridges the gap between early-stage innovation operations, and further development and implementation operations in the context of FutureLAB. Infrastructure and urban planning are chosen as the application domain.

1.2 Research context

The graduation assignment is conducted in cooperation with the Governmental company Rijkswaterstaat (RWS), an executive agency of the Ministry of Infrastructure and Water Management in the Netherlands, more precisely LEF Future Center in Utrecht.

1.2.1 Company introduction

LEF Future Center organises and facilitates creative design sessions to increase understanding of the challenges, create breakthrough ideas and solutions and last, test their validity. These sessions aim to achieve social innovations in current and future societal challenges. The vision of LEF is "*Let's experience the future*", which also explains its abbreviation LEF. Its vision is driven by five major 2050 transitions, namely Climate & Energy, Smart Mobility, Circular Economy, Climate-Proof Design and Liveable & Accessible Cities (Figure 1)(Parraguez & Cuppens, 2019).

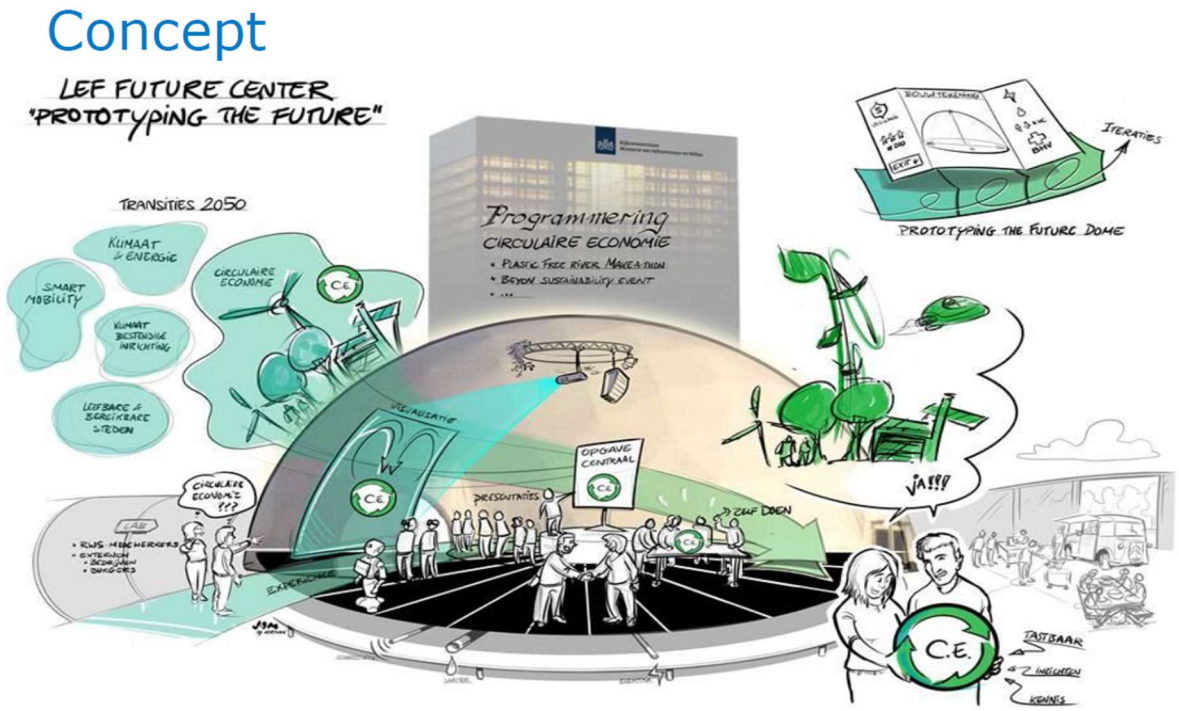


Figure 1: Concept of the LEF Future Center

Depending on the session's purpose, the main goal is typically or (1) to create the desired concept, or (2) to achieve an organizational change. The sessions are facilitated in the spaces of the LEF, usually lasting from a half- to a full day. Each session is tailored to a

specific client and its aim. Besides regular sessions, LEF also offers LEF-on-location sessions, LEF-events and newly introduced Future Lab sessions.

This graduation assignment is part of the LEF Future Center project, called LEF FutureLAB.

1.2.2 FutureLAB

FutureLAB is a space and a three-day design session model, which converts client pioneer's idea(s) to a concept or a prototype. FutureLAB provides a safe environment where participants can dream, imagine, visualize, prototype and simulate their ideas (Meijer, 2020a). There are three main value propositions for the client pioneer participating in the FutureLAB session:

1. visualized and simulated prototype or a concept as an outcome of the session, which can be used as a visual communication tool
2. defined further development and implementation steps of the innovation project
3. networking with professionals during the session, required in the development and implementation steps

From an organisational perspective, FutureLAB is set up as a collaboration between two departments in RWS, namely LEF Future Center and DataLAB. LEF Future Center provides expertise in facilitating and organising design session, while DataLAB supports with digital applications and tools to use data as an innovation driver during the FutureLAB session. FutureLAB is designed as a simple concept – one space, three days and five building blocks, namely Data, Technology, Working methods, Lab as space and People. The outcome of the session is indicated as the Minimum Awesome Product (MAP) and used as a starting point for the development process (Figure 2)(Meijer, 2020c).

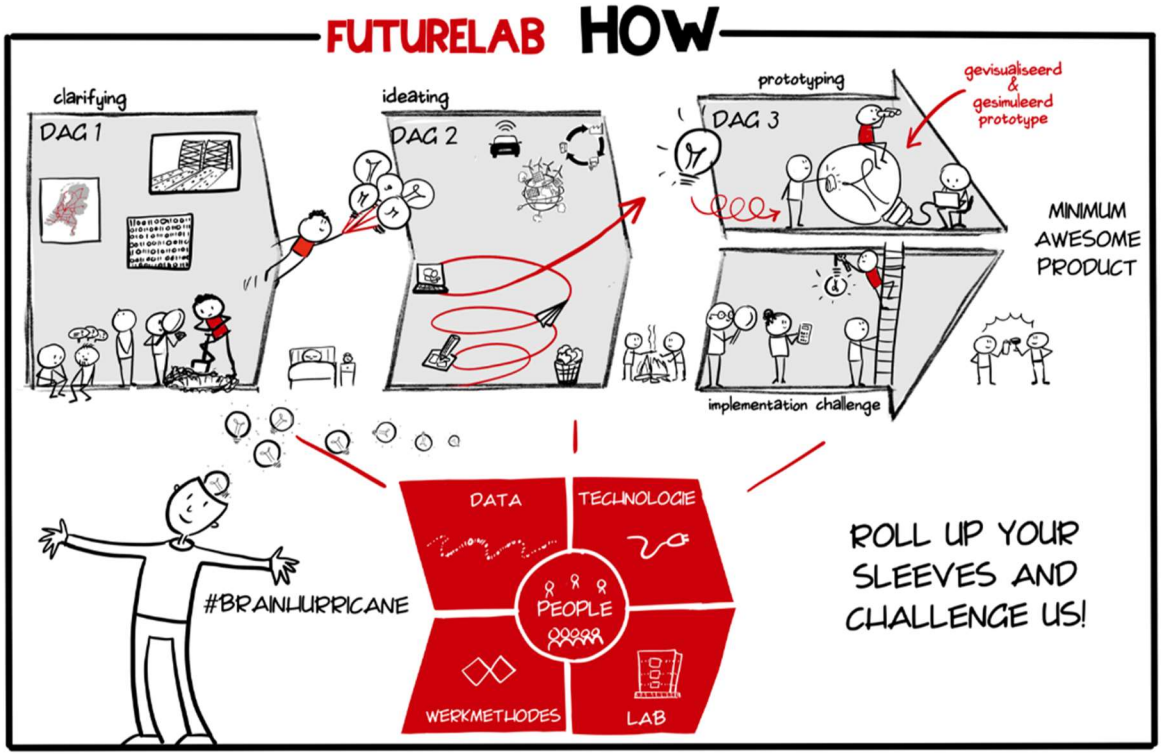


Figure 2: FutureLAB session design model

1.3 Approach and research boundaries

The broad scope of the assignment and the set of underlying design challenge factors initiated the process of defining the research boundaries. Therefore, ensuring the balance between the research, design, its application and validation. After defining the assignment design challenge, the iterative research, analysis and decision making steps were taken to upon the GTS experience, outcomes and approach to scope further research and analysis of the methodology game elements. Concurrently with the game element research and analysis, the GTS concept was produced which lead GTS design process. After the design, the methodology was applied, evaluated and concluded.

1.3.1 Research boundaries

Upon the value proposition of the FutureLAB and session design model, research boundaries are defined to scope the research and design of the assignment:

- The methodology should apply and integrate elements of game, design, technology and visualization
- The methodology should utilize new technologies for prototyping and its visualization
- The methodology should be aligned with the FutureLAB's functional model and Design Thinking method
- The methodology should be a stand-alone product, which can be connected and integrated with other facilitation methods and technological applications

1.3.2 Design case study

Based on the research boundaries, the project called Tankstation of the Future (TOFT) is selected in the pool of FutureLAB projects as a design case study. The client pioneer expects the developed methodology will help him to prototype and visualize the concept in a way that brings all required project's stakeholders on-board and convenience management team to invest in further development steps. Therefore, the involvement of all required project's stakeholders during the methodology application represents the final research boundary point.

1.4 Research structure and reader's guide

The report is divided into four main parts (Figure 3). First, in chapter 2, the exploration of the FutureLAB and its underlying problems and wishes is executed. This lead to the identification and research of the assignment design challenge in the FutureLAB. As a result, further research and analysis steps are defined based on identified conditions to tackle Implementation challenge and their value for the individual user, team and produced concept.

In the second part, the conclusions of the Implementation challenge in the FutureLAB are used to conduct additional research and analysis of the user experience, envisioned outcomes of the GTS, the Game approach and its elements. In chapter 3, experience framework is designed to divide the player experience into three parts and focus only on designing a safe, fun and inclusive environment for the internal development team to create concepts and stimulate them to take ownership. Chapter 4 describes the envisioned outcomes of the GTS methodology as an output of the GTS methodology. Chapter 5 explains the game approach, which provides a means to create concepts of envisioned solutions. In chapter 6, game elements describe who the users are and what is its role during the GTS, mechanisms used to facilitate the methodology and its process, applied design methods in the combination with physical and digital design tools. In chapter 7, the conclusions of chapter 3, 4, 5 and 6 are integrated into the Game the System concept supported with the requirement lists. Those are used as an input for the further design process.

The third part describes the GTS design process, starting with individually explaining three worlds of the GTS are connecting those into integrated GTS design. Chapter 8 describes the relations of the GTS to reality and its functionalities. Second, it provides information about Game strategy, mechanisms and plan to provide the value for the players and the client. Last, it defines how GTS is played, which design tools and technologies are used, and last, how the gameworld is created. In chapter 9, those elements are integrated into the GTS design represented by the player journey map. The GTS design is applied and validated in the next step.

In the fourth part, integrated GTS design is applied and demonstrated, evaluated and concluded. First, chapter 10 describes the gameplay characteristics and the outcomes of the GTS application and demonstration. Next, in chapter 11 evaluation is conducted upon the outcomes of the application and requirements list. Those are further discussed and compared to the predefined game goal, purpose and meaning. Lastly, chapter 12 wraps up the assignment with the conclusions and recommendation for further developments.

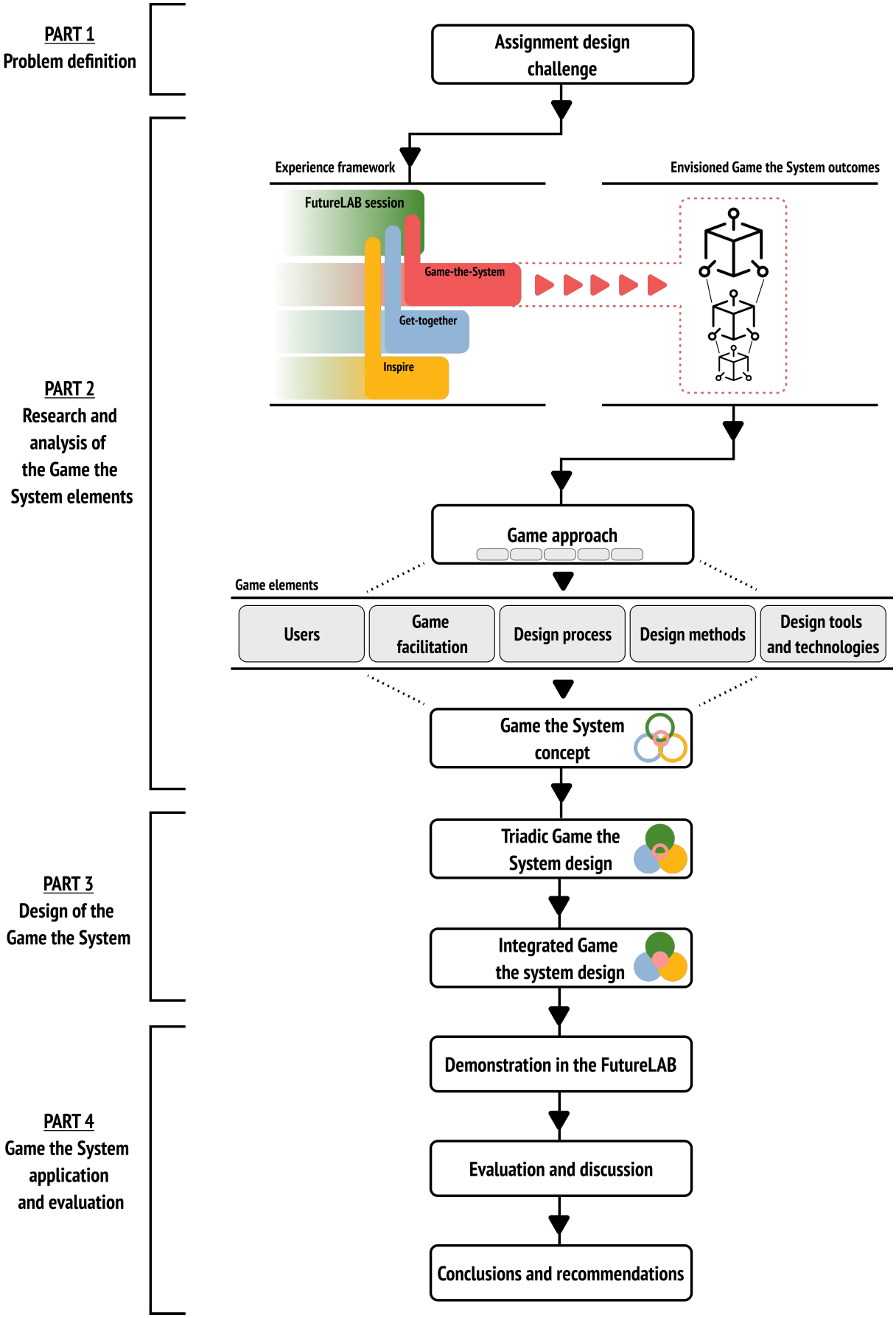


Figure 3: Research structure outline

PART 1: Problem definition

In part 1, the exploration of the FutureLAB and its underlying problems and wishes is executed to define the assignment design challenge, understand its context and define further research and analysis steps.

2. Assignment design challenge

In this chapter, first problems and wishes are identified in the FutureLAB environment and later mapped and analysed. Upon its analysis, the design challenge of the assignment is defined as the Implementation challenge. Last, Implementation challenge analysed and positioned into the FutureLAB functional model to define four methodology conditions to overcome Implementation challenge.

2.1 Identification of problems and wishes

Set of surveys and interviews were applied to identify the problems and wishes related to the FutureLAB operations and involved main stakeholders. Those are a facilitator, a session participant, a client pioneer and the FutureLAB team, consisting of the project manager, account manager and business developer.

In surveys and interviews, S-P-I-N sale technique was used to construct the core question structure to identify the problems and wishes of the stakeholders (Jamie, 2017). S-P-I-N technique is a sequence of steps that leads the questioning process of the interviewer during a conversation with a prospect. Its goal is to identify the prospect's situation and problems, perceived solution and the value of its implementation for the prospect. In combination with S-P-I-N technique, the DRIIIL questioning process was applied to drill down to the core issue, find the impact, imagine possible solution on the problem and identify how this solution can be achieved (Performance, 2020).

Due to the extensive set of identified problems and wishes, they were coded in a form of simplified keywords language and mapped into a network based-graph (Appendix A).

2.2 Mapping and analysis of problems and wishes

Identified problems and wishes of the FutureLAB main stakeholders has been mapped into a network-based graph using online tool Kumu with the main purpose of identifying and analysing the relations and dependencies between problem owners and their problems and wishes (Figure 4) (Zavrnik, 2019). Moreover, the map was used to communicate and validate identified problems with internal FutureLAB team.

Identified problems and wishes are classified into three classes. Those are (1) people-related, (2) process-related and (3) tools-and-approach-related problems and wishes. The classification helped to identify more connections inside a specific group and revealed that the most problems and wishes are people and tools related. Moreover, problem owners are divided into internal and external stakeholder FutureLAB group, to identify the relations between internal and external problems and wishes. It showed the problems and wishes from the facilitator (internal stakeholder) are highly related to the problems of the participants and clients (external stakeholder).

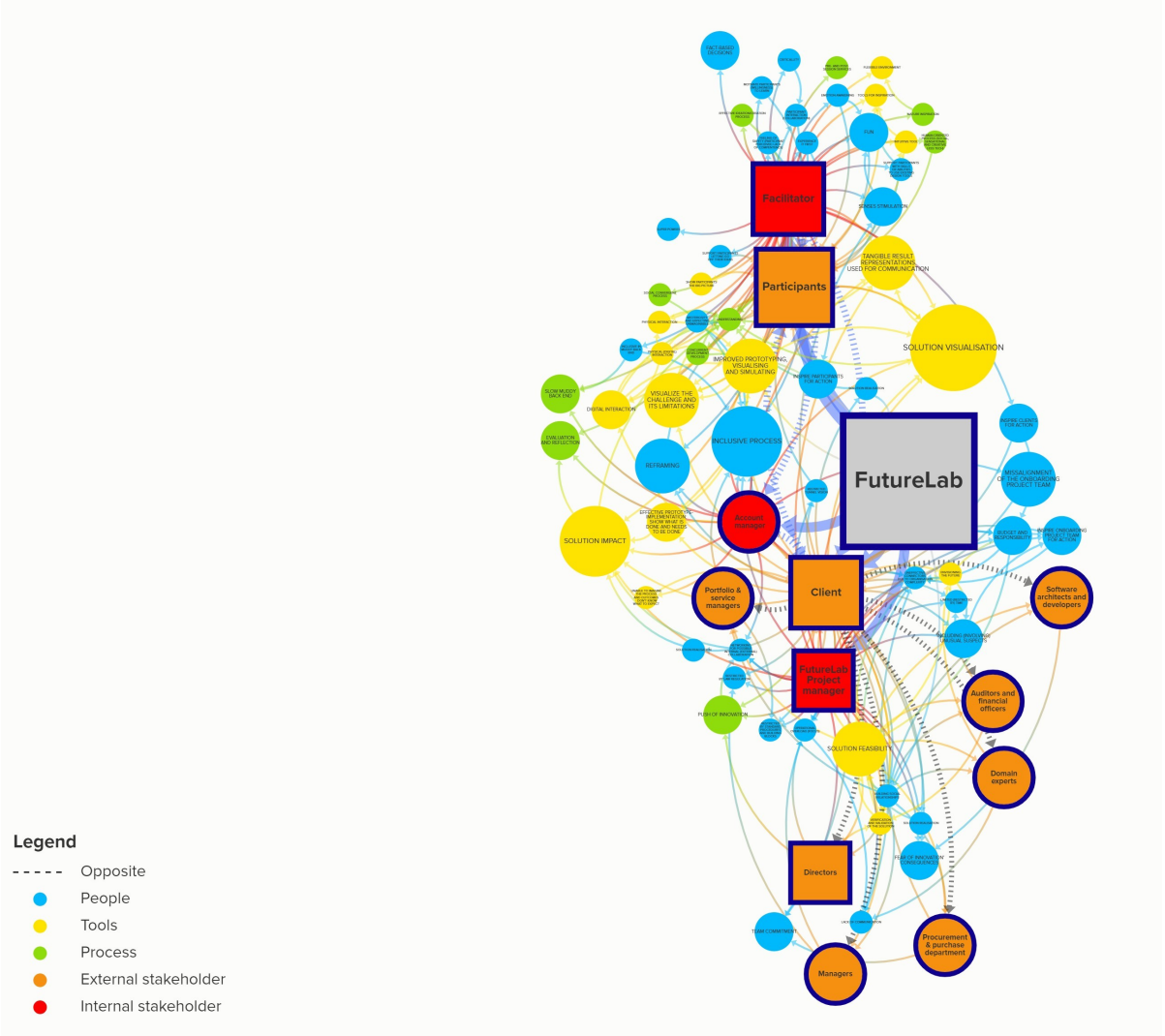


Figure 4: Mapping of problems and wishes

To prioritise the problem owners, Social Network Analysis is applied by using online tool Kumu. The results of the analysis, using metrics of degree and closeness, ranked facilitator first, client second and participants third. However, participants are prioritized over the client, while their problems and wishes during the session directly influence the outcomes of the session, which correlates to most of the client's problems and wishes. Therefore, solving the participant's problems means solving the client's problem. The facilitator is placed in the first place, while its problems and wishes based on practical experience with participant's and its problems and wishes. Moreover, its wishes represent the high correlation of the client's wishes to solve the problems of its internal development team. According to that, the problem owner's priority list is constructed:

1. Facilitator
2. Participants
3. Client pioneer and its internal development team

In the last stage, the network-based graph is used for analytical discussion with FutureLAB project manager (Meijer, 2020b). The analysis revealed that multiple ideations of innovation

are produced in the Future Center and FutureLAB, while not many have been implemented in its envisioned environment. Clients typically push their pioneering ideas into the innovation process of the Future Center. However, this client's push towards its internal development team usually results in their unacceptance of even resistance of the innovation project. Thus, the majority of produced concepts and pilots never enters the development and/or implementation phase. In case innovation projects are initialized outside of the organisation and its standard procedures, the probability for the gap between innovation operation, development operations and implementation increases (Kune, 2019) (Dvir, Schwartzberg, Avni, Webb, & Lettice, 2006). Commonly, those externally facilitated innovation projects are accepted by the internal management, but often delayed or cancelled after entering the organisation due to misfit with the daily organization operations of the internal development team. Difficulties appear in translating created concepts and pilots into practice and getting the internal development team to accept and adapt to the needs of a newly introduced pilot and its further development (Kune, 2019). Assignment design challenge is constructed upon the conclusions of this analysis.

2.3 Design challenge definition

This assignment aims to develop a methodology to bridge the gap between early-stage innovation operations, and further development and implementation operations in the context of the FutureLAB (Kune, 2019). The assignment design challenge is further referred to as the Implementation challenge.

The most important factors for Implementation challenge are:

- not involving internal development team in the early design stage
- different worldviews and languages are spoken by members of the internal development team
- lack of communication during the development process

Those lead to team misalignment, which causes Over-the-wall syndrome and demotivate employees to take ownership over their work (Wahl, 2017). Over-the-wall syndrome occurs, when professionals from different company departments do not communicate necessary information to other professionals required for further developments.

2.4 Implementation challenge in the FutureLAB

Implementation challenge is positioned into the FutureLAB session design model to define the context of the assignment design challenge (Figure 5). Implementation challenge appears between the transition from the innovation operations during the FutureLAB session to the development process, and from the development process to implementation operations. For the scope of this assignment, only the gap between FutureLAB session and further developments is analysed. During the process of FutureLAB's prototyping and concept pitch, two groups are involved. The client pioneer as the problem-owner with its internal development team, and session participants, which participate in the FutureLAB session.

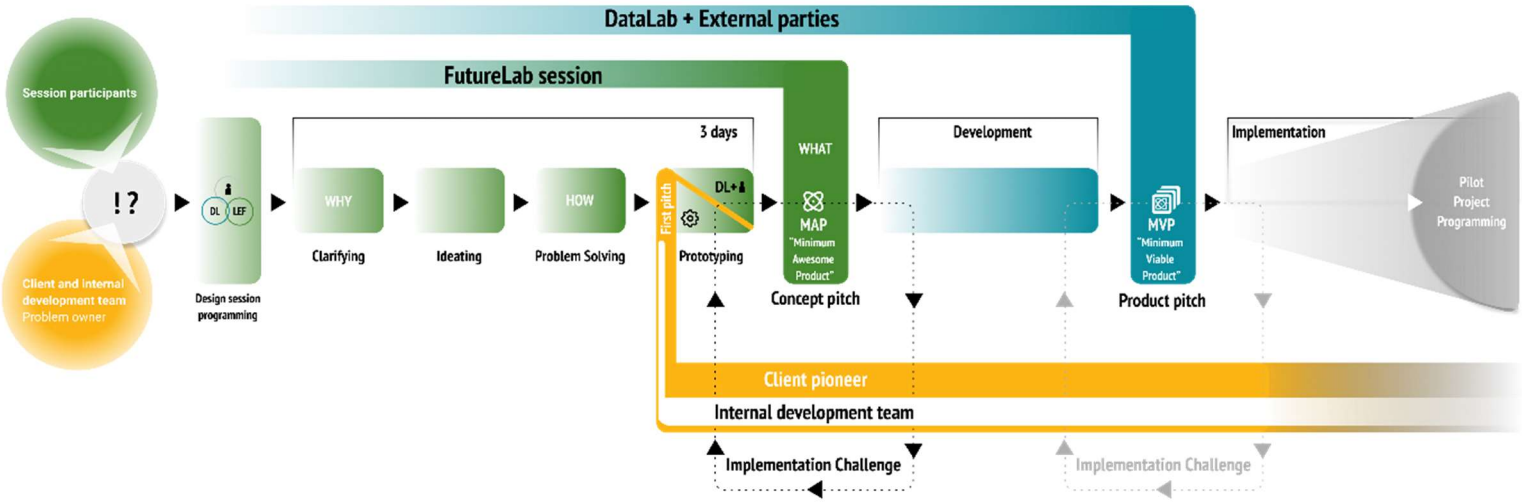


Figure 5: Implementation challenge in the FutureLAB session design model

Upon the theoretical research and analysis of the FutureLAB of the Implementation challenge, four elements need to be considered in methodology design to tackle the Implementation challenge in the FutureLAB (Dvir et al., 2006):

1. *Create a safe, fun and inclusive environment to facilitate effective communication and social interaction between the internal development team*
2. *Include and involve internal development team in the early design process to address needs, challenges, trends and opportunities of the specific area where a problem is being solved*
3. *Motivate the internal development team to exchange ideas and thoughts, and translate them into actions and designs to trigger an exploration of new concepts and stimulate taking ownership over produced concepts.*
4. *Bring internal development team out of its "tunnel vision" and increase awareness upon their perceptions and worldviews, and stimulate the creation of break-through concepts*

The value and the effect of those four elements are perceived differently by individual members of the internal development team and the client in a request for the visualized concept. Therefore, the methodology and the delivered value is divided into three levels by designing Experience framework – (1) individuals, (2) the internal development team and (3) produced concept (Figure 6). Consequently, the scope of the assignment focused on supporting internal development team to create concepts and stimulate them to take ownership. Furthermore, it leads to the exploration of envisioned Game the System outcomes by the client and its development team, and research of methodology approach, which provides a safe, fun and inclusive environment.

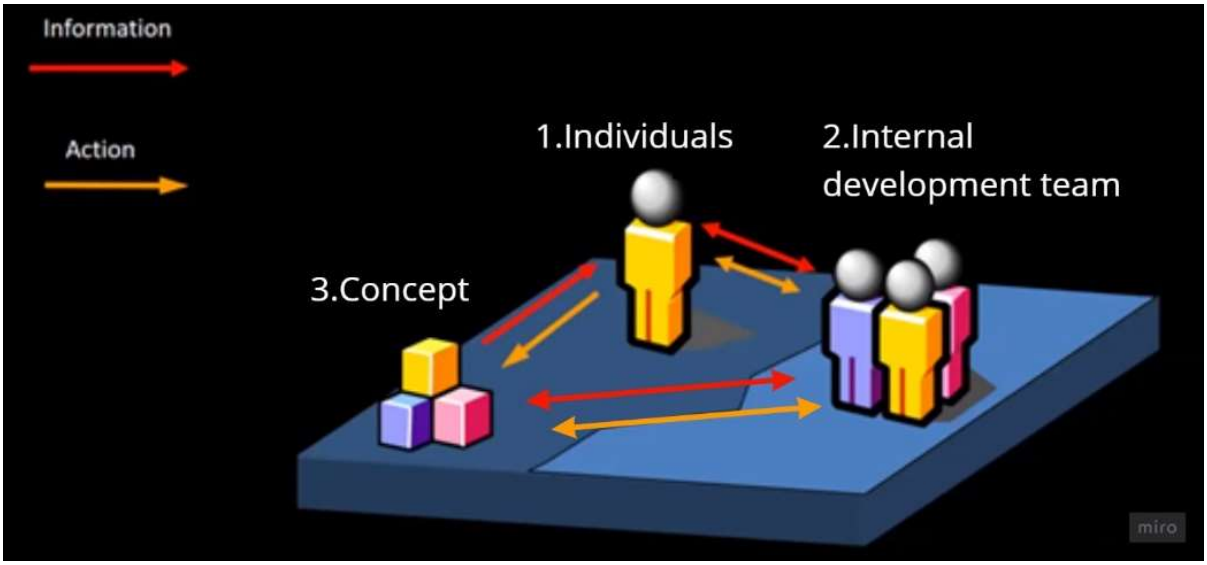


Figure 6: The GTS value for individuals, team and the concepts

PART 2: Research and analysis of the Game the System elements

In the second part, the conclusions of the Implementation challenge in the FutureLAB are used to conduct four research and analysis steps, and synthesize them in the Game the System concept as a starting point for the Triadic GTS design.

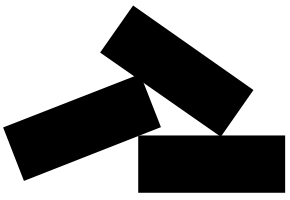
In chapter 3, experience framework is designed to divide the player experience into three parts and focus only on designing a safe, fun and inclusive environment for the internal development team to create concepts and stimulate them to take ownership.

In chapter 4, envisioned outcomes of the GTS methodology have been researched to define the output of the methodology and question the approach to achieve those.

In chapter 5, the game approach which provides a means to create concepts of envisioned solutions is described. Its research identified the lack of information and knowledge upon the GTS users, game facilitation, design process, design methods and last, design tools and technologies.

In chapter 6, five elements are researched and analysed. This chapter explains who is the users and what is its role during the GTS, how GTS facilitates those users and which mechanisms it applies, what are the GTS inputs, outputs, and the process. Moreover, it describes five major design methods, which define a combination of physical and digital design tools.

In chapter 7, the conclusions of chapter 3, 4, 5 and 6 are integrated into the Game the System concept supported with the requirement lists. Those are used as an input for the further design process.



3. Experience framework

The complexity of the Implementation challenge and the value provided by the proposed methodology lead to the design of Experience framework in chapter 3. This allowed subdividing the FutureLAB experience into three parts for the internal development team to tackle the Implementation challenge in parts (Figure 7). While the research and design of all three parts exceed the scope of this assignment, only the third step Game the System (GTS) is brought to further development steps. Therefore, designing the methodology, which facilitates a safe, fun and inclusive environment for the internal development team to create concepts and stimulate them to take ownership.

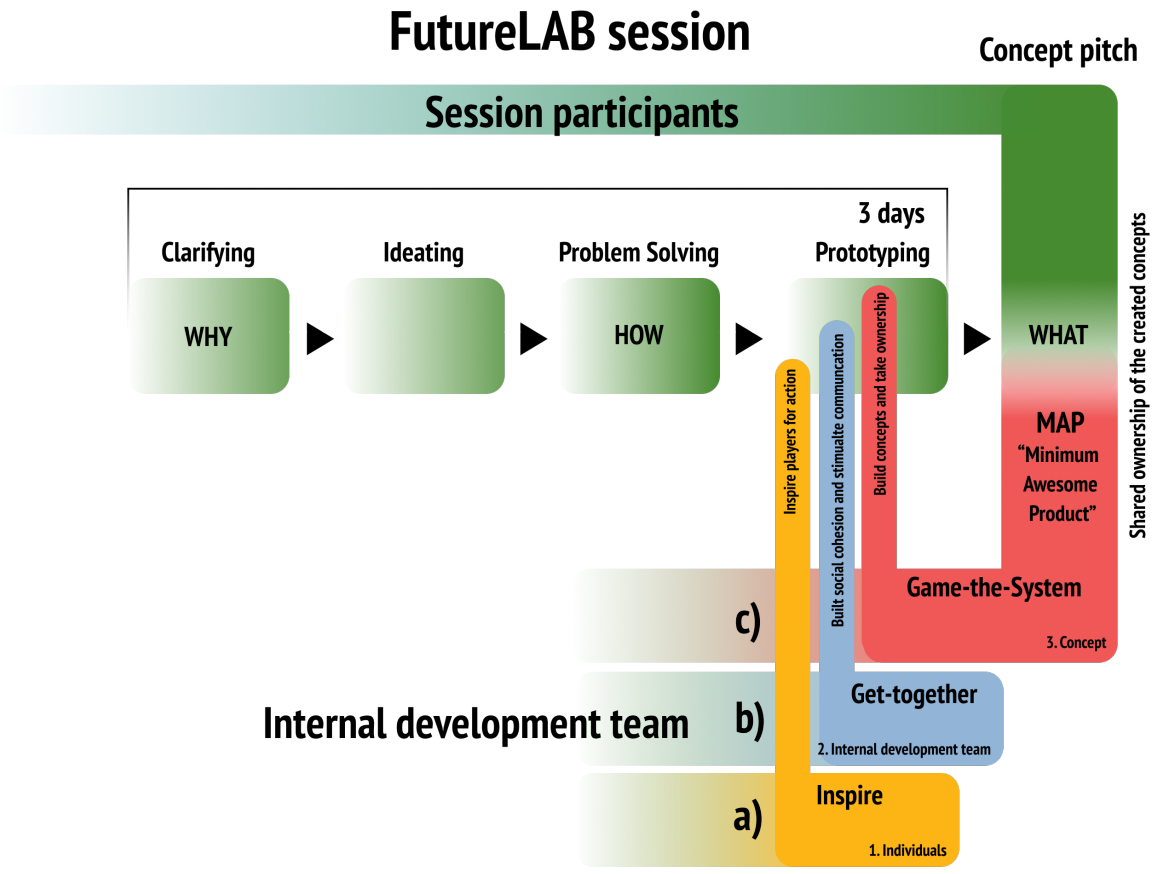


Figure 7: Experience framework

Inspire part focuses on the individuals, Get-together on the entire internal development team and Game the System (GTS) on concept creation. Each part of the experience framework has its own goal:

a. Inspire - to inspire and get individuals enthusiastic about the concept creation
b. Get together - to stimulate communication and build social cohesion to create a stimulating environment for the concept creation
c. Game the System (GTS) - to create concepts and stimulate players to take ownership

While the session participants of the FutureLAB are involved in the FutureLAB session from the first day on, the internal development team joins in the FutureLAB session at the start of the third day. Depending on their needs, the can join all consecutive parts a), b) and c), or combination of those. The ultimate goal of the Experience framework is to integrate the internal development team in the last day of the FutureLAB session and involve session participants in the Game the System (GTS) to generate a concept of the envisioned solution (MAP) and share ownership with them.

3.1 Inspire

The goal of the Inspire is achieved by projecting inspirational videos of the FutureLAB sessions, produced concepts and prototypes to the internal development team. Moreover, by allowing the internal development team to play, interact and explore with physical, AR and VR concepts and prototypes created in the FutureLAB. Thus, they can imagine the possible outcomes of the FutureLAB and get motivated to participate in it.

3.2 Get together

In Get together, the internal development team is brought into unfamiliar space of the escape room with a common goal and time restriction. The unknown space brings individuals out of the comfort zone, into a more curious and open mindset. By applying time pressure and a common goal in this part, they are extrinsically motivated to communicate and socially interact to escape from the escape room and achieve a common goal. Consequently, they achieve social cohesion and bring up the team spirit.

3.3 Game the System

GTS facilitates different design methods and design tools for individuals to imagine, express and visualize their ideas, and create concepts in a safe, fun and inclusive environment. Moreover, GTS triggers their perspectives by questioning produced concepts and stimulate communication during its creation. This leads to the birth of new ideas, motivates individuals to continue with the creation process and take ownership of produced concepts.

GTS is identified as the most crucial part of the internal development team's experience, while it considers all four Implementation challenge elements into its methodology. In the scope of this assignment, only GTS is further researched and designed. However, it is proposed to further develop the remaining two parts to effectively tackle the Implementation challenge.

4.Envisioned Game the System outcomes

In chapter 4, the project Tankstation of the Future (TOTF) is applied as a design case study to support the design of the envisioned GTS outcomes and evaluate the actual outcomes of the methodology after its application. During the TOFT development session, the client explained the design information needed to present it to the management team and convince them to invest in the next development steps (Appendix B). Those were translated into the envisioned outcomes of the methodology. It is concluded that the GTS outcomes should visually represent the concept by three system-detail levels and three perspectives describing social, environmental and economic dimension. Moreover, to describe the desired concept functionalities and influence of cultural and political factors, information from technical, cultural and political dimensions should be captured by GTS methodology as well (Garcia, 2019; Innovation, 2020).

Upon the wishes of the FutureLAB's participants and client, visual representation of envisioned outcomes is created by the means of the co-creation with the participants of the Dutch Design Week (Figure 8).

Figure 8: Envisioned outcomes of Game the System

On the first system-detail level, GTS concept represents the envisioned solution, positioned in the context environment, i.e. urban planning map. Second system-detail level exhibits a simplified 3D model of the envisioned solution, representing the functionalities and interaction with the surrounding environment. Last, third system-detail level visualises a detailed 3D model of the envisioned solution with a description of its elements. Information comprising social, environmental, economic, technical, cultural and political dimension is brought to the GTS by users owning domain knowledge and experience and applied on the three system-detail levels.

5. Game approach

In a search for an appropriate approach to create envisioned concepts in a safe, fun and inclusive environment, additional analysis of the identified problems and wishes is conducted in this chapter. The analysis of participants, client and facilitator exposed their wish to apply game and play elements into the GTS methodology. This lead to further research revealing a need in society for digital, creative and collaborative play happening inside the same room using physical objects (LISA, 2020). Upon this need and wishes from facilitator, participants and client, the decision is made to apply the game approach. To design and integrate the game approach into the GTS methodology, Triadic game design method is used. It is chosen because it represents a framework which promises to design a game with a purpose, that is fun, meaningful and is connected to the real world (Harteveld, 2011). Thus, GTS provides a means for users to create concepts of envisioned solutions and bring them into the real world during the digital, creative and collaborative play, happening inside the same room using physical objects. Therefore, GTS is divided into three inherently connected and interdependent worlds:

- World of Reality – questions what it is and could be possible in the real world
- World of Play – questions what the solution could or should be
- World of Meaning – captures and translate the insights and meanings created during the GTS, bring experience from the game into the real world

In order to design the GTS game approach, game elements needed to be researched and analysed. To lead this process, a set of questions are given for each game element required for the GTS methodology:

1. *Who is involved in the GTS? What role do they have in the game?*
2. *How to facilitate the GTS, to provide safe and inclusive gameplay? How to simulate effective communication and social connection? How to increase awareness of the player's perceptions and stimulate them to take ownership of produced concepts?*
3. *What are the inputs and outputs of the GTS? What are the phases in the Game process?*
4. *Which design methods are needed in GTS, to support players imagining, expressing, exchanging and visualizing of their ideas and thoughts to construct the concept?*
5. *What design tools and technologies are needed to support those design methods?*

6. Game elements

In this chapter, five game elements are researched and analysed. Those are the GTS users, game facilitation, design process, design methods and last, design tools and technologies. The conclusions upon each element are integrated into the Game the System concept and requirement list in chapter 7.

First, the users of the GTS are described and divided into three main roles, namely client, facilitator and players with session participants. Second, game mechanisms are described to facilitate the GTS creation process. These mechanisms are applied to stimulate the communication between players, building social connections and increase awareness of their perspectives and worldviews to take ownership of produced concepts. Third, four-phased GTS design process is defined which leads through the process of understanding the design challenge and creating a concept, to verifying and validating the concept. Fourth, five design methods are applied to facilitate GTS visual-verbal communication and concept creation, namely visual imagination, drawing and sketching, physical prototyping, digital prototyping and the “wrong” model method. Last, the GTS design tools and technologies are described, which construct a mixed reality GTS environment that combines physical and augmented reality design tools.

6.1 Users

Three types of users are involved during the FutureLAB sessions and Game the System – participants, a client, and a facilitator. The facilitator plays the role of an intermediary and conductor to orchestrate the creative design process and exchange the value between participants, client and facilitation organisation. In this triadic composition, the client remains the owner of the problem, and the facilitator leads the participants through the GTS.

6.1.1 Session participants and internal development team

The users of the GTS are divided into two groups. Those are session participants which are involved entire three days of the FutureLAB session, and internal development team which gets involved in the last, third day of the FutureLAB session. Members of the internal development team are referred to as the players of GTS.

Session participants are groups of people brought by client pioneer, usually comprising experts from specific domains and industries, as well as unusual suspects owning required skills and knowledge to contribute to the innovation project and challenge internal development team to search for solutions out of their "tunnel vision" (Meijer, 2020d).

The internal development team is responsible to produce concepts on which they are proud, so they will take ownership and bring them further into the next development steps (Meijer, 2020c; Parraguez & Cuppens, 2019). Their multidisciplinary team typically consist of directors and project managers as decision-makers, auditors, law regulation and financial officers, procurement and purchase officers, portfolio and service managers, software architects and developers, and last domain experts. Each of them has different roles, responsibilities and pains during the development process (Table 1).

Internal development team	Role & Contribution	Main Pains
Director	Main decision maker for innovation project; Pushing the innovation	Concerns including project team taking the commitment and responsibility
Project manager	Main decision maker for innovation project; Pushing the innovation	Operational overload
Auditor, law regulation and finance officer	Responsible for legal and financial affairs	Restricted by law regulation, and concerned by responsibility
Procurement and purchase officer	Managing and coordinating the procurement process	Concern about time for project preparation and team commitment to the project
Portfolio and service manager	Responsible for investment decisions and business services	Ineffective in connecting internal projects and required people due to the complexity of the organisation
Software architects and developers	IT support and development	Restricted by standard development procedures and building blocks
Domain experts	Own natural and social science knowledge	Afraid of innovation and lack of effective communication skills

Table 1: Roles, contributions and pains of the internal development team

To answer the main questions of the looks, functions and interaction of the envisioned concept produced by the GTS, four members of the internal development team have been chosen. Those are directors, project manager, procurement and purchase officer, portfolio and service manager, and last domain experts.

6.1.2 Client

Clients pioneers are the owners of the innovation project idea and its underlying design challenge, which they bring to the FutureLAB session. Their vision of the innovation project, its requirements, wishes and needs are used as an input for the GTS design challenge. He or she is typically responsible to take and present the outcomes of the session to the organization management team, and convince them to continue with the concept development process.

6.1.1 Facilitator

As a Game facilitator, he or she takes the role of a mediator and moderator, which is responsible to evoke unusual dimensions and switch mindsets of the players (Parraguez & Lelie, 2020). Furthermore, a facilitator is responsible to energize, empower, support and stimulate effective communication between the participants(Prodan, Prodan, & Purcarea, 2015). During the GTS, he or she is responsible to guide players through the GTS design process using design methods, design tools and technologies.

6.2 Game facilitation

Facilitation is used to lead the interaction between a group of players and session participants. This results in the creation of the concept, which cannot be predicted due to uncertainty of design challenge, players and the session itself (Parraguez & Lelie, 2020).

Referring to the underlying factors of the Implementation chalenge, the GTS facilitation provides a safe and inclusive environment for players and session participants, to stimulate effective communication and social connection. Second, it increases awareness of the player's perceptions and worldviews. Last, it motivates them to exchange ideas and thoughts and stimulate taking ownership over produced concepts.

6.2.1 Safe and inclusive environment

A trustworthy and safe environment is the first prerequisite for players to personally connect, avoid anxious and stressful state, and transition to curious state crucial for the creation of spontaneous, controversial and not expected ideas (Parraguez & Lelie, 2020) (Prodan et al., 2015; Thurber, 2016) (Mosterd, 2020). The freedom and flexibility of an individual player's interpretation of GTS, based on their perceptions and beliefs, creates uncertainty. This uncertainty engages the player's curiosity about the unpredictable outcomes and stimulates them to act upon their interests and wishes. This leads to the player's perception of a safe and stimulating environment. Therefore, Fishbowl facilitation for cooperation (FFFC) is applied to give a choice of GTS interpretation and the possibility to decide when they want to participate actively or passively in the GTS (Wageningen).

Furthermore, a communication rewarding mechanism (CRM) is integrated to establish a safe GTS environment, where players are stimulated to freely communicate, identify and connect mutual interests, feelings and emotions to the common ground. This allows to exchange and built upon other's information, let that be similar ideas and meanings of a specific topic, similar perspectives or experiences, expertise, values or other, crucial for the concept creation (Kune, 2019). As a consequence, the team aligns, establish cooperation and avoid Over-the-wall syndrome (Wahl, 2017).

However, to avoid separate developments during the FutureLAB session and GTS, which occurs due to lack of communication and exchange of information between session groups, the session participants are included in Game the System. In the case of separate session developments, the internal development team can reject the concepts created by session participants at the end of the session and again causes Over-the-wall syndrome. When the individuals do not find or build the connection between their ideas and other's concepts, their probability to adopt those concepts decreases. This occurrence is defined as Not-invented-here syndrome (NIHS) (Piller, 2015). Thus, a player switch mechanism (PSM) is needed to connect individual developments during the FutureLAB session.

6.2.2 Communication

Effective communication is crucial for transferring information and social interactions, which represent the foundation of building relationships and allows players to properly express emotions and feelings(Liddell, 2015). This leads to connecting and aligning individual thinking paths into the same direction with other players, finding a common ground of different interests and avoids individualistic focus on the solution. When the player is not able to translate and convey its thoughts and ideas in a language understandable to the listening person, communication gaps can occur, leading to loss or misinterpretation of information (Figure 9).

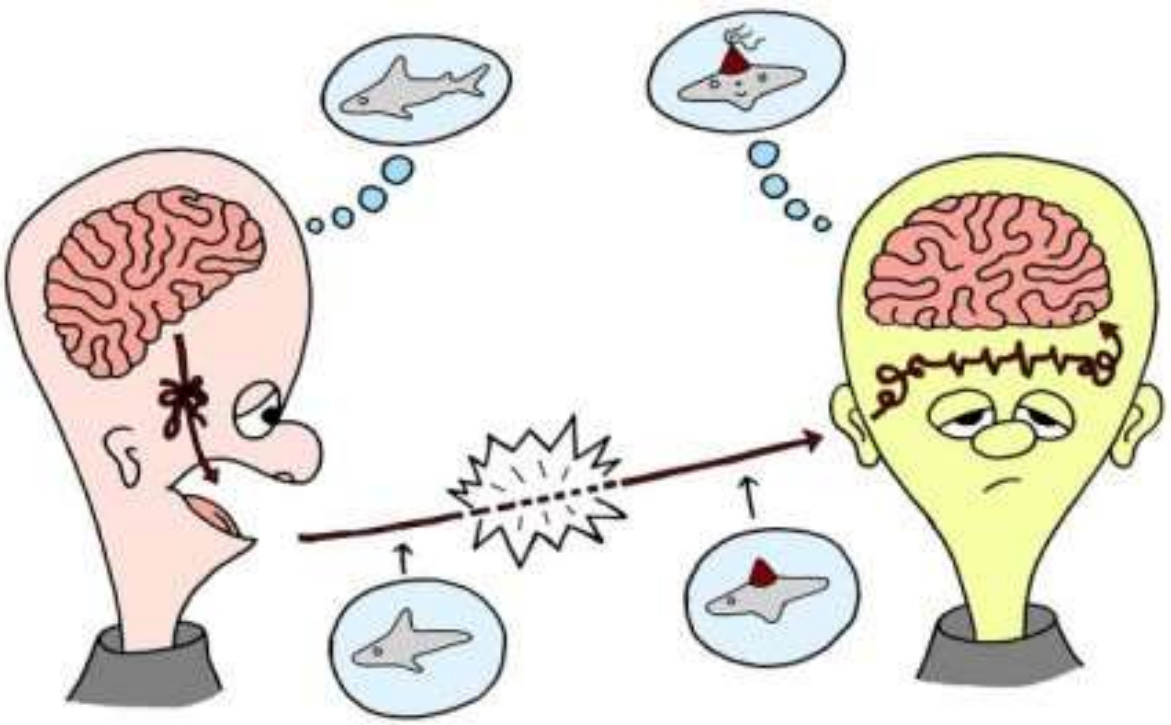


Figure 9: Communication gap

To overcome this, four basic principles are used in GTS design – (1) using simple words and keywords during the GTS gameplay, (2) facilitates utilization of design tools for creating and communicating ideas, (3) using Game canvases to note design rationale and last (4) storytelling to share ideas and underlying rationale.

Simple words and keywords are used to communicate with vocabulary known by the entire internal development team. Design tools allow players to visually communicate information-rich ideas and thoughts understandably (Gray, 2019). Game canvases provide physical paper models to helps players to organize the ideas and thoughts concerning the envisioned solution. Last, storytelling provides an approach to present ideas with its context and connect facts to people, situations and events(Ramakrishnan, 2017).

6.2.3 Worldviews and behaviour change

Players perceive and interpret the world upon their own, different perspectives and worldviews (Grave, 2020). Those originate from their subconscious beliefs, assumptions, needs and past experiences (Figure 10)(Grave, 2020).

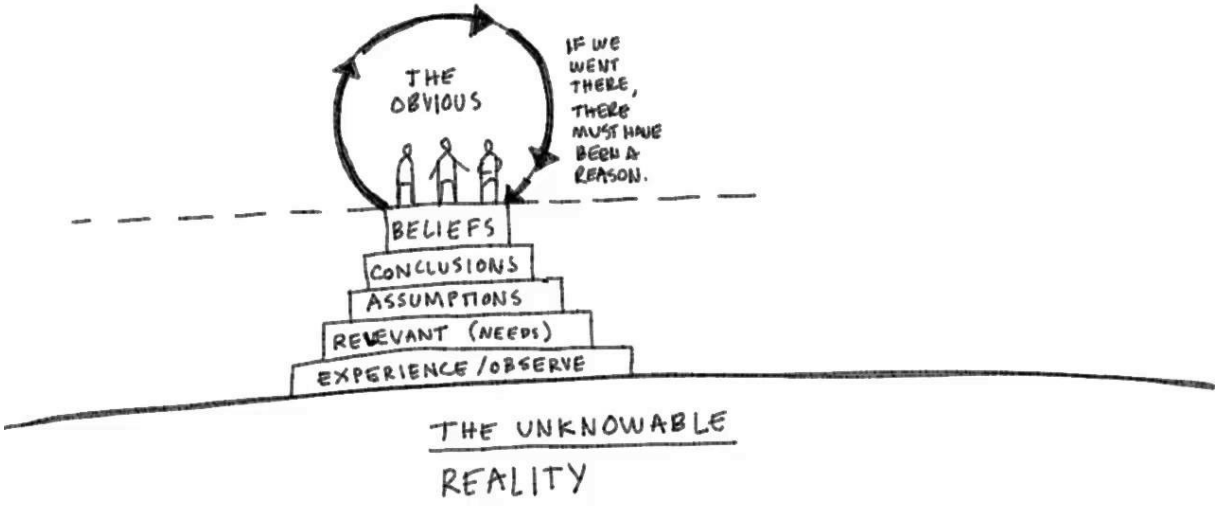


Figure 10: Pyramid of belief

When an experience occurs, the human brain interprets the experience aligned with its current assumptions and beliefs, which define its perspectives and worldviews (Parraguez & Lelie, 2020; Ramakrishnan, 2017). In the case of a strange or unexpected experience, which exposes a gap in player current understanding of reality, the brain responds by filling the missing explanation and change player's worldview. In this manner, games are recognized as an effective tool to persuade people to change, while they provide a media for experiential expressions and tap into the player feelings and emotions during the gameplay (Harteveld, 2011).

With the reason to stimulate finding new solutions upon the design challenge and change the player perspectives, players are brought into a non-familiar GTS mixed reality game world with other players. This transfers players in the uncomfortable zone, which triggers them to question their worldviews and open towards each other. In the process of finding answers, they transition into the place of curiosity and not-knowing, which stimulates creativity, communication and building a social connection between players (Michiel Prins, 2019; Sanders & Stappers, 2008; Shum, 2018). Consequently, it helps players to identify and understand its own and other player's perspectives, beliefs, assumptions and needs, upon which its design approach depends (de Witt; Innovation, 2020). This leads to more coherent conceptual designs and change of player's perspective towards the conceptual designs, as well as other players (Ely, 2017).

6.2.4 Motivation drivers

When the basic needs of a player are satisfied, traditional motivators of fear, money or rewards aren't so effective when it comes to creative and innovative tasks, such as creating concepts (Pink, 2009). Therefore, players seek the accomplishment of psychological and self-fulfilment needs (Maslow, 1970). GTS motivation driver mechanisms use three psychological and self-fulfilment motivators to intrinsically motivate players to actively participate in GTS:

1. Autonomy – players have the freedom to define how they play the GTS and choose their own set of design tools to express their ideas and thoughts. This allows them to satisfy its interests, intentions and expectation during the GTS gameplay(Garcia, 2019)
2. Mastery - through the gameplay, players increase their visual-verbal communication skills by expressing, visualizing and sharing their ideas and thoughts in the form of mixed reality concepts
3. Purpose – players have the freedom to construct and translate meaning from GTS according to their perceptions (Garcia, 2019)

GTS motivation driver mechanisms are designed upon those three motivators and game mechanics to stimulate communication and expanding player perspectives. This enables an individual player and the entire team to stimulate concept creation:

1. ***Empowerment*** *– freedom of GTS interpretation, type of gameplay and choice of design tools to increase the degree of autonomy and self-determination in player*
2. ***Achievement and progression*** *– creating concepts purposefully and successfully with effort, skill, or courage that leads towards more advanced concepts*
3. ***Social cohesion*** *– including session participants and building a social connection between players to promote trust, create a sense of belonging and align expectation and intentions to work together towards the common goal of creating a coherent conceptual design*
4. ***Taking ownership*** *– being proud of the created concepts of the Game and see its purpose, take responsibility and give a commitment to the next development steps*

6.3 Design process

GTS design process is positioned in the early design stage of the product development process. To tackle the Implementation challenge, the design process is driven by the client's vision. Moreover, the internal development team is included from the start of the GTS, which initializes the product development process.

6.3.1 Input-output model

GTS leads players from design challenges, aligned with the client's vision, to the generated conceptual design of the envisioned solution. During the GTS design process, it focuses on:

1. Increase player understanding of the design challenge by sharing client vision and player perspectives
2. Achieve common agreement upon the concept baseline by defining main requirements and share player wishes, obstacles and envisioned outcomes
3. Create conceptual designs of the envisioned solutions
4. Capture and evaluate generated concepts

During the GTS design process, four major input-output elements are applied - Client vision, Players, Game canvases and generated conceptual designs (Figure 11).

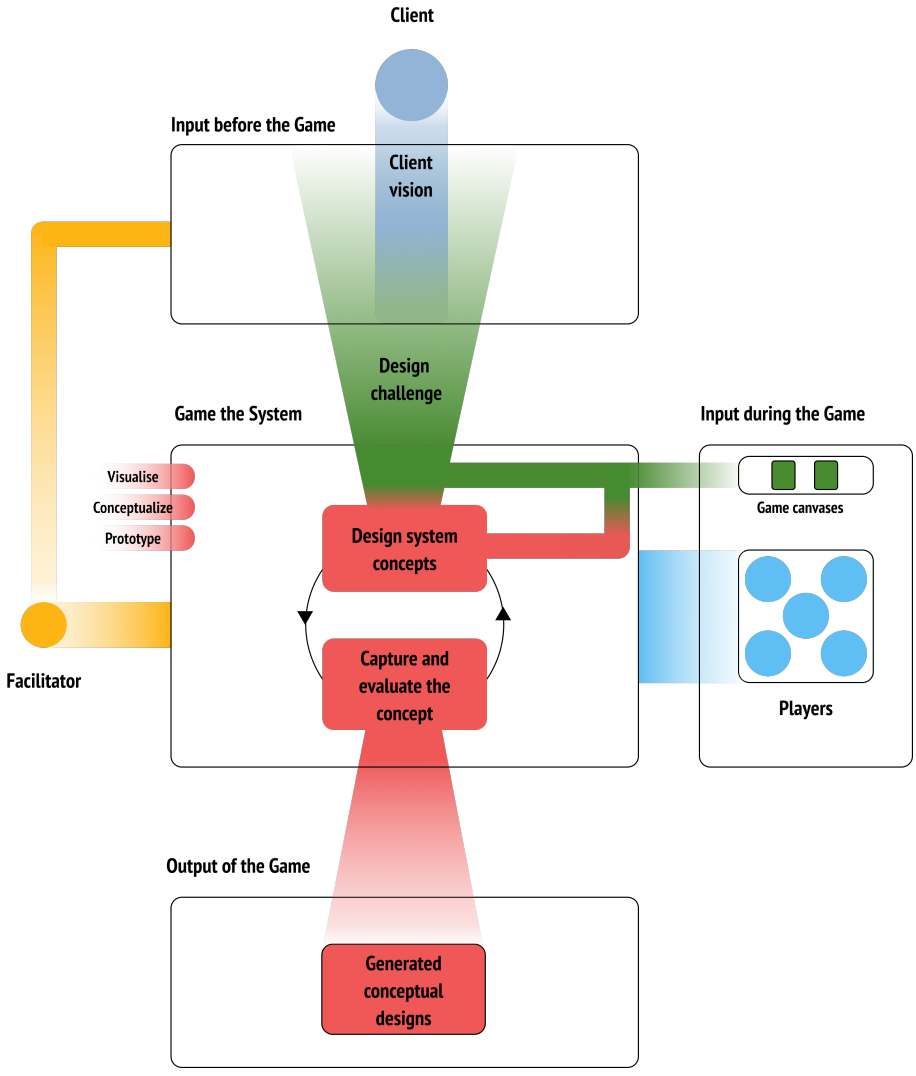


Figure 11: GTS input-output model

First, (1) the client shares the product vision and its underlying design challenge with facilitator and players in a form of videos, pictures and storytelling of facilitator. This defines the purpose of the GTS, to give the player a meaning and intrinsically motivate players to play the Game (Sanders & Stappers, 2008). Additional contextual information is given by facilitator and client to the players to increase understating of the product environment, such as industry and specifics of an innovation project. Those are for example market research, trends, objectives, strategies, functional requirements, business goals, etc. Second, (2) wishes, obstacles and envisioned concepts design specifications are noted by players in a form of Game canvases. Third, (3) facilitator forms the groups to start with conceptualization and prototyping of concepts by applying GTS design tools and technologies. Last, (4) conceptual designs are captured and evaluated.

6.3.2 Design process model and group dynamics

GTS design process is divided into four design phases called Understand, Create, Validate and Verify, and Reflect. Those together construct the GTS design process model, applying elements of the design methods Design Thinking, Double Diamond, IS-DC group dynamics model and Lego Serious Play (Figure 12). Design Thinking method has been chosen because it provides a framework to create, prototype and test innovative concepts upon ill-defined and ambiguous design challenges and challenges the designer's assumptions (Siang & Foundation). The double Diamond method is chosen, while it exhibits a divergent and convergent process of exploring design challenge more widely or deeply (Heffernan, 2017) (Council, 2019). IS-DC defines the social and cognitive perspective of the group divergent and convergent process during Game design phases(Parraguez & Cuppens, 2019). Lego Serious Game helps to unleash player capital by the means of conceptualisation and prototyping (Group, 2020).

The GTS design process model supports players to create the concept, which represents a desirable, feasible and viable envisioned solution. The concept contains the information of three system-detail levels and six system design dimensions of the envisioned solution. Consequently, players take ownership of the collaboratively produced concepts and use them as a communication tool for further discussion and questioning (Mosterd, 2016, 2018; Mostert, 2016). Concepts are created through the four-phased process.

Understand phase - to explore and support players to discover what the design challenge is. Additionally, players share their interests and expectations, perspectives, worldviews and knowledge to frame design question(s). Last, they define and scope the concept creation process in the following Create phase. Before the creation of the concept, players define:

1. Why should the envisioned solution exist and what is its meaning?
2. Who is involved during the concept creation and what are their roles?

Create phase – to facilitate players building and testing conceptual designs of the envisioned solution through the set of Game steps. Moreover, question the player's design rationale and their perspectives. The created concept captures the information describing:

1. What is the location of the envisioned solution and how is it connected to the surroundings?
2. How does it work and what are its functionalities?
3. What are its entities and the relationships between them?
4. What social, environmental and economic value would it create?
5. How do cultural and political factors influence it?

Verify and Validate phase - to check and evaluate if the solution is aligned with predetermined requirements and expectations of the players, as well as if it satisfies the needs of the future customers. The concept desirability, feasibility and viability are questioned:

1. Does it solve a customer problem and is it desired by the customer?
2. Can we do it, is it possible?
3. Should we do it, will it be successful?

Reflect phase – to carry out retrospection of actions happened and lesson learned through the GTS, as well as to define the next development steps.

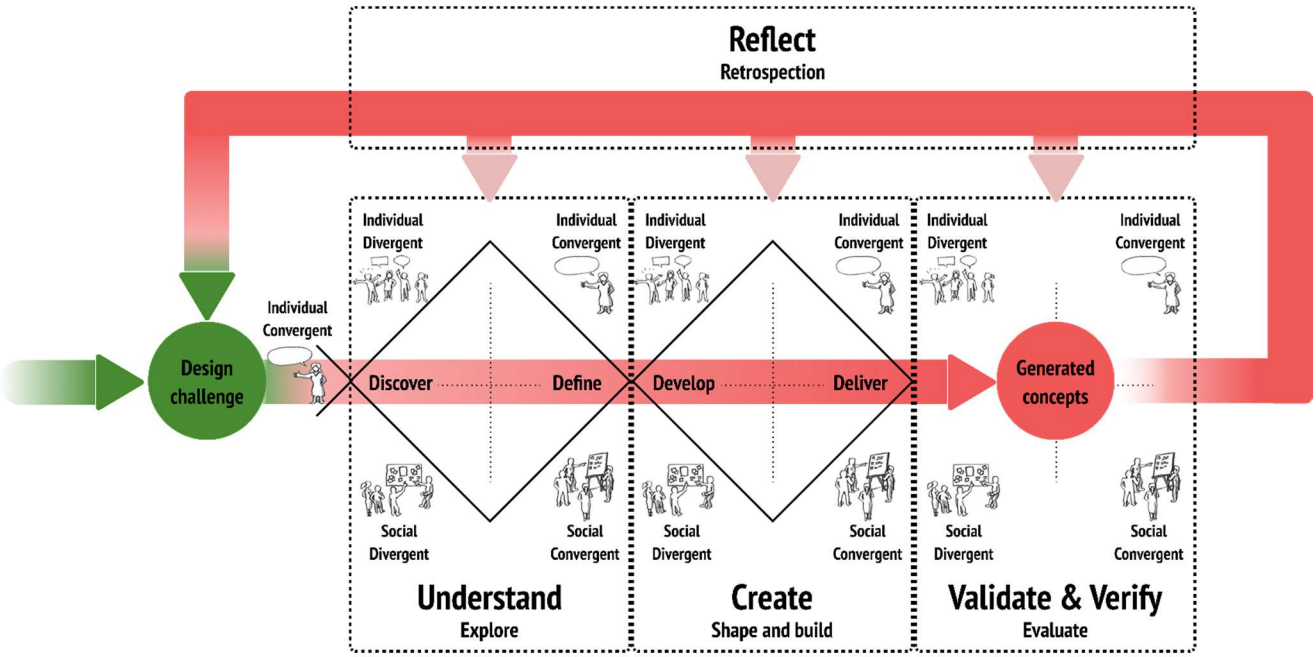


Figure 12: GTS design process model

In the Understand, Create, Validate and Verify phase, player transition through all four stages of IS-DC group dynamics model and connect individual ideas to the common concept:

1. Individual convergent thinking - players think for themselves, share their point of view and contribute their interest and to the group
2. Individual divergent thinking - players individually explore new possibilities, come up with additional ideas, construct individual concepts and give their meaning to them
3. Social divergent thinking – players share the design rationale of those individual perspective-defined concepts by using metaphors, search for connections between them and collectively create new concepts upon the diversity of other ideas
4. Social convergent thinking - players create a common concept and socially connect, which further spark group creative thinking and identification for new connections between concepts

6.4 Design methods

GTS players use visual-verbal language to express their ideas and thoughts in a form of the visual conceptual designs. The design applies verbal and visual language through the utilization of words, images and shapes (Figure 13) (Horn, 2020).

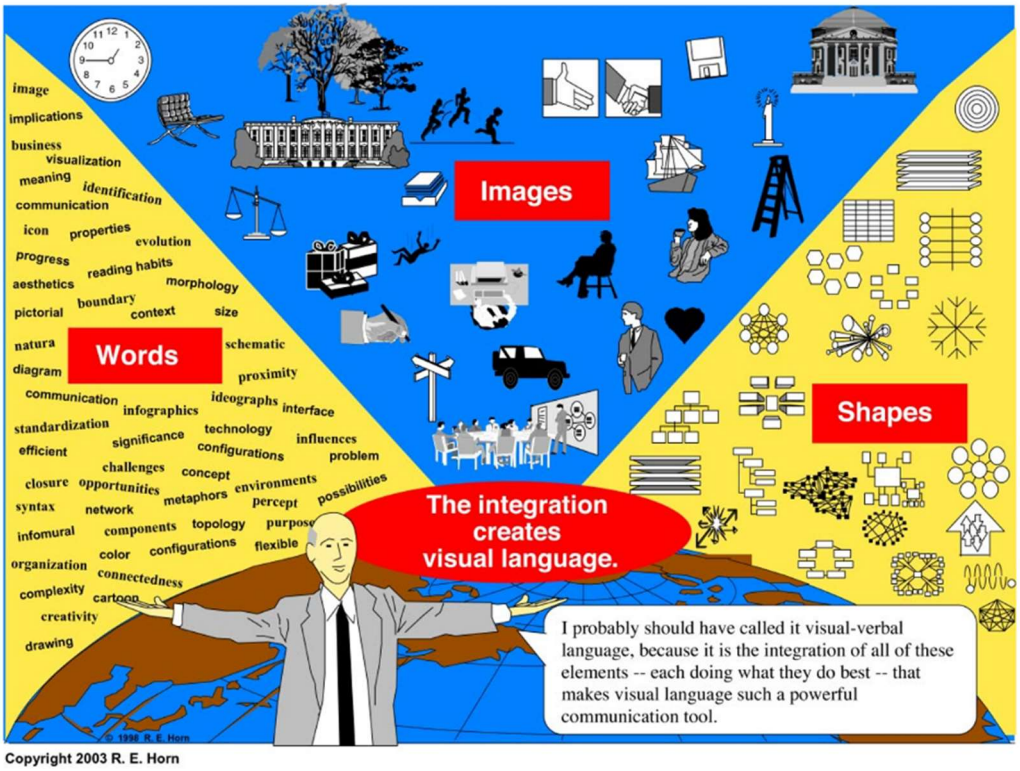


Figure 13: Visual and verbal elements of the design

Spoken verbal language is applied by players to present their ideas and concepts to fellow players, and question others. Written verbal language is utilized to create and capture design information into paper form. Visual language is used to translate and represent a substantial amount of design rationale information, produced by spoken and written verbal language, into visualized concepts by using shapes, icons and keywords. Five design methods are applied to facilitate GTS visual-verbal communication, namely visual imagination, drawing and sketching, physical prototyping, digital prototyping and the “wrong” model method.

6.4.1 Visual imagination

In the words of Albert Einstein, all meaningful and lasting change starts first in your imagination and then works its way out. Imagination is more important than knowledge. Therefore, visual imagination is facilitated to help players to imagine solutions on a defined design challenge.

Players are asked to close eyes and are given questions by the facilitator, which leads them through the process of gradually building a visual image of the envisioned solution in their brain (Costandi, 2016).

Visual imagination is facilitated around three main questions to stimulate the imagination of the envisioned solutions:

- How does it look? What feelings and emotions are engaged?
- How does it work and functions? What is needed for that?
- How is it positioned in the environment and how does it interact?

By tapping into player emotional topics, and asking them for their hopes, dreams, fears and frustrations reveals the system of their latent wishes, obstacles and envisioned solutions (Ramakrishnan, 2017). To support that process, WOOP tool is applied because it provides a structured approach to find and expose connections between those and support creation of new solutions (Salzgeber, 2016). It combines methods of mental contrasting and implementation intention:

1. Wish – players choose a challenging, compelling, and realistic goal they want to accomplish during the GTS
2. Outcome – players define desired outcomes of the GTS and define how would they feel if they achieve the goal
3. Obstacles – players definite personal, organizational and environmental obstacles which prevent them from achieving the goal
4. Plan – players define the actions, which will help to overcome the obstacles

By helping players to ground their positive fantasies to greedy reality, unfeasible or uncostly wishes are identified, reconciled and/or let go. Additionally, the concept creation process is stimulated by facilitating players to imagine perceived problem or obstacles, which causes a natural response of the human brain to find a solution. Moreover, the set of newly imagined solutions expands the player's creative boundaries. Due to that fact, players become more perceptible to other ideas (Chowdhury, 2020; Duckworth, Kirby, & Gollwitzer, 2013; Santos, 2019a).

6.4.2 Drawing and sketching

Paper drawing and sketching support players to visualise ideas and thoughts, thus explore design directions or respond to unforeseen actions during the creative process. It precedes oral language by making thoughts visible and giving imagination tangible form. It gives a voice to the unspoken, allowing players to explore, discover and experiment in a safe environment even before they can attach words and meanings to the sketches(Howe, 2015).

Players make drawings and sketches by apply elements of visual language, which are icons, shapes, images (Sjauw, 2019). This allows them to organize their thoughts, remember them and improve the ability to think and communicate complex or potentially confusing information (Gray, 2019). Furthermore, drawing and sketching represent a social experience, essential to building the social connection between players and share ideas to create concepts during the GTS (Howe, 2015).

6.4.3 Physical prototyping

Physical prototyping with objects provides a hands-on-way to explore, discover and understand the physical world by using five human senses, especially in game-driven

setting(Howe, 2019). Moreover, the player comes across new insights and obstacles that they did not discover in a flat drawing. This especially helps player defining concept functionalities and its interaction with the environment, because tangible 3D models possess more defined space dimension compared to drawing and sketching(Sjauw, 2019). It gives the freedom to the player to intuitively create tangible concepts and see immediate consequences. The immediate results intrinsically motivate players by giving them the feeling of achievement and progress during the creation process. Additionally, kinaesthetic activity during physical prototyping improves a player's concentration, choice-making, problem-solving, evaluating, reworking and persistence(Howe, 2015).

6.4.4 Digital prototyping

Alternatively, digital prototyping provides a way to construct 3D digital designs by applying digital design tools. Compared to the physical prototyping, digital prototyping allows less intuitive interactivity and has a slower learning curve, but provides a wide array of functionalities for a designer to produce high-quality designs. This is proven by conducted experiment to examine participant's interaction and operations skill of used physical and digital design tools (Appendix C). Digital prototyping allows the player to enhance physical prototypes by inserting, connecting, updating and deleting digital words, icons and shapes (Horn, 2020; Michiel Prins, 2019).

6.4.5 The "wrong" model method

The "wrong" model method is designed, to explore the GTS design challenge and analyse current solutions of the GTS design challenge to increase understanding of the design challenge and accelerate finding better solutions. Consequently, it stimulates the discussion about the looks, function and interacts of the envisioned solution, captured in the "right" model. The "wrong" model is a simple 3D model in the AR application, representing current or possible solution on the existing Game design change. This method engages three human cognitive processes(Frederiks, 2016):

1. prospective thinking with future-oriented imagination
2. counterfactual thinking with imagination geared to finding alternatives
3. perspective-taking by mentally changing the viewing lens

Players apply prospective thinking to extrapolate the past and present state of the analysed "wrong" model into the future and create potential futures. This gives the player a higher understanding of what would be the consequence of that specific scenario or the future (Garcia, 2019). By understanding that, the "wrong" model is explored and analysed, to define its necessary changes to achieve the envisioned solution.

To stimulate finding alternatives to envisioned solutions, players utilize counterfactual thinking to question if certain factors of the design challenge would be different. By interacting and changing the "wrong" model, they broaden their perception towards the design challenge and spark creation process.

Perspective taking is applied to investigate and discuss the "wrong" model upon six concept perspectives, namely **social, environmental, economic, technical, cultural and political dimension.**

6.5 Design tools and technologies

The research of the GTS design tool and technology trends showed that games are leaning towards video gaming and merge of real with the virtual world on one hand, as well as participatory culture and social networking on the other (LISA, 2020). Due to that fact, an idea to combine physical and digital design tools was born. To validate it, an experiment with participant and facilitators was conducted to examine how they perceive and use different physical and digital design tools to support their process of imagination, ideation and conceptualization (Appendix D). It showed they are interested in trying new digital technologies for designing, but they are often perceived impractical, not intuitive enough and it often takes too much time to learn them. During the experiment observation, it has been seen that physical design tools are still more intuitive and easy to use for short and simple ideation and conceptualization. Its utilization of building a tangible concept is more fulfilling compared to "artificial" satisfaction from digital production(Reisinger, 2018). However, digital design tools are beneficial when more information-rich and diverse concepts are desired. Digital design tool becomes effective when users are acquainted with its functionalities and obtain skills to operate with it. In the context of the advanced and intuitive digital design tools, application of virtual reality (VR) and augmented reality (AR) has been identified as the most prominent (Ammerlaan, 2020; Damgrave, 2018). Both applications reproduce potential reality that enables users to experience, modify and to interact with it. This helps then to communicate their visualized thoughts and opinions more effectively and lead to higher understanding. However, the application of AR is chosen, because compared to the VR, it blurs the reality and virtuality continuum, and thus keeps the connection between players, physical and digital world.

Upon the conclusions of the research and analysis, a combination of physical and digital AR design tools is chosen for GTS. The combination of using physical design tools, to which people can easily relate to, and immersive augmented reality (AR) design tools, brings unusual and substantially different conceptualization and prototyping experience in the mixed reality environment (Baha, Lu, Brombacher, & van Mensvoort, 2012; Dam, 2020). Consequently, players are able to:

- *Intuitively build physical concept with familiar physical design tools*
- *Enhance it with AR design tools and gradually transition to more digital concept*
- *Communicate its ideas simple and fast, and socially connect with others*

Conclusions are further elaborated in the paragraphs physical and digital design tools.

6.5.1 Physical design tools

Three physical design tools are applied in the GTS for concept creation, and two for capturing design rationale and scoping concept creation. Physical design tools for concept creation represent an intuitive way for players to express their ideas and imaginations into a physical world which provoke further discussion, problem-solving and collaboration (Howe, 2019; Mooij, 2019):

1. Sticky notes and paper – to explore and express ideas by the means of drawing and sketching
2. Lego blocks – to explore and express ideas by the means of physical prototyping with tangible blocks
3. Icon stickers – to enhance physical concept created by drawing, sketching and physical prototyping with icons, symbols and emoji's stickers

Sticky notes and paper are selected because they are well known by players and facilitators, and their application (size, number of elements, shape) can be easily adjusted to the GTS needs. Second, Lego blocks are chosen due to their recognized nature to express and visualize ideas into physical prototypes fast and intuitively. Additionally, its application stimulates the player's creativity, problem-solving and imagination (LISA, 2020). Third, icon stickers are used because they are easy to apply to sticky notes, paper and Lego blocks by the means of sticking them on the surface, and represent rich-information in a simple form.

Two physical design tools are designed and applied in the GTS, for capturing design rationale and scoping concept creation. They are defined as the Game canvases, for which first allows players to note and insert design rationale on the canvas, and thus organise their ideas and thoughts during the concept creation. This avoids players to be overloaded with design rationale information, which leads to decreased decision making and loss of focus (Ely, 2017; Mosterd, 2020). However, the second provides a tool for scoping the creation process and reflecting during this process.

6.5.2 Digital design tools

Digital AR application provides a way to enhance the real world with an extra layer of virtual objects and allows sophisticated intuitive interaction with the real world (Ammerlaan, 2020; Damgrave, 2018). AR application allows players to express their ideas and create concepts by applying three different types of virtual objects:

1. Keywords – to insert additional descriptions and ideas to the mixed reality concept
2. Digital icons – to enhance mixed reality concept with icons, symbols and emoji's
3. Digital 3D blocks – to explore and express ideas by the means of digital prototyping with digital blocks

Keywords are chosen because stimulate players to express their ideas and thoughts simply and concisely, and thus not oversaturate the concept. Too immersive concepts can be overwhelming for the user and give an unpleasant user experience (Digishape, 2020). Second, digital icons are used, because they are recognized as the most important digital visual-verbal language elements for expressing ideas and stimulating ideas(Zavrnik, 2020a). Third, digital 3D blocks are applied due to its simple form, which provides a wide variety and flexibility of creating and modifying spacious elements required for player's imagination of the concept.

7.Game the System concept

GTS concept is constructed upon the conclusions of chapter 3, 4, 5 and 6 (Figure 14). The concept is divided into the World of Reality, World of Meaning and World of Play, corresponding to the Triadic Game design method applied for the GTS design. This concept represents one collective reference to lead the GTS design process.

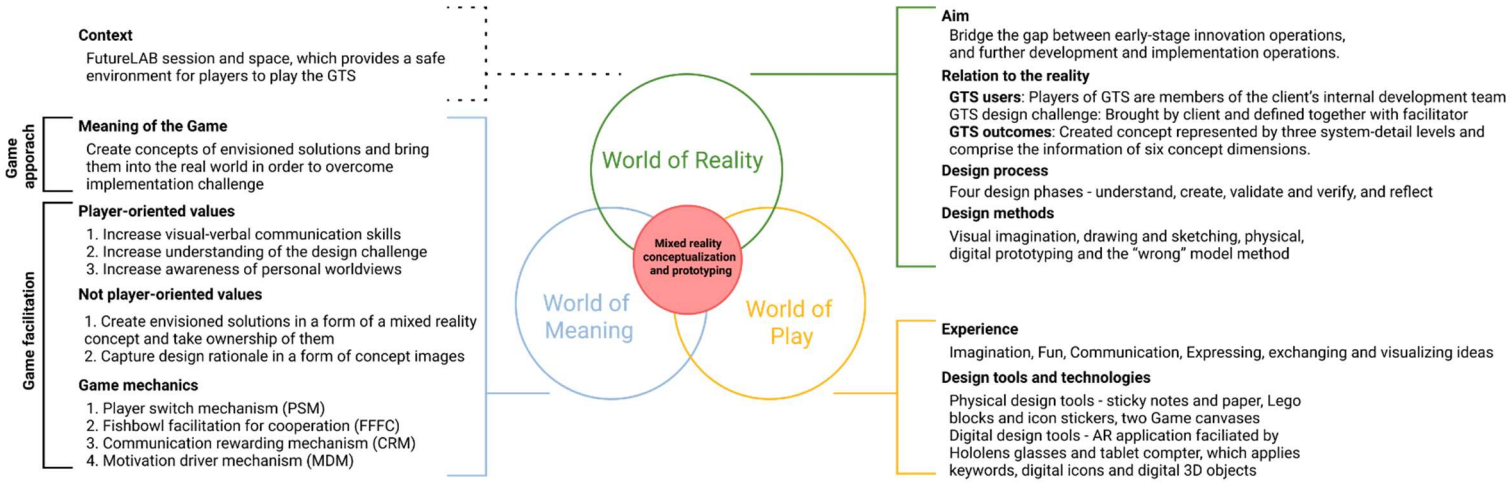


Figure 14: GTS concept

Aim: The methodology, which bridges the gap between early-stage innovation operations, and further development and implementation operations in the context of FutureLAB.

Context: FutureLAB session and space, which provides a safe environment for players to play the GTS.

Experience: Imagination, fun, communication, expressing, exchanging and visualizing ideas.

Outcomes: Created concept represented by three system-detail levels and comprise the information of six concept dimensions.

Users: Client provides the information about the vision of the innovation project and GTS design challenge. However, the facilitator is in charge to guide players and session participants through the GTS design process. Players are responsible to produce concepts during the GTS and bring them into the next development steps.

Game facilitation: The facilitation of players in a safe, mixed reality GTS environment stimulates the communication, building social connections and increase awareness of their perspectives. This sparks player's creativity and collaboration that leads to the creation of more coherent conceptual designs. To achieve that, PSM, FFFC, CRM and MDM are applied as the Game mechanisms to motivate and stimulate players to stay engaged in the GTS creation

process. Moreover, to obtain the feeling of achievement and progression, empowerment, social cohesion and take ownership of the produced concepts. Players increase their visual-verbal communication skills by expressing, visualizing and sharing their ideas and thoughts in the form of mixed reality concepts. Additionally, they increase understanding of the design challenge by exploring the "wrong" model and capture design rationale in the form of taken concept images.

Design process: Players through four design phases called Understand, Create, Validate and Verify, and Reflect, generated conceptual designs upon the design challenge:

1. Understand phase - players explore of the design challenge, frame design questions and scope the concept creation process
2. Create phase – to build conceptual designs of the envisioned solutions through the set of Game steps and question their design rationale
3. Verify and Validate phase - to evaluate concept desirability, feasibility and viability
4. Reflect – to carry out retrospection of actions happened and lesson learned through the GTS

Design methods: Five design methods are applied to facilitate GTS visual-verbal communication, namely visual imagination, drawing and sketching, physical prototyping, digital prototyping and the "wrong" model method. First, visual imagination stimulates player's imagination to construct envisioned solution in their heads. Second, drawing and sketching makes thoughts visible and gives imagination tangible form. Third, physical prototyping a hands-on-way to explore, discover and understand the physical world by using five human senses and intuitively create tangible concepts. Fourth, digital prototyping enhances physical prototypes by inserting, connecting, updating and deleting digital words, icons and shapes. Last, the "wrong" model method helps to explore the GTS design challenge, analyse current solutions of the GTS design challenge to increase understanding of the design challenge and accelerate finding better solutions.

Design tools and technologies: The combination of using physical design tools, to which people can easily relate to, and immersive augmented reality (AR) design tools, brings unusual and substantially different conceptualization and prototyping experience in the mixed reality environment. Three physical design tools for tangible concept creation are sticky notes and paper, Lego blocks and icon stickers. Moreover, two physical Game canvases are designed and applied for capturing design rationale during concept creation. However, the AR application facilitated by AR Hololens glasses and tablet computer represents a digital design tool. It applies keywords, digital icons and digital 3D objects to create a digital layer of the concepts.

Game approach: Triadic game design is applied to design a game methodology, which facilitates digital, creative and collaborative play happening inside the same room using physical objects, is perceived meaningful by players and owns the connection to the real world. Consequently, give players a tool to create concepts of envisioned solutions and bring them into the real world to overcome the Implementation challenge.

7.1 Requirements list

Upon the Game the System concept, requirements list is created to design GTS accordingly to the GTS concept and evaluate it after the application and demonstration.

1. A safe, inclusive and playful game environment which rewards;
   a. active listening and questioning other's ideas and perspectives
   b. sharing stories of imagined solutions and building upon each other's ideas
   c. non-judgemental, transparent and effective communication
2. Intuitive and easy to learn design tools, which allow a team of multidisciplinary players to express their ideas in the mixed reality environment
3. Simple gameplay with immediate feedback, which allows players to explore and create concepts
4. Sufficient time and space for players to reflect, celebrate take ownership upon the produced concepts
5. The produced concepts are represented in three system-detail levels and comprise information of six concept dimensions
6. Capture and use concept's design information as a communication tool to convince management team to invest in further development

7. A flexible Game functional model which allows:
   a. application of design challenges from different domains, besides construction and urban planning
   b. facilitator to apply its own facilitation methods
   c. players preferred way of gameplay and the suitable type of design tools

PART 3: Design of the Game the System

In the third part, the Game the System concept and supporting requirements are used to steer the GTS design process. First, three worlds of the GTS are described individually and then connected into integrated GTS design. This design is applied and evaluated in part 4.

In chapter 8, first, the World of Reality is described, explaining the relations of the GTS to the reality and its functionalities. Second, World of Meaning provides information about Game strategy, mechanisms and plan to provide the value for the players and the client. Third, the World of Play defines how GTS is played, which design tools, technologies are used, and how the gameworld is created.

In chapter 9, the elements of the three world are integrated into the GTS design, which represents methodology, which provides a collaborative and fun approach to construct imagined concepts in a mixed reality environment to overcome the Implementation challenge in the FutureLAB. To support facilitators executing the methodology systematically, the player journey map is designed and elaborated for each step.

8. Triadic Game the System design

Chapter 8 describes three worlds of the GTS, the World of Reality, World of Meaning and World of Play by applying Triadic Game Design principle (Harteveld, 2011). Those together define elements of the GTS methodology to facilitate digital, creative and collaborative play happening inside the same room using physical objects.

8.1 The World of Reality

Representations of the real world in the GTS are made to illustrate, clarify and experiment with possible concepts and futures constructed during the gameplay (Harteveld, 2011). Those consist of physical elements and augmented elements. It is crucial to understand that while those representations are linked to the real world, they are not the real world itself. Their interpretation of reality inside the GTS is described as the Model of Reality. Two models of reality help players to explore and construct concepts inside the safe GTS environment and translate those into the real world. Those are constructed upon the “wrong” model method.

8.1.1 Game purpose

Game purpose is defined upon the aim defined in the GTS concept. Its purpose is to facilitate social play and collaboration between multidisciplinary teams to create imagined concepts in a mixed reality environment. Infrastructure and urban planning are chosen as the application domain.

8.1.2 Relation to the reality

Users of the GTS are members of the internal development team, which represents a multidisciplinary team of players owning different perspectives, roles and pains during the development process. Second, the client brings the vision of the innovation project into the GTS, upon which GTS design challenge is defined together with the facilitator. Third, created concept represent GTS outcomes, which consist of three system-detail levels and comprise the information of social, environmental, economic, technical, cultural and political dimension of the concept.

8.1.3 Game functional model

Ten core Game functions are designed upon the first four requirements from the requirements list.

1. Imagine envisioned solutions
2. Explore the Game environment and functionalities
3. Express individual ideas
4. Connect individual ideas
5. Question the player perspectives

6. Collaboratively (re)build the model
7. Question the model
8. Involve external session participants
9. Capture the image of the concept
10. Pitch the model

Those Game functions are integrated into the Game functional model, designed based on GTS design process model, design methods, and design tools and technologies. In the process of players through four phases, they (Figure 15):

1. Understand phase
    a. share individual worldviews and questions upon their intentions and expectations towards the Game
    b. question the design challenge and share their wishes and envisioned outcomes
    c. individually imagine possible solutions and use storytelling to communicate them
    d. walk-through, explore and interact with the "wrong" model in the mixed reality environment to increase understanding of the design challenge and identify other wishes
2. Create phase
    a. scope the creation process and define development direction
    b. iteratively produce physical prototypes of a concept, enhance it with the AR layer and compare it to the predefined scope
    c. involve external session participants to capture their insights and question concerning the created concept
    d. capture the image of the concept
3. Validate and Verify phase
    a. pitch the concepts to the session participants
    b. capture their feedback and rebuild the concept
4. Reflect phase
    a. give the main pitch of the concept to the management team
    b. reflect upon the Game process and celebrate its success

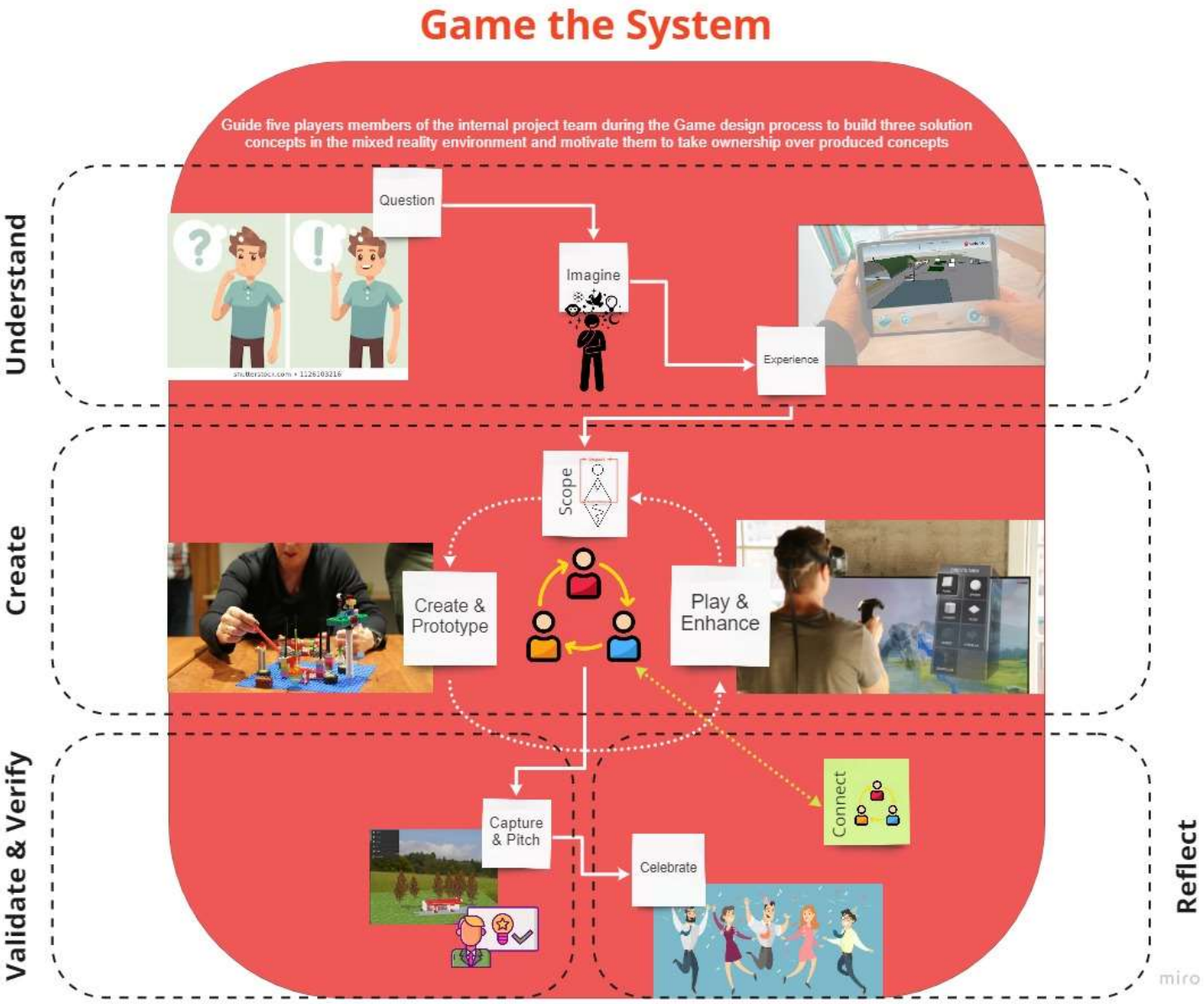


Figure 15: Game the System functional model

The produced concepts represent the outcomes of the GTS and are used as a communication tool to transfer key concept information to the management team about the envisioned infrastructure or urban plan and convince them to invest in further development.

However, the flexibility of the functional model allows GTS to adapt to the inputs and environmental factors. This can be achieved by (1) changing the layout of the four Game design stages or time dedicated to a specific stage, (2) changing the set of players and/or (3) using different design facilitation methods during the Create phase (Table 2).

Game is able to	In order to	By	Results
Adapt to different domains of design challenges besides infrastructure and urban planning	Tackle other social design challenges	Using different gameboards, using other design tools, and building different "wrong" model	Versatile application of GTS
Adapt to different working methods of the facilitator	Motivate facilitator and give him/her a feeling of ownership	Using facilitators preferred design facilitation methods during the Create phase	Intrinsically motivated facilitators
Adapt to different types of player(s) gameplay and design tools they use	Allow self-initiated exploration and creation of concepts by players	Giving freedom to players and the possibility to choose its preferred design tools for exploring and creating concepts and give space to players to transition between their active and passive participation in the GTS	Self-actualized and more intrinsically motivated players(Maslow, 1970)
Create and evaluate concept from a social, technical, environmental, economic, cultural and political perspective	Integrate all perspective of the internal development team	Switching the set of players	Social cohesion and coherent concepts
Facilitate multiple iterations of the Game Create phase	Capture missed elements of the real world and allow players to translate them into the reiterated concept	Repeating the Create phase	Coherent concept

Table 2: Flexibility of the GTS functional model

The Game functional model provides a means to integrate physical and digital worlds into the mixed reality gameworld. Because players require more time to obtain skills to operate with digital AR application, compared to the physical design tools, AR application and its functionalities are introduced gradually during the GTS (Shum, 2018). Players transition from intuitively constructed physical concepts to enhanced mixed reality concept using AR design tools and last, to the final completely digital, 3D concepts presented in the AR gameworld.

8.1.1 Models of reality

Two models of reality exist in the gameworld. The "wrong" and the "right" model (Figure 16). The "wrong" model is used as a tool to stimulate discussion and argumentation over the represented AR concept and to identify how the "right" concept should not look, function and interact with the surrounding environment. The facilitator creates the "wrong" model by using GTS design tools or upload its file from 3D design software. Upon the gathered insights on how the concept should not look, function and interact from the exploration of the "wrong" model, players create the concept representing the "right" model.

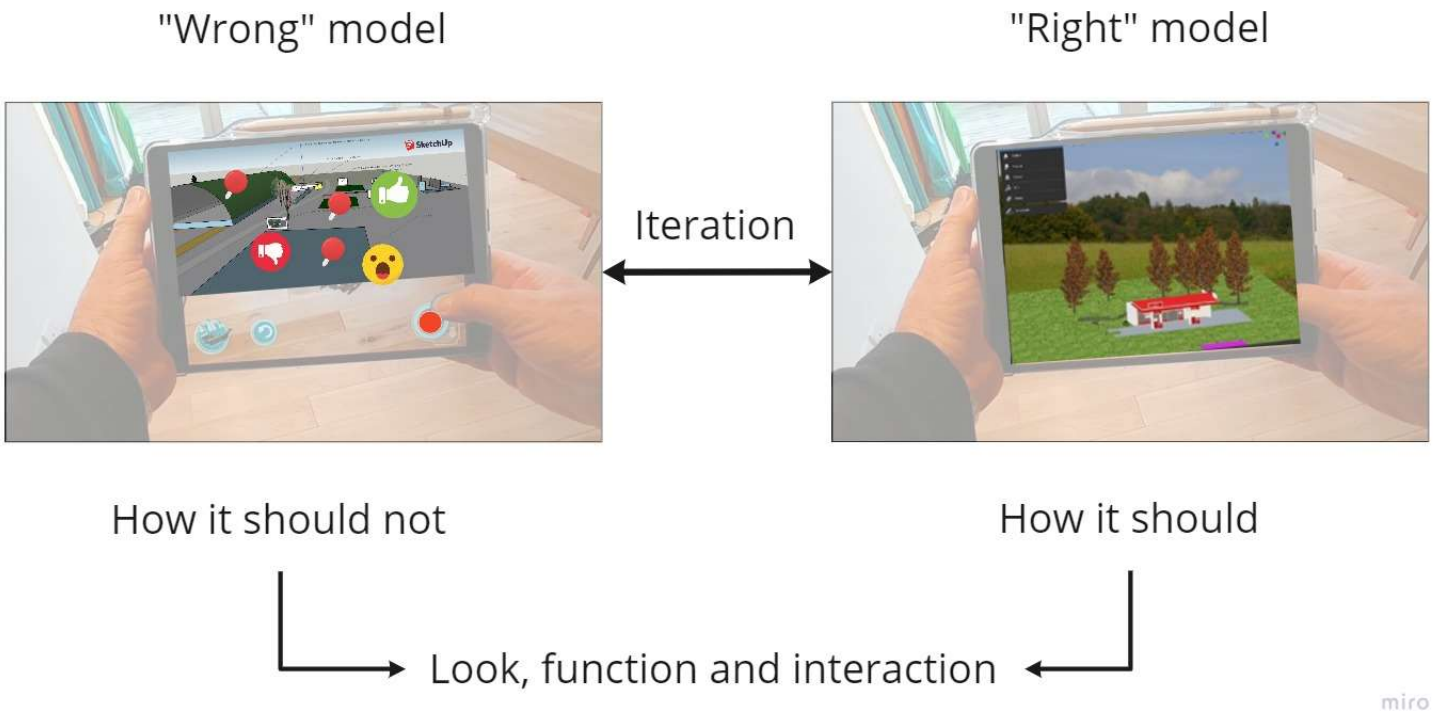


Figure 16: The "Wrong" and "right" model

In order to introduce AR design tool gradually, players first explore, walk-through and interact with the “wrong” model in a mixed reality environment. Afterwards, when players obtain the necessary skills to operate with AR glasses and the computer tablet, they insert emoji’s and keywords to input their ideas and thoughts. There are five types of emojis expressing the emotions of like, dislike, wow, happy and sad. When they become confident operating with AR application, they start inserting digital icons and digital 3D blocks.

8.2 The World of Meaning

For a player to be motivated to participate in the GTS, they need to see the meaning of it for him or herself. Upon the Game strategy, Game mechanisms and the Game plan is designed to deliver the proposed value.

8.2.1 Game meaning

The Game meaning is translated from initial meaning defined in the GTS concept. Therefore, GTS meaning is to support multidisciplinary teams to take ownership of produced concepts and overcome the Implementation challenge.

8.2.2 Game strategy

It has been proven that intrinsic motivation is more effective compared to extrinsic motivation when extracting value(Pink, 2009). Therefore, Game the System facilitates the gameworld in a way that players can express their ideas and build their concepts to obtain the feeling of empowerment, achievement, progression and ownership. This intrinsically motivates them to participate in the GTS and contribute with their ideas, information and knowledge to the created concept. However, CRM rewards players with points in case of effective communication. This represents extrinsic motivation driver for players to build social cohesion. Last, PSM is designed to switch players and session participants, and gradually includes session participants in the GTS. Thus, session participants share their insights and ideas with the players, and further question concepts created by players (Figure 17).

This is achieved by four-game ingredients described in chapter 8.3 – (1) Game goal which defines the purpose of the player playing the GTS. (2) Gameplay takes players through the (3) gameworld using different (4) Design tools and technologies to achieve the (1) Game goal.

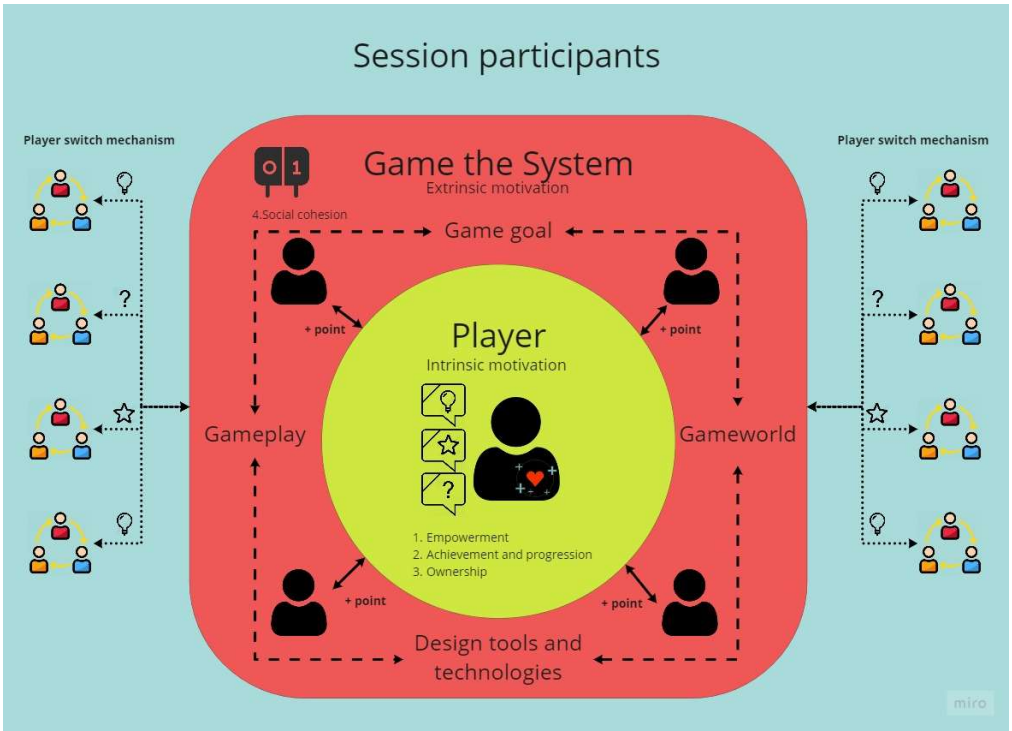


Figure 17: Game strategy model

8.2.3 Game mechanisms

The purpose of Game mechanisms is to promote desired actions of the player and guide them towards the Game goal. Four Game mechanisms are designed and applied:

1. Player switch mechanism (PSM)
2. Fishbowl facilitation for cooperation (FFFC)
3. Communication rewarding mechanism (CRM)
4. Motivation driver mechanism (MDM)

Player switch mechanism (PSM) is utilized to avoid two or more separate developments during the FutureLAB session. During the Create phase, one member of the session participants is switched with a player for 5 minutes. In this process, both individuals at the different groups question the produced concepts and share insights from its group. This is crucial, to capture the design rationale and insights of existing concept produced by the session participants and reapply them into newly create GTS concepts(Michel Prins, 2020). Consequently, it connects GTS with the FutureLAB session (Figure 18).

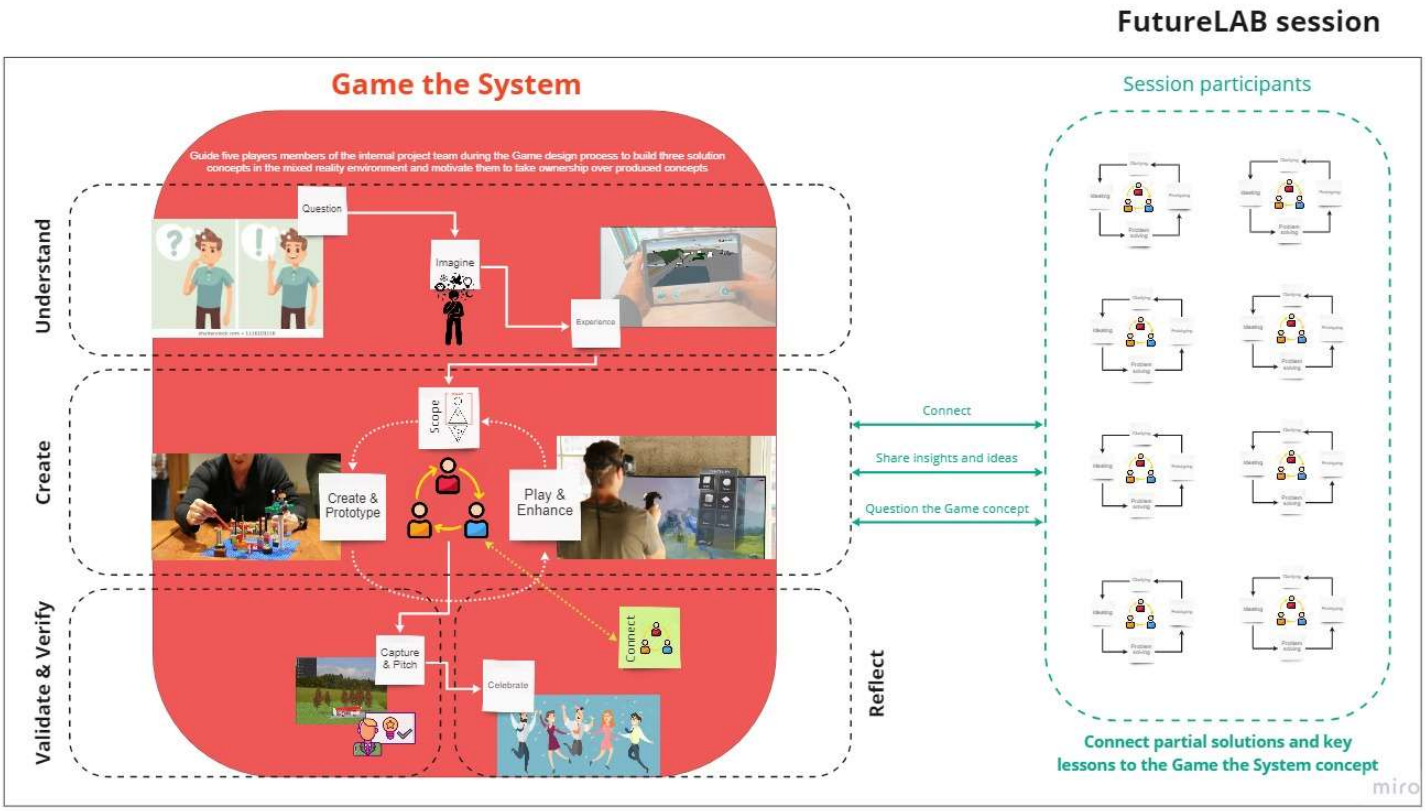


Figure 18: Player switch mechanism in the GTS

Fishbowl facilitation for cooperation (FFFC) is applied to give a choice to players when to participate actively and passively in the GTS (Wageningen). In the case of active player's participation, they are positioned as creators in the GTS inner circle, while session participants are placed in the GTS outer circle as passive participants (Figure 19). They are allowed to listen, observe and think in the outer circle. However, when they want to actively participate in the GTS and create concepts, they have the freedom to step to the Game table and continue the creative process. Thus, players have the opportunity to step out of the GTS, when they need time to rest, reflect or think for themselves in case of cognitive overload during the creation process (Harteveld, 2011). Moreover, this increases the probability to discover and produce new innovative ideas (Archibald, 2011; Shum, 2018) The transition between circles is additionally stimulated by Player switch mechanism (PSM).

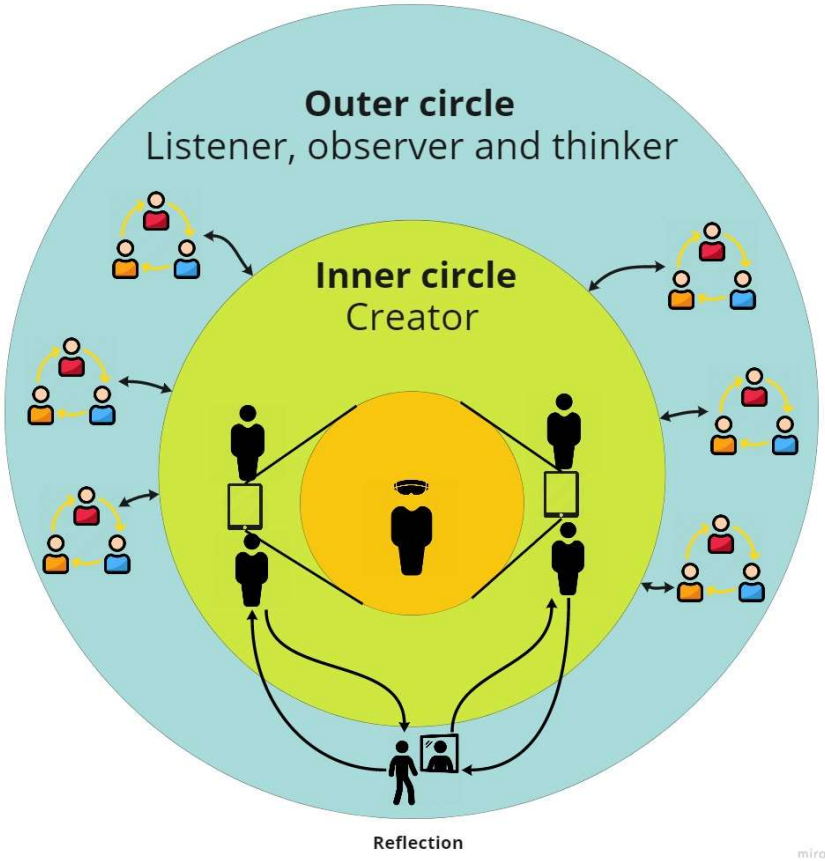


Figure 19: GTS fishbowl facilitation for cooperation

Communication rewarding mechanism (CRM) in the GTS is used to stimulate the player's communication and questioning. The facilitator plays the role of a judge, which is responsible for giving points to the players, while individual players have a responsibility to note those points on the Game scoreboard. Consequently, they as a team compete with the GTS to gather the points and celebrate team success. When all players together collect 1500 points, the GTS is stopped and FutureLAB lights in the area of the GTS turns red (Figure 20). The red colour initializes the celebration moment and symbolises excitement, energy, passion, action and love.

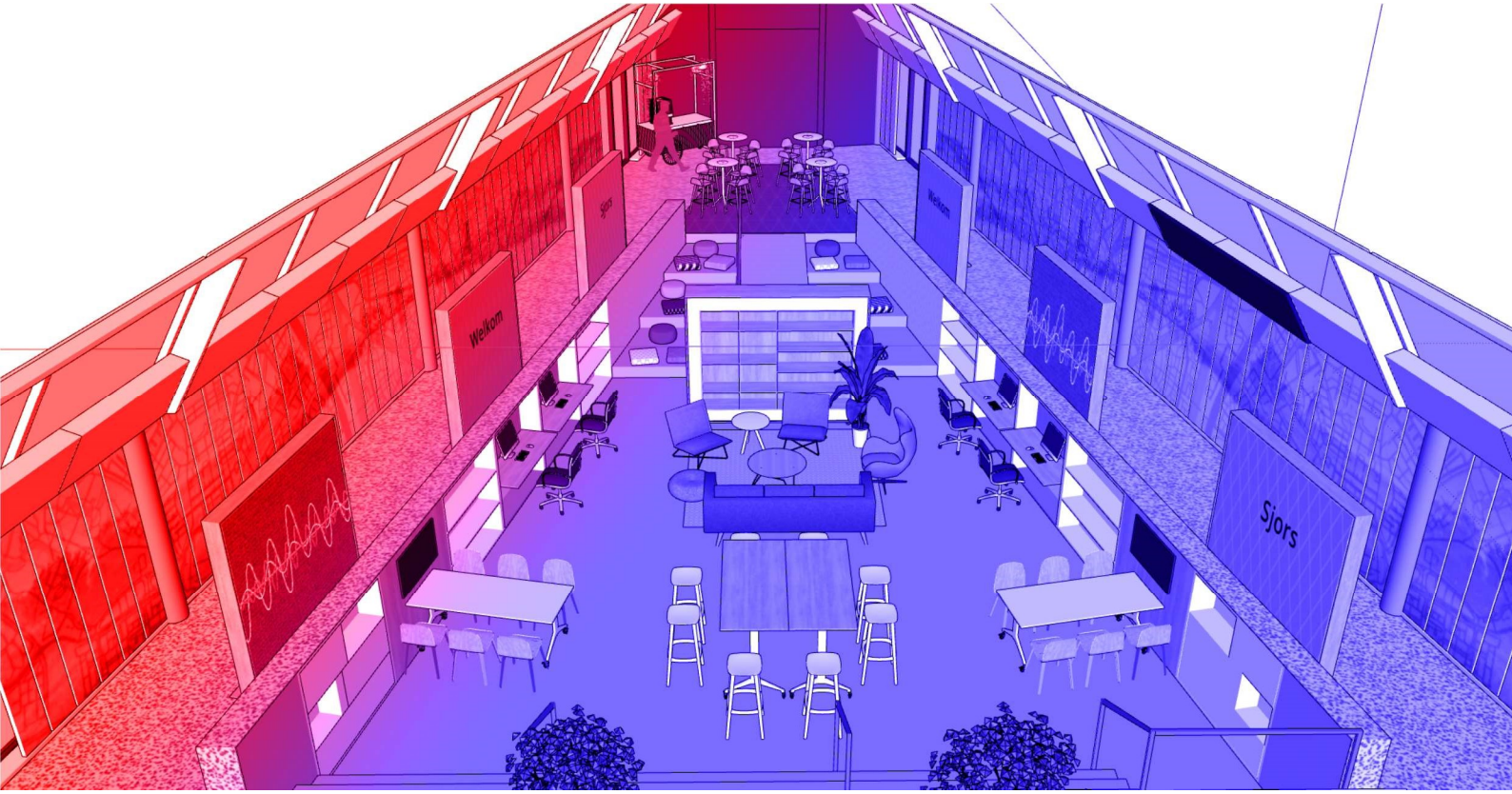


Figure 20: GTS celebration moment in the FutureLAB

1500 points are needed to initialize the GTS celebration moment. This is calculated by multiplying assumed 20 communication actions per players by 5 players and an average number of 17.5 points received by executing the action. The assumption of the number of communication actions is based on the observation of participants during the FutureLAB session. Especially during the ideation and prototyping phase, participants tend to not communicate and individually focus on the creation of concepts. Four communications actions are rewarded in the GTS (Table 3).

Rewarded communication action	Number of points per action per player
Share ideas, opinions and thoughts owned by the players	10
Connecting at least two different ideas, opinions and thoughts shared by the players	25
Questioning the concept and underlying rationale	10
Referencing fellow player for use and application of the information given by him or her	25

Table 3: Rewarded actions in the GTS

Those actions can be executed verbally by talking or visually by using GTS design tools and technologies. They are rewarded with game points during the GTS, which stimulates them to:

- Listen to each other that provides the feelings of value and importance to the player
- Accept and process other ideas and thoughts, constructed on the base of other player perceptions and beliefs, gives a player the feelings of acceptance and constructs social cohesion
- Increase understanding of different perspectives by discussing and connecting different ideas, which increases empathy of players and their acceptance of new ideas
- Build on each other ideas that bring an increased feeling of importance and social cohesion

Motivation driver mechanism (MDM) is employed to motivate players during the creation process. Social play and shared experience with other players at the same time by itself motivates them to participate in the GTS (LISA, 2020). However, four motivation drivers are integrated into the Game mechanism:

- Empowerment intrinsically motivates players by giving the safety and freedom to choose and apply the set of preferred design tools, construct its meaning of the GTS and define the type of their gameplay aligned with its interests. The freedom of gameplay is facilitated by Fishbowl facilitation for cooperation.
- Achievement and progression are achieved by two means, player mastery and concept evolution. Player mastery is reached by developing designing and communication skills by using intuitive mixed reality design tools. On the other side, seeing and experiencing the evolution of the concept during the creation process by itself is rewarding for the player. However, captured image compilations of evolving concepts are given players, which they can bring home to remember the GTS experience.
- Social cohesion is reached by Communication rewarding mechanism, which rewards social inclusivity, communication and connecting individual ideas. Additionally, Player switch mechanism is applied to accelerate the exchange of new ideas and questions concerning concepts. Consequently, players socially interact and build social connections, which gives them the feeling of importance, recognition, being listened to and a sense of belonging to the team.
- Taking ownership is accomplished by the means of all three motivation drivers. Players increase their commitment, responsibility and feeling of pride towards the project. This is achieved by obtaining mastery to express their idea, given autonomy of gameplay and freedom to define its purpose in cohesion with the entire player team, and lastly obtain the feeling of achievement and progression during concept creation.

The representation of the motivation driver's contribution to the Game goal and Game purpose is captured in the Motivation driver mechanism pyramid (Figure 21).

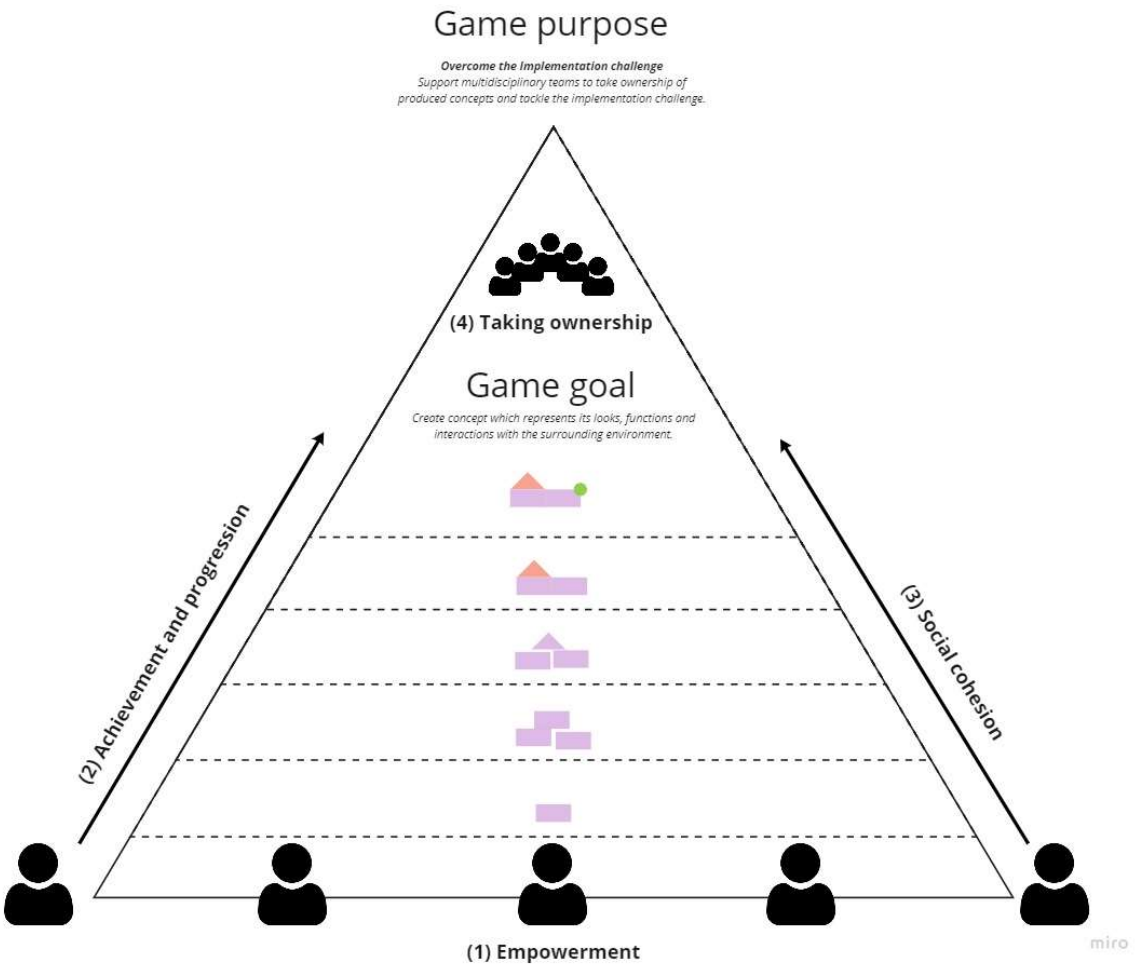


Figure 21: Motivation driver mechanism pyramid

In the process of GTS, individual players climb the pyramid towards the Game goal. First, players are (1) empowered through the mixed reality gameworld to express their ideas and see immediate results after the player's concept creation. This generates a feeling of (2) achievement and progression which releases endorphins and gives players the experience and feelings of fun, satisfaction and enthusiasm(Harteveld, 2011). Due to their positive feelings, they are more open to capture, (re)use and share ideas of other players. In this process of social interaction, they obtain a feeling of recognition, importance and connection to the team, which drives players towards (3) social cohesion. Because of all three motivation drivers, players create concepts and reach the Game goal. After seeing the created concepts and celebrating with the team, they obtain the feeling of proudness and joy. Consequently to all of these positive feelings, players take (4) ownership of their produced concept and commit to continue with further development and implementation steps.

8.2.4 Game plan

The Game plan is designed upon the Game strategy, which defines and integrates Motivation driver mechanisms, Game functions, its objectives and correlating design phases into one Game plan description (Table 3). However, the Game plan is created to visualize the Game plan description more coherently and understandably. It consists of six major functional transitions, which lead players from the design challenge to the Game goal (Figure 22).

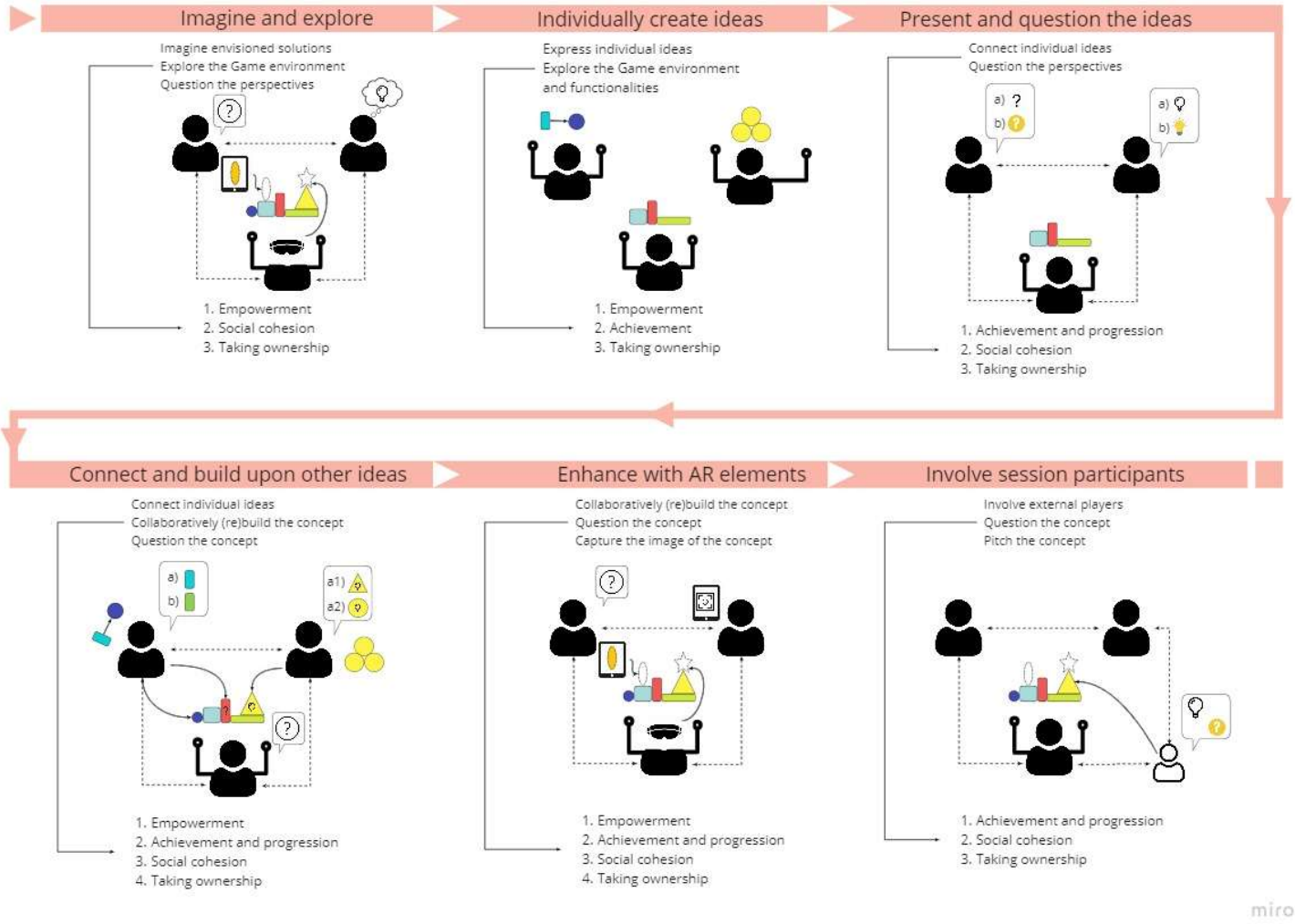


Figure 22: Game plan

Players (1) imagine solutions, explore the gameworld and question other player perspectives. Next, they (2) express and explore individual ideas, and transform those individual ideas and expressions into the form of physical prototypes. Third, players (3) present produced prototypes using storytelling and metaphors, and ask for other player perspectives. Through discussion and questioning the produced prototypes, player personal and domain-specific relationships and inter-dependencies are revealed. This leads to strengthening the social connection between players and initiates the process of taking ownership over their prototypes. Fourth, they (4) connect individual ideas and build upon each other ideas to build a tangible concept. Fifth, players together (5) enhance created concept with AR visual-verbal elements and capture the image of the mixed reality concept. Last, they (6) involve session participants to obtain their insights, ideas and questions concerning the concept and pitch it.

Design phase	Motivation driver	Game function	Description	Objective
Understand	Empowerment; Social cohesion; Taking ownership	Imagine envisioned solutions	The facilitator facilitates visual imagination to spark the player's imagination of the envisioned solution	Players create visual concepts of the envisioned solutions in their head and use storytelling to share with others
Understand	Empowerment; Social cohesion	Explore the Game environment and functionalities	The player applies AR glasses and tablet to interact with the "wrong" model	Get familiar with the AR tools, explore and interact with the "wrong" model to stimulate a discussion
Understand, Create	Empowerment; Accomplishment and progression; Taking ownership	Express individual ideas	The player builds concepts	Use physical and AR design tools to express their ideas in the form of concepts and prototypes
Understand, Create	Accomplishment and progression; Social cohesion; Taking ownership	Connect individual ideas	The player seeks connections between other players ideas in a mixed reality environment	Questioning, explaining and storytelling of ideas; Connecting concepts and building upon each other ideas
Understand, Create	Social cohesion	Question the perspectives	The player questions other player perspectives on the created concepts and the design challenge	Increased awareness of personal worldviews, reflection and empathy
Create	Empowerment; Accomplishment and progression; Social cohesion; Taking ownership	Collaboratively (re)build the concept	The player (re)builds the concept based on the team input in the mixed reality gameworld	Translating and visual expressing ideas and thoughts; Connecting concepts and build upon each other ideas
Understand, Create	Accomplishment and progression; Social cohesion	Question the concept	The player questions the model	Identify the design gaps, reflect upon created concepts
Create	Accomplishment and progression; Social cohesion; Taking ownership	Involve external players	Players involve other necessary session participants in the game	Obtain insights, ideas and questions from the session participants; Connect concepts and build upon each other ideas
Create, Validate and Verify	Accomplishment and progression; Social cohesion; Taking ownership	Capture the image of the concept	The player captures images of the produced concept with the AR application and produce image compilation	Capture design rationale in an image; Give players the feeling of progression by seeing image compilation; Give printed images to the player to take feelings from the GTS home
Validate and Verify, Reflect	Social cohesion; Taking ownership	Pitch the concept	Team of players represents the model to the management	Convey key information and convince the management team to invest in further developments

Table 4: Game plan description

8.2.5 Value proposal

Besides increased visual-verbal communication skills, understanding of the design challenge and awareness of their worldviews, which players obtain during the GTS, they receive three other values after the GTS in the FutureLAB:

- Empowered, personally proud and satisfied individual members of the team
- Engaged and motivated individuals taking ownership over their work and anticipating in the next development and implementation steps of the project
- Increased social cohesion between the team members

The value the client receives after the GTS in the FutureLAB:

- The motivated team which takes ownership over their work and committed to continue with development steps
- Concept pictures of the envisioned solution representing its looks, functions and interactions with the environment, to communicate concept key information with the management team

To measure the value of the GTS for players, the PARMA model of well-being and happiness with 23 questions is applied before and after the session (Butler & Kern, 2016; Santos, 2019b). It is chosen because it represents a validated approach to measure players positive emotions, engagement, relationship, meaning and achievement. Those can be translated into player values received after the GTS. The difference between the average score of all 23 measures before and after the GRS identifies the relative value for the players. It is assumed that the measure of engagement, meaning and achievement reflects the value and quality of the created concept.

8.3 The World of Play

The GTS is defined with four primary aspects. The aspects comprise the GTS Game goal, its gameplay, the gameworld and design tools and technologies, and last the gameworld. Those are interconnected and facilitated by game mechanisms and game rules.

8.3.1 Game goal

The Game goal is defined upon the GTS outcomes, described in GTS concept and conveys the information to the player what he or she should do during the GTS. The goal of the GTS is to create a concept that describes how the model in the real world should looks, functions and interacts with the surrounding environment.

8.3.2 Gameplay

The Gameplay defines the player's roles and interactions with the GTS. Those are characterized by the gameplay characteristics and facilitated by the game rule.

Gameplay characteristics of the GTS are described by combining gameplay elements of simulation, strategy, action and adventure games (Harteveld, 2011):

- Close to reality: realistic representation of the real world using a minimalistic design of 3D shapes, icons and keywords
- No story: players produce scenarios and stories by its interpretation of the GTS and imagination
- Free-form and open-ended: players choose their preferred physical and/or AR design tools to express their ideas and define their sub-goals of the GTS
- Isometric perspective: diagonally bird's eye perspective to give a good overview of the game which provides tangible objects-of-discussions
- Resources: Limited amount of object to create a concept is given to the team of players, to not overload the concept with information
- Time restriction: 90 min
- Score: a scoreboard indicates the progress of the team
- Setting: players walk-through the "wrong" model to input their ideas and opinions by inserting emoji's and keywords
- Point-and-Click: players interact with the game by pointing, grabbing, dropping and moving the elements in a mixed reality environment using AR glasses and tablet computer

Interactivity, a cyclic process between two or more active agents, is an important factor for integrating gameplay characteristics effectively into the Gameplay. GTS interactivity is divided into four interaction stream (Figure 23).

- Player-to-player interaction
- Player-to-participants interaction
- Player-to-AR design tool interaction
- Player-to-physical design tool interaction

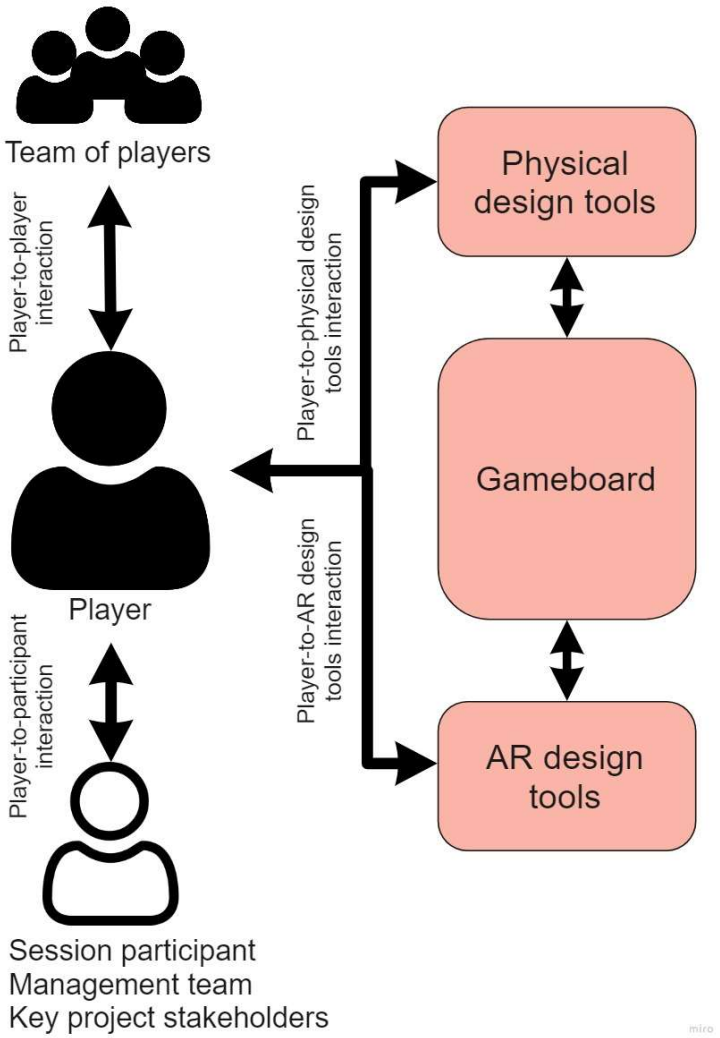


Figure 23: GTS interactivity

During the player-to-player and player–to-participant interaction, players use verbal communication to question, listen actively and present ideas and thoughts. The player-to-AR design tool interaction is provided by the AR application interface. Through the interface, players visually construct digital prototypes by inserting keywords, drag & drop digital 3D objects and digital icons found in the AR library of elements. Last, player-to-physical design tools interaction allows creation by the means of drawing and sketching on sticky notes and paper, as well as building physical prototypes using Lego blocks and icon stickers. Additionally, two canvases are used to support players using physical design tools.

Player roles are used in the Game to convert members of the internal development team to players with specific responsibility inside the Game. Players are allowed to choose their preferred role, which doesn't need to match their function in the real world. By giving this possibility, it contributes to the player empowerment. Four roles are connector, thinker, constructor and collector (Figure 24):

1. A connector is responsible for checking the player's energy during the GTS and making social connections between people
2. A thinker is responsible for observing, analysing and stimulating discussion by giving its opinion and questioning
3. A collector is responsible to keep on time, check if the team is aligned with scope and collects the outcomes of the Game
4. A constructor is responsible to take the lead in the production of the concept

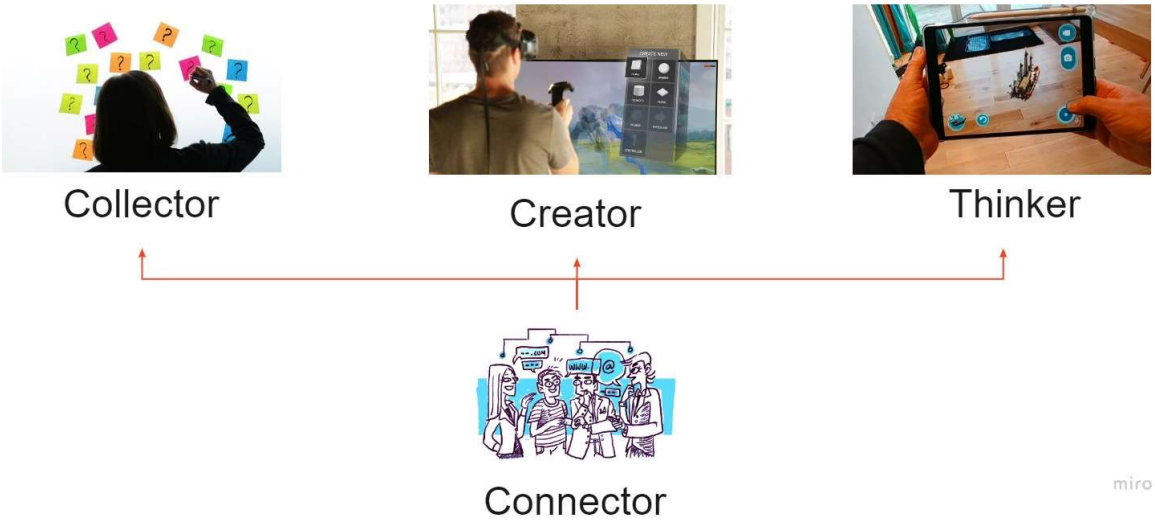


Figure 24: Four-player roles

The Game rule is utilized to empower players and give them the option to create concepts aligned with their interests, wishes, perceptions and beliefs. To achieve that and not design a complex set of rules, which would present another challenge for the gameplay, only one game rule is defined. The entire team of players is allowed to use only a hundred tangible and augmented building elements. Thus, the players become aware and critical which and how many elements are required to build the concept. Players bring this game lesson bring back to reality i.e. to *be responsible for their actions, while each action has a consequence on the surroundings*. Secondly, players are stimulated to construct ideas simply and concisely. This avoids unclear and information overwhelming concepts.

8.3.1 Design tools and technologies

Combination of physical and digital AR design tools is used by players to create in the GTS gameworld (Figure 25). Those design tools allow players to express their ideas by the means of three types of visual-verbal languages, i.e. shapes, icons and words. However, two Game canvases are designed to capture design rationale and scope concept creation.

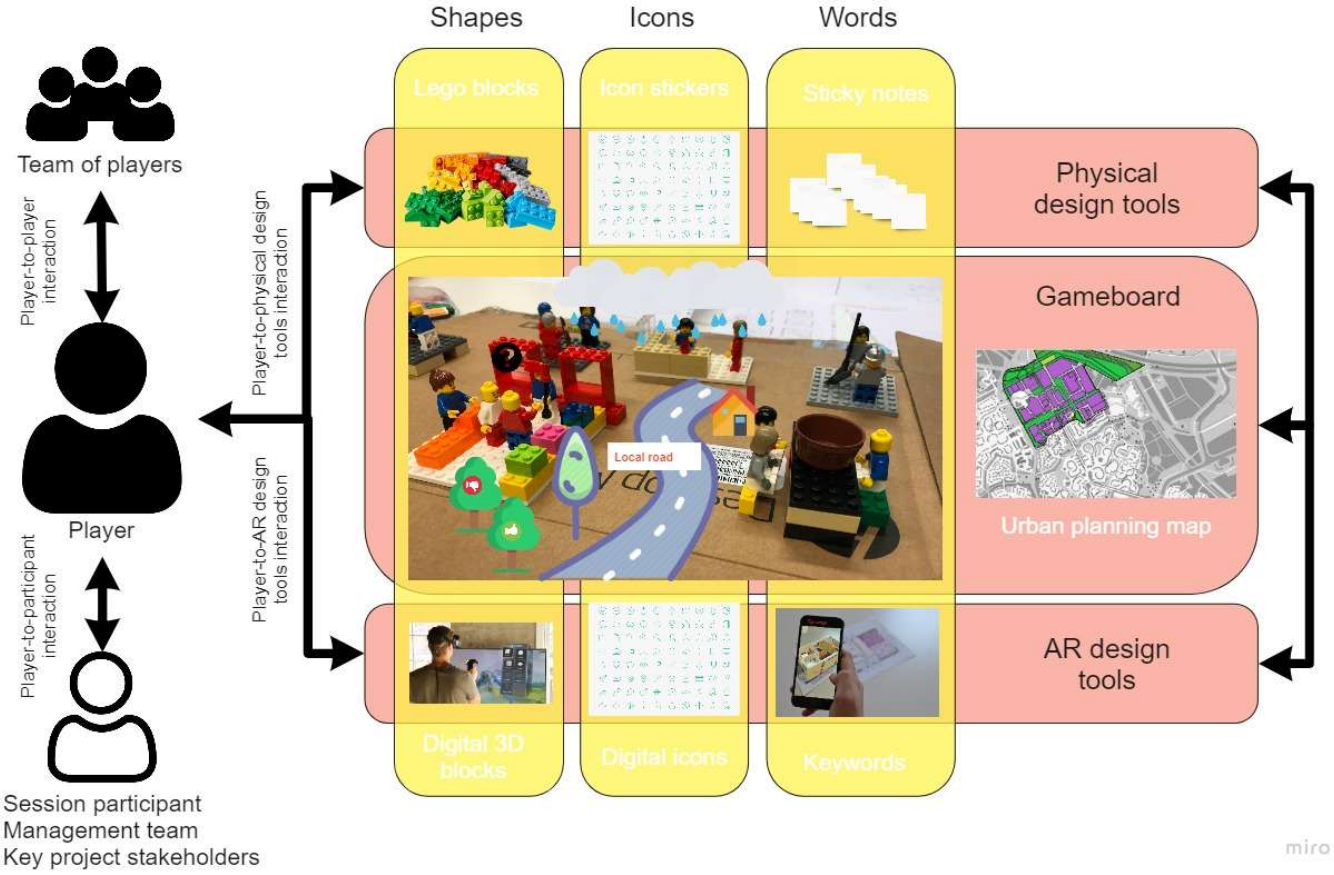


Figure 25: GTS design tools and technologies

Physical design tools for creation consist of Lego block, icon stickers and sticky notes with paper. AR design tool is facilitated by AR HoloLens glasses and a tablet computer. This supports players to construct digital layer on physical prototypes, by inserting digital 3D blocks, digital icons and keywords. Last, the gameboard template is extracted from real-world urban planning map, printed and placed on the GTS table.

Considering technologies supporting design tools, five major elements are considered namely hardware on which the game is played, software used to create and develop the game, its underlying programming language use to code, type of interface used to interact with the game, type of visual-verbal language and its application output (Table 5).

Hardware	Software	Programming language	Type of interface	Type of visual-verbal language	Output
Lego blocks	/	/	Physical	Shapes	Lego structures
Icon stickers	/	/	Physical	Icons	Attached icons
Sticky notes	/	/	Physical	Words	Attached notes
AR Microsoft HoloLens glasses	ARCore or ARKit; Unity	C#	Digital	Shapes and Icons	Inserted digital 3D blocks and icons
Tablet computer	ARCore or ARKit; Unity	C#	Digital	Shapes, Icons and Words	Inserted digital 3D blocks, icons and keywords

Table 5: GTS design tools and technologies description

Relating to software and hardware required for the AR application, game engines, its plug-ins and AR devices are researched. In the variety of game engines like Unity, Unreal Engine and GameMaker: Studio, Unity is chosen to code the AR application. It represents the all-in-one platform for mobile game development capable to work as a cross-platform game development tool and uses well-known C# programming language. Additionally, Unity plugin-in ARKit/ARCore is used to integrate two different hardware applications into one game - Microsoft Hololens AR glasses and Apple/ Windows tablet computer. Microsoft HoloLens allows players to drag & drop and modify digital 3D objects with hand gestures, and thus provide new design experience to the player. However, the tablet computer is chosen while it represents a familiar device for the player, which allows inserting keywords, icons and digital 3D blocks. Contrary, the set of physical design tools can be changed or expanded upon the needs of the GTS design challenge and the facilitator.

In addition to physical and AR design tools for creation, two Game canvases are designed and applied. The first, Connect-the-Dots (CTD) model is used to stimulate divergent thinking and second, Sea-Mountain-Sun (SMS) model is applied to encourage convergent thinking. The purpose of the CTD model is to identify connections and gaps between elements of design rationale (Figure 26). That is GTS design challenge, player wishes, envisioned outcomes (concept definitions) as well as obstacles that might restrict them to achieve the desired outcomes. WOOP tool is applied to support identification and definition of those (Salzgeber, 2016). It allows the player to note, insert and connect chunks of design rationale on the CTD model. This supports players to organise their ideas and thoughts during the concept of creation and avoids their overload with information. This maintains the player focus and connection between the design challenge and envisioned concept, as well as aligns multiple perspectives of players within a framework that sparks effective conversations and decision making (Devos, 2018). Three actions are applied to reduce system complexity, shift perspectives and propel imagination of new ideas and constraints – reducing, combining and abstracting information on sticky notes.

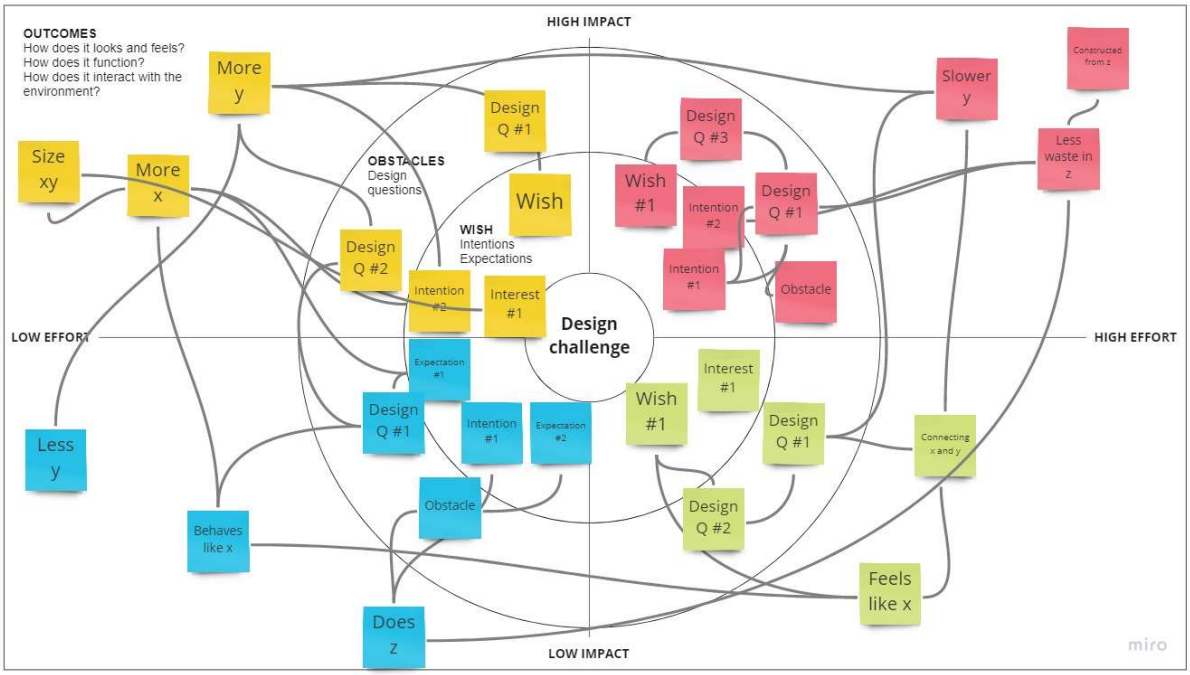


Figure 26: Connect-the-Dots (CTD) model

The purpose of the second, SMS model, is to scope the creation process and stimulate the reflection of players during this process (Figure 27). It is applied in combination with the CTD model and the WOOP tool, to support identifying key design information required for conceptual design and defining actions to achieve the desired concept. By reapplying the questions of WOOP tool after the construction of the CTD model, players together discuss, pick and attach sticky notes with key design information to the SMS model. The iterative process between CTD and SMS model continues during the creation process.

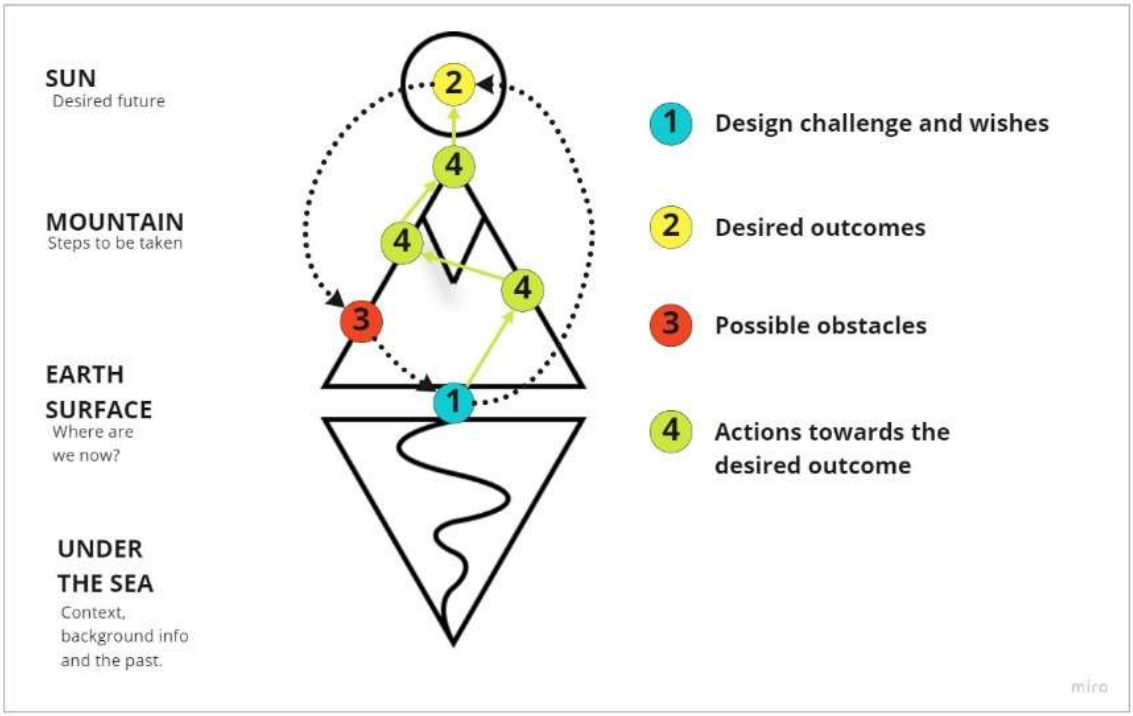


Figure 27: Sea-Mountain-Sun (SMS) model

8.3.2 Gameworld

When starting the GTS, players enter the environment called the GTS gameworld. It supports players to achieve the Game goal through the utilization of the design tools and technologies during the GTS gameplay. The GTS gameworld is constructed of physical, temporal, environmental, emotional, and an ethical dimension (Table 6). Those dimensions construct the GTS gameworld by using visual-verbal elements (Figure 28). However, the sound is left out in the scope of the GTS design to keep the focus on visual-verbal communication and minimize the complexity of the AR application.

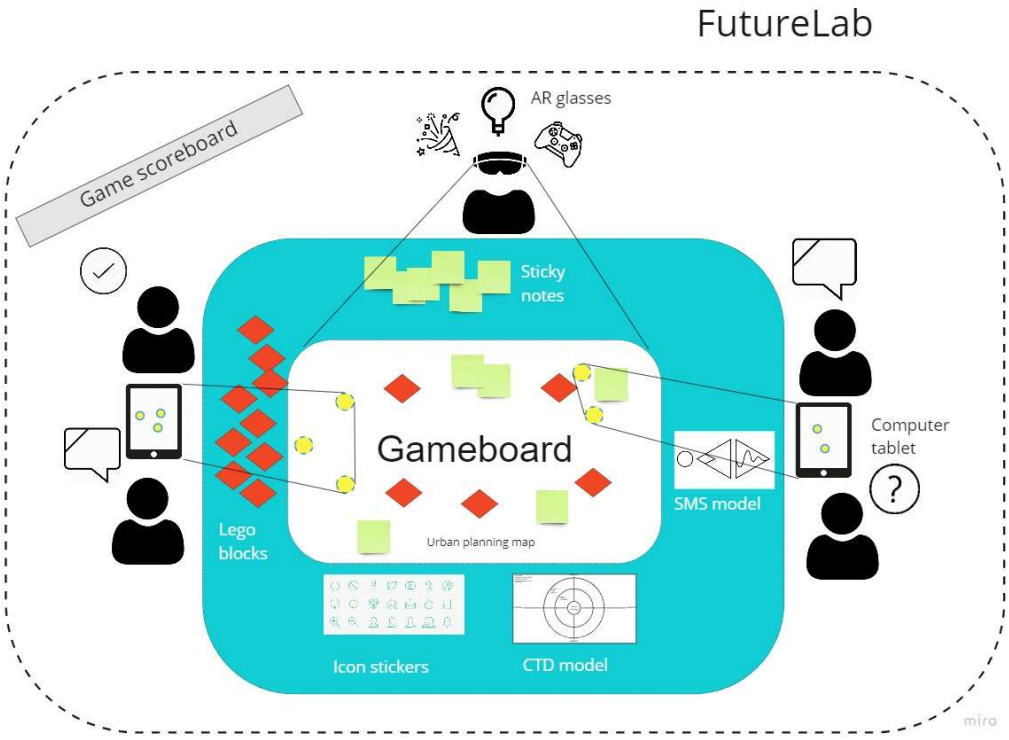


Figure 28: GTS gameworld

Players use physical design tools to create physical prototypes, enhance it with AR application using AR glasses and tablet computer. The player with AR glasses is the main creator of the GTS, while two pairs of two players create parts of the concepts. The situation of having one tablet computer for two players leads to more social interaction, while they are forced to communicate to operate the tablet together. The game scoreboard is positioned beside the GTS table, to allow players to note the points given by Communication rewarding mechanism.

Physical	Temporal	Environmental	Emotional	Ethical
Flat table 1,5m x 1,5 m in size, around which players can stand around in the circle. Concepts are built in the middle of the table for each player to reach it.	Ninety minutes during the third day of the FutureLAB session	GTS in the space of the FutureLAB.	Joy and fun of players while building with the team and seeing the results. Proudness and excitement after concept creation.	Rewarding communication, including players and session participants, giving players the freedom of GTS gameplay

Table 6: Gameworld dimensions

9. Integrated Game the System design

Chapter 9 describes the GTS methodology, which provides a collaborative and fun approach to construct and visualize imagined concepts in a mixed reality environment to overcome the Implementation challenge in the FutureLAB (Figure 29). The GTS methodology is a stand-alone product, which can be connected to other FutureLAB facilitation methods and technological applications. The GTS methodology consists of:

1. Player journey map, which explains the process of the GTS step by step and supports facilitator with the GTS facilitation (described below)
2. Set of physical design tools (Lego blocks, icon stickers and sticky notes) and AR application (two computer tablets and AR glasses)
3. Two game canvases (CTD and SMS model)
4. Gameboard (adjusted to the design challenge)
5. Game scoreboard

Players integrate bits of individual solutions into a coherent visual-verbal model that defines a concept with a set of shapes, icons and words. The utilization of physical and AR design tools helps the player to simplify, synthesize and translate the complex information from the GTS gameworld into reality. As a consequence of the GTS process, players are gradually included in the FutureLAB session to obtain key information from session participants, take ownership of produced concepts and bring them into the next development steps.

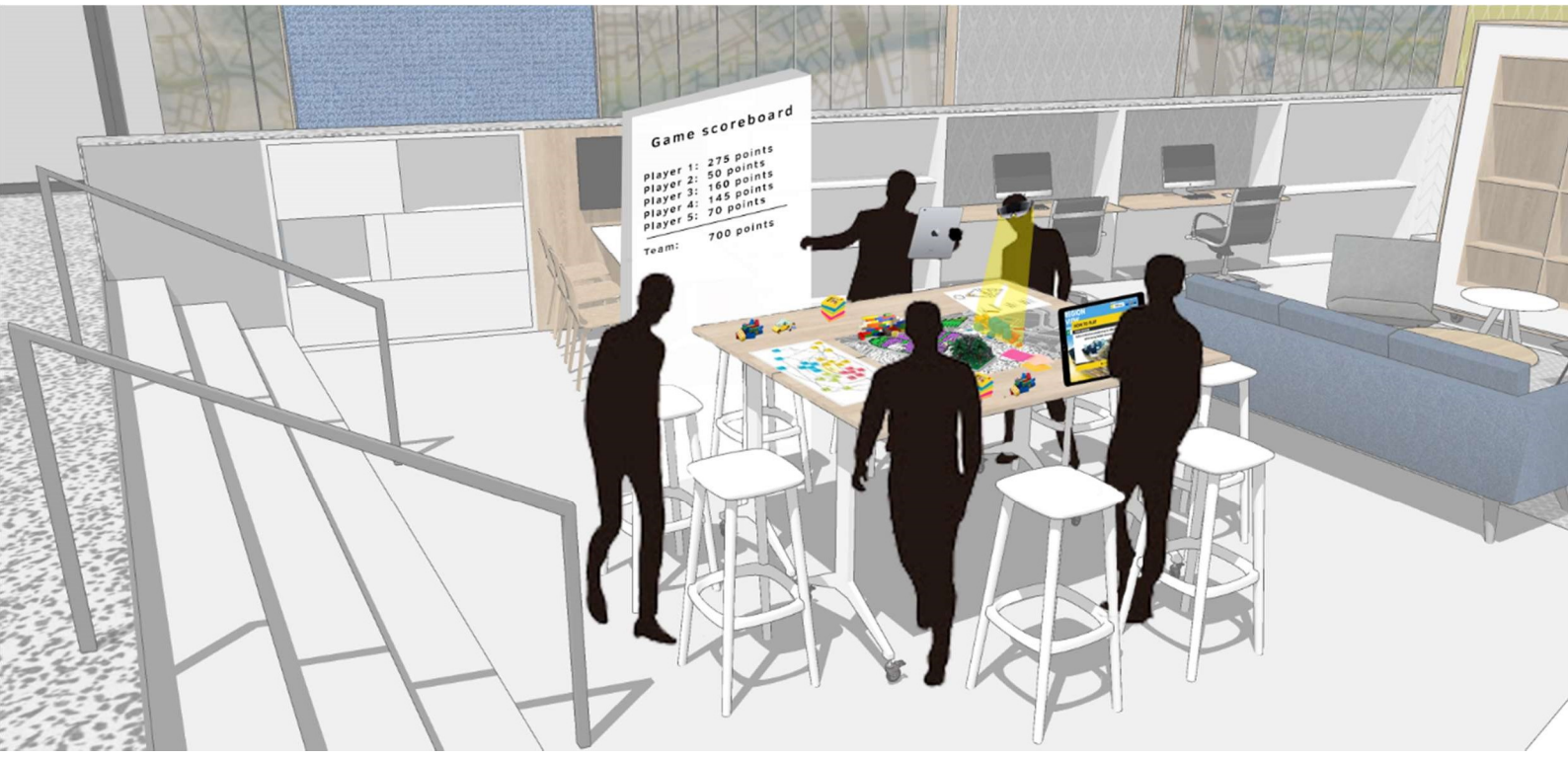


Figure 29: Game the System in the FutureLAB

To give a tool to the facilitator to systematically facilitate 4 to 6 players in 90 min through four GTS phases, the player journey is designed (Figure 29). During its design process, guided visual imagination was applied to iterate and validate the GTS player journey, and align goals of the steps with the player (re)actions, game touchpoints and group dynamics (Zavrnik, 2020b). Design case study TOFT was applied, to give practical and tangible design challenge to the validation group, consisting of two facilitators, project manager and creative lead.

To design the map, Future B2C Customer Journey has been used as a framework and adapted to the GTS needs. It has been chosen because the player journey in GTS highly relates to the customer journey in the real world. The same as customers, players have their own goals, thoughts and feelings upon which they act and react during the GTS to achieve their goals (Agius, 2019; Team, 2017). The player journey map consists of fifteen steps. Each step is described with seven subcategories, to describe the relation and interaction between the GTS and players:

- Game steps – elements of the player journey
- Player goals – objective player want to achieve in a specific step
- Player thoughts and feelings –expected player's thoughts and feelings in a specific step
- Group dynamics – social and cognitive perspective of the group divergent and convergent process
- Player actions – activity player executes to achieve the goal
- Game touchpoints – player's interaction point with the GTS
- Player reactions – post-activity player executes in reaction to the GTS output to achieve the goal

In the map, four colour tags are applied in Game touchpoints to define the type of GTS interactivity:

- Red tag – Player-to-player interaction
- Blue tag – Player-to-participant interaction
- Yellow tag – Player-to-AR design tool interaction
- Green tag – Player-to-physical design tool interaction

Afterwards, each step of the player journey is described systematically, explaining applied game elements and aim of each one.

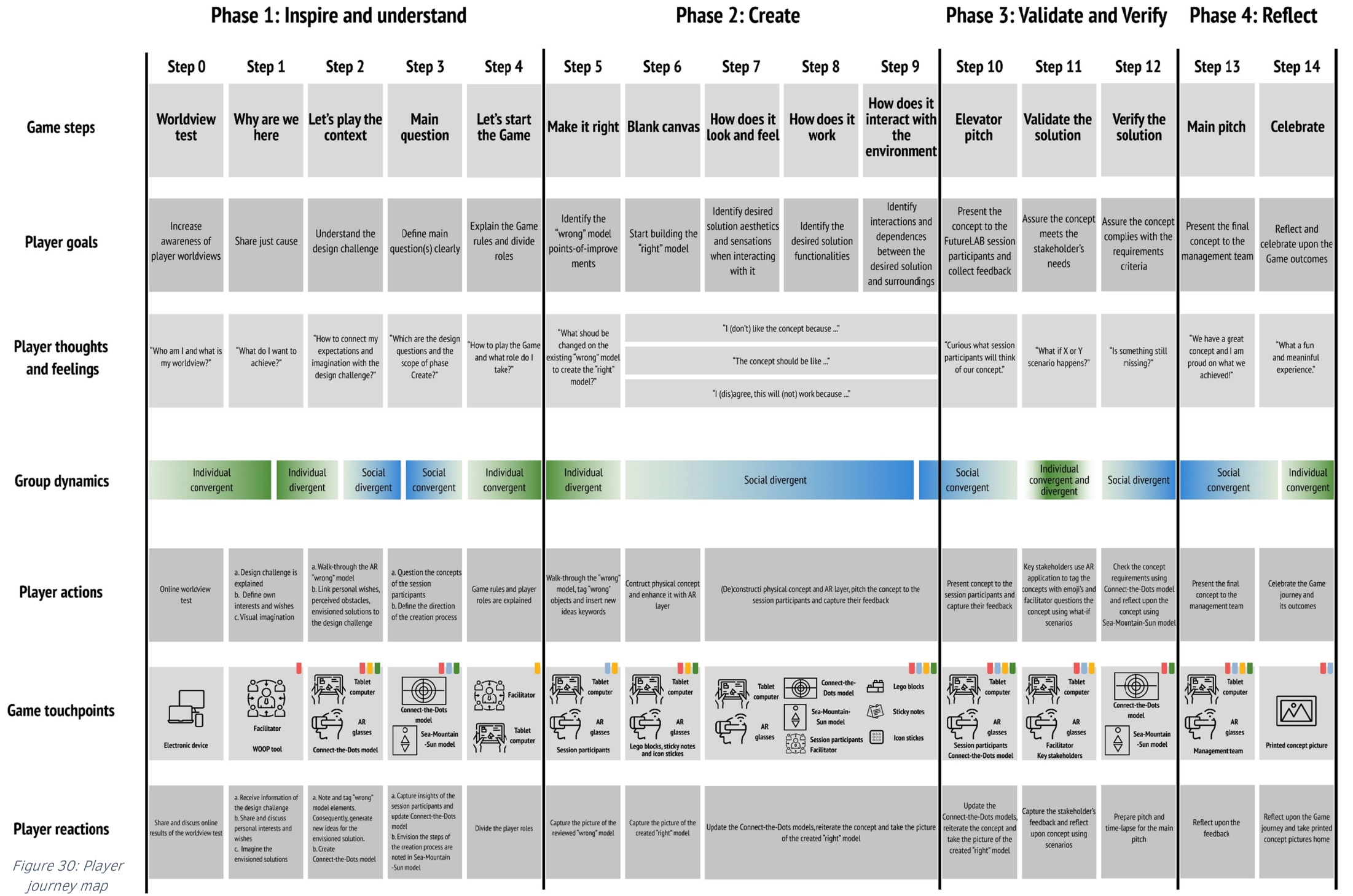


Figure 30: Player journey map

9.1 Phase 1: Understand

Game the System starts with the phase Understand, with the main aim to explore and increase understanding of players about the design challenge and ideate possible solutions. The phase is divided into five steps:

Step 0. ***Worldview test,*** to increase awareness of player perspectives
- To achieve that, the online worldview test on the computer is used (de Witt)

Figure 31: Experiencing the "wrong" model

Step 1. ***Why are we here,*** to share just cause
- Show the inspirational video to bring players into a positive and constructive thinking mindset before the tackling GTS design problem (Garcia, 2019)
- Explain the design challenge to clarify the reason players are in the GTS
- Players define its wishes, obstacles and envisioned solutions using WOOP tool
- Visual imagination is facilitated to stimulate the player's solution imagination upon the design challenge

Step 2. ***Let's play the context,*** to increase understanding of the design challenge
- AR "wrong" model is used to visualise the current solution upon the design challenge and generate new ideas for the envisioned solution (Figure 31)
- Generated ideas, wishes, obstacles and questions are captured in CTD model

Figure 32: GTS startup interface on the tablet

Step 3. ***Main question,*** to define the main question(s) clearly
- PSM is applied to switch players and session participants to obtain information about existing session participant's concepts and capture ideas and questions upon the player's concept from session participants
- Player define design questions and construct design statement using SMS and CTD model, to effectively manage individual intentions and expectation in the Create phase (Devos, 2018)

Step 4. ***Let's start the game,*** to explain the game rules and divide the roles (Figure 32)

9.2 Phase 2: Create

In the Create phase, players express and connect individual ideas and thoughts into a concept representing one of the possible solutions on the design challenge. The phase is divided into five steps:

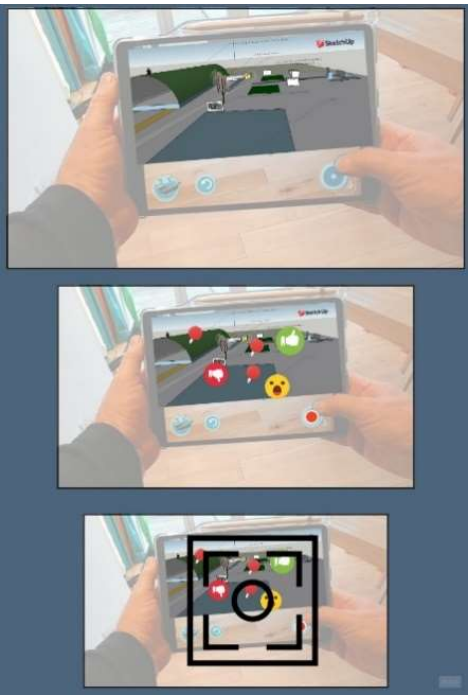


Figure 33: Walking-through, tagging and capturing the "wrong" model image

Step 5. ***Make it right,*** to identify the "wrong" model points-of-improvements (Figure 33)

- players individually walk-through the AR "wrong" model to tag the objects which need to be improved and capture additional concept ideas
- afterwards, players discuss with others objects-to-improve and generated ideas to ensure that there is no predominant conformism (Parraguez & Cuppens, 2019)
- PSM is applied to capture the perspectives of session participants in the "wrong" model
- Image of the "wrong" model is captured with the AR application to retrieve and reuse generated ideas for concept creation

Step 6. ***Blank canvas,*** to start building the "right" model

- Upon objects-for-improvement and generated ideas, players create first physical prototypes on the gameboard and enhance it with AR elements (Figure 34)

Step 7. ***How does it look and feel,*** to identify and define desired solution aesthetics and sensations when interacting with it

Step 8. ***How does it work,*** to identify and define the desired solution functionalities

Step 9. ***How does it interact with the environment,*** to identify and define interactions, relations and dependence between the desired solution and surrounding environment

- In steps 7, 8, and 9 players iteratively (de)construct physical concepts, enhance with AR layer, pitch it to the session participants and capture images of produced concepts (Figure 35)

Figure 34: Conceptualization in the mixed reality Gameworld

9.3 Phase 3: Validate and Verify

The third phase of the Game the System is called Validate and Verify, with the ambition to assure produced concept satisfies the needs of the involved stakeholders and is compliant with the concept requirements. The phase is divided into the following three steps:

Step 10. ***Elevator pitch,*** to present the concept to the FutureLAB session participants and collect feedback

- Players pitch the final AR concept to the session participants using AR application and images captured during the concept creation to capture feedback for further development steps

Step 11. ***Validate the solution,*** to assure the concept meets the stakeholder's needs

- Player present and discuss the final AR concept with the client, other members of the internal team and external partners to question six concept dimensions

Step 12. ***Verify the solution,*** to assure the concept complies with the requirements criteria

- Players use CTD model to check if the concept complies with the individual interests and satisfies the requirements regarding looks, function and interaction

9.4 Phase 4: Reflect

In the Reflect phase, players present final concepts to the management team, take time to reflect upon their game journey and celebrate upon the outcomes. It consists of two steps:

Step 13. ***Main pitch,*** to present the final concept to the management team

- Players pitch the final concept to the management team to communicate concept design rationale and convince them to invest in further development steps

Step 14. ***Celebrate,*** to reflect and celebrate upon the Game outcomes

- Players celebrate by looking at the final AR concepts and capture concept images to share the feeling of achievement, proudness and progression
- Captured concept pictures are printed and given to the players to take home as a memory. This allows players to relive the GTS experience after coming in contact with an image at home

Figure 35: Produced and captured image of the mixed reality concept

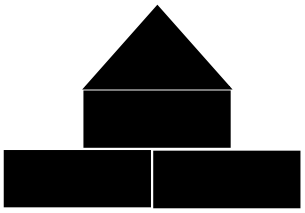
PART 4: Game the System application and evaluation

In the fourth part, integrated GTS design is applied, evaluated and concluded.

In chapter 10, the GTS design is applied and demonstrated to the LEF internal team. The GTS gameplay characteristics and the outcomes of its application are described, and used for further evaluation.

In chapter 11, evaluation is conducted upon the outcomes of the demonstration and the requirements defined accordingly to the GTS concept. The results of the evaluation are further discussed and compared to the predefined game goal, purpose and meaning.

In chapter 12, the assignment is wrapped up with the conclusions and recommendation for further developments.



10. Application in the FutureLAB

Chapter 10 explains the application and demonstration of the integrated GTS design. However, all proposed functionalities and mechanisms of the integrated GTS design could not be fully applied and demonstrated in the period of this assignment. The reasons for that are (1) Corona measures, which did not allow hosting the physical session and (2) non-working prototype of AR application. Moreover, GTS could not be applied to the predetermined design case study TOFT, because the project was not ready in the period of GTS application and demonstration. Therefore, the online demonstration of the Game the System was conducted to validate its value for the players and the FutureLAB (Appendix E). The demonstration focused on validating the GTS functions and mechanisms in the Understand and Create phase to stimulate the concept creation process. The application aims to test whether:

1. the players perceive the GTS creation process as fun, enjoyable and meaningful
2. the session participants are included in the GTS process
3. the players feel empowered during the GTS to create concepts and exchange ideas
4. the team of players is more connected after the GTS
5. the players are satisfied with the produced concepts and obtained the feeling of achievement and progression
6. the players feel proud and took ownership of the concepts and are motivated to continue development steps

Due to online demonstration, physical and AR design tools were replaced with only digital ones, using the Tactive online platform. Tactive is online whiteboard used for facilitating the creative process, where users can express their ideas by the means of words, shapes, images, icons and symbols. Moreover, the SMS model and CRM were not applied, due to lack of space on Tactive online platform and difficulties to facilitate GTS through the online platform. Last, the gameplay was simplified by excluding game rule and not defining player roles.

Because the TOFT project could not be used to validate the GTS, design challenge from the FutureLAB has been applied for that purpose. The group of 8 players have been given the design challenge to identify and define the furniture and technology elements required in the FutureLAB. Upon this design challenge, two concepts have been created representing the looks, functions and interaction with the surrounding environment, from social, technical and business perspective. The group was divided into two teams of four players. Each team was facilitated by one facilitator and played its own Game.

GTS gameplay characteristics of the GTS application are described below:

1. **Connection to reality**: finding a solution on the FutureLAB design challenge
2. **Design challenge:** identify and define the furniture and technology elements required in the FutureLAB
3. **Player team:** Two teams of four players
4. **Free-form and open-ended:** Tactive online design tools, which allow users to express their ideas by the means of words, shapes, images, icons and symbols.
5. **Gameplay perspective:** top-down 2D perspectives, directed by the Tactive tool
6. **Resources:** Unlimited resources (not applied game rule)
7. **Time restriction:** 70 min
8. **Score:** No scoreboard (not applied CRM)
9. **Gameboard layout:** players using CTD and "wrong" model to input their ideas on it and create concepts on the "right" model
10. **Interaction**: Zoom for online facilitation and computer for pointing, grabbing, dropping and moving the visual-verbal elements in the Tactive

Two simultaneously played GTS produced two concepts with different development focus (Figure 36). One of the groups focused on the nature-technology aspect of the furniture, while others on technology, fun and functionality of the space and furniture. The possible reasons for that are:

- Different facilitator's interpretation of the Game instructions, which leads to different facilitation approach
- Different group dynamics, due to different multidisciplinary teams of players
- Different player's interpretation of the design challenge
- Different player's interests and wishes towards the GTS and produced concepts
- Different player's attitudes and skills concerning the design tools

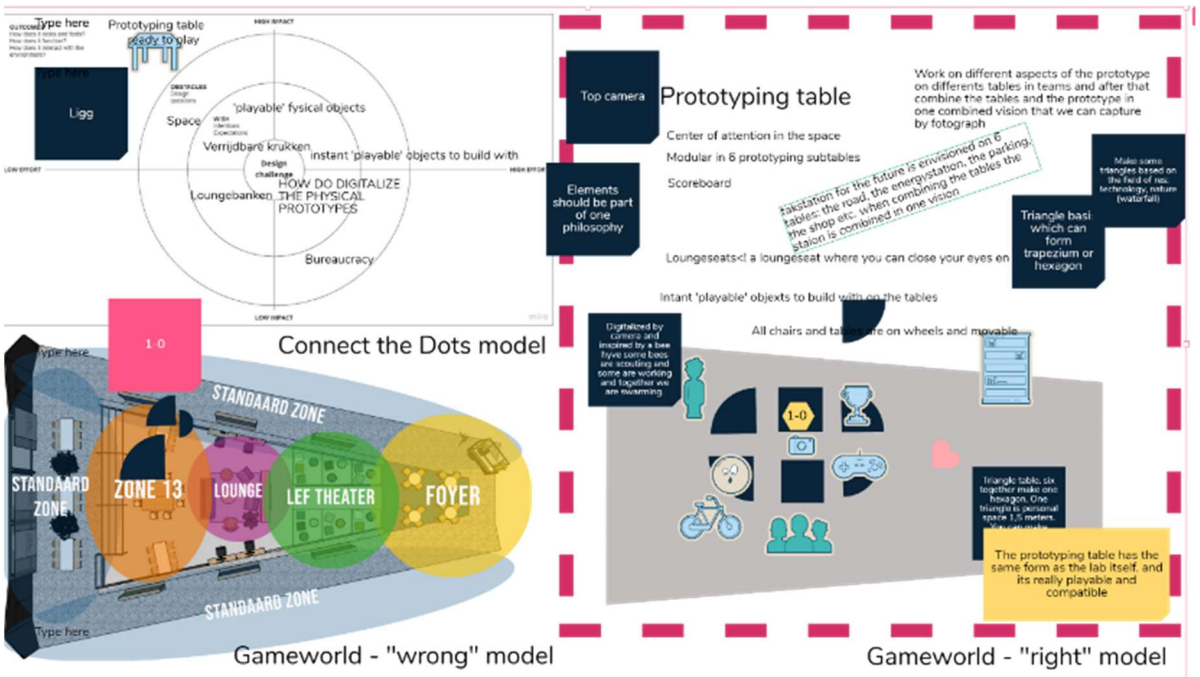


Figure 36: One of the created concepts during the GTS application

11. Evaluation and discussion

The GTS application, presented in chapter 10, supports the evaluation of the methodology based on the requirements defined in chapter 7. Second, the evaluation points are discussed upon the game goal, game purpose and game meaning described in chapter 8.

11.1 Evaluation

GTS is evaluated upon the seven requirements, defined accordingly to the GTS concept.

Safe, inclusive and playful game environment – the GTS application showed that players are eager to listen and question each other's ideas, especially when they are brought into the "not-knowing" state or they find a common ground of specific idea. This is achieved by creating multidisciplinary teams of players, using PSM and giving the flexibility to the player to choose and play with preferred design tools.

Intuitive design tools – the functionalities of the Tactive digital design tool were found intuitive to use, while some operating problems occurred due to interface malfunctions. It can be assumed that players would found AR application intuitive to use, while both possess the same digital functionalities and differentiate only in the interface. However, GTS application demonstrated player miss physical design tools, besides digital ones. While they find digital design tools interesting and promising, especially because of rapid and different creation functionalities compared to the physical tools, physical tools are still perceived as more intuitive and fun. Additionally, CTD is found too complex and complicated to use and should be applied in the Create phase to steer the creation process and not diverge play and ideation in the Understand phase.

Simple Gameplay – the Gameplay is simple and allows player playing immediately after the Understand phase. However, the simplicity of the Gameplay is challenged with the application of digital (AR) design tools and player skills to operate with those. Moreover, players perceive Game canvases and the "wrong" model method not useful in the Understand phase, due to its complexity. They were found beneficial and understandable during the Create phase when converging process was required. However, visual imagination was easy to follow by players and incredibly effective in stimulating diverging thinking in the Understand phase.

Capture an image of a produced concept – the images of the evolving concept were taken with the online digital tool the Tactive tool during the Gameplay. Sending the concept images after the GTS to the players, resulted in their satisfaction and amazement especially when

they saw the results of the other team. Nonetheless, it is not known if the concept images were further used as an input to communicate the results with the management team and continue the developments using the GTS concepts.

The flexibility of the Game functional model - the Game functional model satisfies the requirement of flexibility with the ability to apply different design challenge, adapt to preferred facilitator techniques and approaches, and provides flexibility players to define its gameplay and preferred design tools. First, the GTS design challenge flexibility was proven by successfully creating concepts for room interior design challenge of the FutureLAB. It is assumed the GTS would be applicable and beneficial for solving engineering, creative and social design challenges. Second, the facilitator liked that he was able to apply its favourite facilitation method. Third, because players were able to act and create upon their wishes using online digital tool Tactive, they felt empowered and motivated to continue the creation process. However, it occurred that players did not act upon the game instructions and individually continue with the creation process. While this was encouraging for the individuals, it made other players question upon the game instruction. Having said that, due to their freedom and flexibility it is hard to control and predict the GTS outcomes. This can reflect in a positive feeling of surprise and engagement for the player, and frustration for the client if the concepts are not aligned with his or her expectations.

Sufficient time and space to reflect and celebrate – the players had enough time and space to think and reflect during the GTS, nevertheless the FFFT was not applied. This was achieved by online GTS facilitation in a way (1) only one player spoke, but everyone listened and thought along with the speaking player, they were able to (2) reflect upon their thoughts and concepts, and (3) create their concepts during the player talk. However, the GTS application did not provide enough time and triggers for celebration due to the fact CRM was not applied.

Produced concepts – players perceived two generated concepts during the GTS application as valuable and useful for further development steps. The concept comprised design information about the looks, functionalities and interaction with the surrounding environment in the 2D model, which correlates to concept three system-detail levels. Three concept dimensions were captured in the concept, namely social, technical and economical.

11.2 Discussion

The evaluation points are used to discuss the effectiveness of the GTS to achieve its game goal, purpose and meaning.

Its goal is to create a concept that describes how the model in the real world should looks, functions and interacts with the surrounding environment.

GTS product – game goal

While the outcomes of the GTS application doesn't directly represent the envisioned GTS outcomes, the methodology still achieves its game goal - creating a concept that describes how the model in the real world should looks, functions and interacts with the surrounding environment. Players perceived the generated concepts as valuable and useful. The concepts contained the design information about the furniture and functionalities of the FutureLAB space. However, the concept comprised the information of only social, technical and economical dimensions, aligned with the expertise of the players. To provide also other three proposed perspectives and find still missing answers after the first iteration of the GTS, players with correlating expertise should be included in the next iteration of the GTS. Last, it is assumed that the combination of physical and AR design tools, which allow creating mixed reality 3D models, would achieve producing concept aligned with the envisioned GTS outcomes.

Its purpose is to facilitate social play and collaboration between multidisciplinary teams to create imagined concepts in a mixed reality environment.

GTS process – game purpose

Players perceived GTS as fun and meaningful, which increases their engagement and collaboration during the gameplay and avoided their fight-flight-freeze mode. This positively affected creative problem solving during the GTS. However, more challenges and competition should be applied in the GTS to achieve more play, fun and out of the box thinking. Players desire some competition using Game score and points. It is assumed that this desire could be satisfied by implementing CRM, game rules and player roles in the next GTS application and validation process.

The GTS application showed small teams, consisting of four players, were big enough to maintain the player dynamics and energy high, while as a team possessing a sufficient amount of knowledge required for the creation of desired concepts. However, teams were

small enough to give enough time and space to individuals to listen and think along with other players, reflect and create the concept with other players. Moreover, player switching mechanism (PSM) represents an effective approach to include other players and session participants from the FutureLAB in GTS concept creation. Its application stimulated the group dynamics and contributed the exchange of knowledge, information and ideas between the teams and questioning the developed concept. Nevertheless, switched players require clear instructions about their action when they are brought to GTS.

The GTS showed a beneficial effect on the convergence process. It stimulated the teams to put their ideas on the gameboard, connect to others and produce one coherent concept all team members agree upon. Convergent thinking is effectively stimulated with the CTD and "wrong" model. In contrast, it has been argued more unexpected and out-of-the-box functionalities should be added to the GTS to stretch the player's mindset and stimulate divergent thinking. While the visual imagination engaged divergent thinking in the Understand phase, it is assumed the exploration and ideation in a mixed reality environment with the combination of AR application and physical design tools, around the table in the physical environment, would provide additional stimulus for player's divergent thinking. Playing with the proposed design tools, exploring the design challenge and ideating in the Understand phase is crucial to expand the player's understanding of the design challenge upon they can define design questions and statement. And second, is important to obtain the necessary skills to operate with the design tools.

The instructions given in each game step during the GTS application by itself were easy for the player to understand. Nevertheless, the challenge of effective application of the GTS appears, when integrating the game approach for problem solving with the design process model and mixed reality design tools. First, players required more support when getting familiar with the online tool Tactive and expressed the wish for using physical design tools. Besides being perceived more fun by players, those provide more social interaction during its use compared to the digital ones, stimulates the exchange of ideas and allow sharing stories upon the created concepts. Comparing utilization of Tactive tool to the AR application in combination with the AR tablet computer and glasses, it is assumed even more support and time would be needed for players to get to know how to operate with the digital tool. Second, players are often not familiar with the design process and methods, therefore extra explanations and its aim of each GTS design step are necessary, to increase player's understanding what they should do and why. It has been proven that application of CTD model and the "wrong" model method, in combination with the newly introduced digital design tool in the Understand phase can be overwhelming for the players. Thus, functionalities of design tools, design methods and players actions must be explained to players gradually during the GTS. Therefore, further development and application of the Experience framework could support players get familiar with design tools, canvases and design model through the Inspire and Get-together part.

Its meaning is to support multidisciplinary teams to take ownership of produced concepts and overcome the Implementation challenge.

GTS outcomes – game meaning

To support teams to take ownership, MDM contributed the most. First, player's flexibility to decide preferred design tools and define when to listen, question or create give them an to act upon their wishes, which further empowered them to share ideas and create concepts. Second, players obtained the feeling of achievement after creating concepts. They were satisfied and even surprised over the concepts created during the GTS, especially when seeing the concept images of other players. Therefore, capturing the concept image is proven a useful method to stimulate the player's reflection, communicate information with others and bring the produced concept back to their company. While mixed reality design tools could not be validated, it has been shown that players like to apply shapes, icons and words to express ideas and create concepts. Moreover, icons and symbols were found the easiest to understand, apply and interpret, especially because it represents universal language, which avoids misinterpretation of ideas and concepts. Third, the player's flexibility, multidisciplinary teams of players and PSM brought them into the "not-knowing" state, which increased awareness of their perspectives, stimulate questioning and exchange of ideas. This led to the more social cohesion of the team during the gameplay, while they did not show signs of social connection after the GTS. It is assumed that CRM could achieve creating more social interaction and connections through competition and play. However, the most plausible reason for lack of social connection between players is that certain players were not part of the FutureLAB project and thus were not even motivated to seek social connection during the GTS. While they were surprised and proud of the GTS outcomes, they did not take ownership of the concepts and were not motivated to continue with development steps. On the other hand, players that are part of the FutureLAB project did achieve that and were curious about what are the next development steps.

12. Conclusion and recommendations

12.1 Conclusions

FutureLAB commonly deals with the challenge of facilitating the production of multiple ideations and concepts of an innovation project, which never get fully developed and implemented. Difficulties appear in getting the internal development team to accept and commit to the development of a newly introduced concept and translating created concepts into practice. The management of the FutureLAB is aware of this challenge and its effect on the success of their operations. To achieve a higher rate of developed and implemented innovations, this research recognizes the need for change in the facilitation approach and applied tools.

FutureLAB operations focus on initiating, creating and accelerating innovation projects, brought by external organisations and clients. However, the holistic and systematic approach is missing to involve the internal development team in the FutureLAB early-design stage, support the creation of visual concepts and convenience internal management team to invest in further developments.

The reasons for a systematic approach absence originate from the complexity of the challenge, which comprises of elements from three interrelated entities – individuals, the team and the concept. First, while it is not difficult to bring internal development team physically to the FutureLAB session, challenges appear to motivate individuals to create, commit and take ownership of generated concepts. In that aspect, their perspectives and worldviews towards effects his or her perception of the innovation project and corresponding design challenge. Those, as well as individual's wishes and interests upon the FutureLAB session and type of language they are speaking, should be considered to satisfy the individual needs. Those factors influence the second entity, the internal development team and its dynamics. Namely, the quality and quantity of the communication between the development team, construction of social connections and team spirit. Third, the aspects of the individuals and the team reflect in the quality of created concepts, as well as the development and management team's satisfaction with those outcomes. To achieve the connection and alignment between those three entities, the appropriate facilitation medium has to be chosen. The challenge appears in balancing facilitation approaches and technologies, which are accepted and promoted by the internal development team on one hand, and on the other hand, achieve to support the FutureLAB operations.

To tackle the challenge of the FutureLAB, this research provided a player journey map, which systematically describes the methodology. The player journey map explains the player actions, game touchpoints and reactions to create envisioned concepts and take ownership

over them. Furthermore, it describes underlying methods, tools and technologies to support facilitation of users through the methodology process.

The application and demonstration of the methodology achieved to include the members of the internal development team in the FutureLAB innovation operations and facilitate the concept creation. However, it did not achieve to fully convince the management team to invest in further concept developments. It accomplished to increase their interests in further concept developments. The methodology application showed that its game elements successfully:

- Stimulate users to explore possible solutions on the design challenge, which leads to increased understanding of the design challenge.
- Brings users into the playful mindset by involving external users and applying design methods and tools, which allowed them to create accordingly to their interests. This empowered users and increased verbal communication between them, accepting ideas of others and the birth of new unexpected ideas. This contributes to the creation of social cohesion between users.
- Enables users to create concepts by applying shapes, icons and words with digital design tools.
- Delivers the feeling of achievement and progression by capturing and sharing the concept images, which contributed to the feeling of ownership.

Because of the methodology application, users create a constructive mindset to obtain the skills to operate with the tools and create the concepts. This leads to a feeling of empowerment, achievement and progression, which stimulates their acceptance of other user's perspectives and achieves social cohesion with the team. Consequently, the probability increases that the internal development team takes the ownership of produced concepts and commits to the innovation project developments after the FutureLAB session. This satisfies the wishes of the client, which receives a motivated development team and designed a visual concept to present and convince the management team.

The generated image of the concept, as an outcome of the applied methodology, represents the effective communication tool to deliver the information of the concept's looks, functions and interactions to the management team. This allows the management team to identify concept strengths, weaknesses, opportunities and threats, and decide upon those to continue its development or not.

In conclusion, the methodology achieved to created desired concepts and support the internal development team to take ownership by applying a set of facilitation approaches and tools. However, the methodology should apply additional game challenges and competition elements to enhance the feeling of a game and achieve more social play and collaboration between multidisciplinary teams. Moreover, the proposed physical and AR design tools should be integrated and validated to confirm the benefits of mixed reality concept creation. The current version of methodology represents the first transitional step from applying solely physical design tools and methods used during the FutureLAB session, towards the methodology working in the mix reality environment.

12.2 Recommendations

This research presented the methodology for creating concepts and taking ownership to continue its development and implementation steps. Following recommendations are given for successful methodology application and further developments.

First, for each design challenge individually, appropriate gameboard should be designed or chosen. In most cases, the client provides with visual material of the design challenge, which can be used to create a gameboard. Second, it is recommended to revise the GTS steps in collaboration between the client and the facilitator. Third, for a specific creation process, additional physical design tools and AR elements should be added.

Second, it is recommended that players apply the methodology multiple times, while they become more familiar with the game approach for problem-solving, the design process model and mixed reality design tools after the first application. This leads to more effective during the creation process in the next GTS application. Additionally, more Game iterations allow players to reflect upon the created concepts, capture extra design rationale in CTD model and digital images of the concept.

Third, in the case of complex design challenges, it is recommended to divide the design challenge in multiple partial design challenges. Simultaneously play of multiple GTS allows creation of ideas and individual concepts tackling partial design challenges. With the application of PSM, player exchange those and align the partial solution to deal with the complex design challenge. In the process of the GTS, tables with partial solutions are gradually brought together to identify connections and align concept system development.

Concerning further developments, it is recommended to conduct additional research and testing about the game rules and challenges that pulls players into the GTS, motivate them to create concepts and take ownership over the produced concepts. Moreover, the proposed AR application should be developed and applied to achieve quality outcomes of the methodology. The proposed AR development steps consist of three stages:

1. The function of inserting AR elements should be added to the online platform Tactive to allow users to implement already existing Tactive elements (words, pictures and icons) as AR layer to the GTS gameboard in the real environment. Therefore, users could enhance physical prototypes built with Lego, sticky notes and icon stickers using online Tactive application and tablet computer with the camera.
2. AR application should be developed for Microsoft Hololens glasses and integrated with Tactive environment, to provide the user with a more intuitive and immersive experience of building the prototype.
3. Camera with image-recognition should be positioned over the GTS gameboard to capture images of physical prototypes and convert them into digital models.

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Appendix A

Stakeholders surveys, interviews and experiments

First, quantitative exploration research was executed upon the LEF environment and shared in cooperation by two other interns at LEF, namely Bastiaan Ilmer and Daphne Koning, with the main aim to understand LEF environment and its dynamics. Concurrently with this research, the problem identification research has been executed within five target groups – LEF facilitator, FutureLAB participants, client pioneer, FutureLAB project manager and business developer, and last LEF account manager.

LEF environment – exploration research - quantitative

Explorative quantitative research was conducted 16th of October and 9th of November, where 21 employees of LEF Future Center participated in an online questionnaire, namely facilitators, creative lead, development advisor and account managers.

The main conclusion of the exploratory questionnaire are:

1. Client and satisfying its needs is the priority;
2. Participants should receive unforgettable experience and mindset change;
3. Facilitation space should be social and inclusive, with philanthropy in mind, using less technological application and more nature-inspired;
4. The LEF sessions should allow more flexibility and promote fun, experimentation and game;
5. During the process of the session, more time should be given to the participant to reflect and connect to others, focus on stimulating their sensation of seeing, hearing and touching during the session, and increase the effectivity of social convergent phase.

Facilitator – problem identification - quantitative

Based on the explorative quantitative research of the LEF environment, qualitative research with facilitators was carried out to investigate their perspectives, needs and interests towards the proposed game and design tool. The research was executed between the 13th and 28th of November.

The extensive online questionnaire was sent through social communication channel Whatsapp to the group of 54 facilitators, and only 5 responses were collected (9%). After the discussion with two facilitators which participated in the online survey, the reasons for low response has been discussed. The most possible identified reasons are that facilitators (1) are not aware of the possibilities and can not imagine the benefits of the proposed game and design tool. Second, they (2) are unmotivated to try and learn new tool which can

disrupt their current operations and is hard to adopt. A third potential reason is that they (3) didn't see the value of the questionnaire and its internal message was conveyed in the language appealing to them.

The main conclusion considering the proposed game and design tool are:

1. It should **inspire and motivate participants and clients pioneers** for action;
2. **Reframe participant's minds and spark out-of-the-box thinking during its usage**;
3. **Participant's human senses need to be stimulated and emotions triggered**;
4. Builds a **safe and inclusive environment**, which stimulate a participant's criticality and fact-based decisions;
5. Build **experience** by using **visualizations techniques and fun elements** to helps participants to clarify the problem questions and thus increase understanding of the design challenge, build **tangible solutions concepts** used for communication with other stakeholders, as well as effectively evaluate and reflect produced concepts;
6. Improve **social convergent process** of the participant's groups on one hand and increase their **feeling of ownership** on the other hand by considering all participant' ideas and help them to let them go;
7. The interaction with the tool should be **intuitive** for the user using a physical interface or a combination of **physical and digital interface**.

Facilitator – problem identification - qualitative

In addition to facilitator's quantitative problem identification, qualitative research with the facilitator Michiel Prins was conducted on 4th of December. This research aimed to obtain more insightful information and understanding of identified facilitator needs.

The conclusions state that participants of the game should be triggered to look differently on the world, design challenge and other participants by being **conscious about their world** and built **empathy to the other worlds**. Additionally, participants should be brought into the **mind of not-knowing** and furtherly **asked different open questions. The creative process begins in the place of curiosity and not-knowing (Ely, 2017)**. Bringing them into **a non-familiar environment** or **giving challenge to them by using new tools and approaches**, can trigger the current perception of the participants.

Dreaming, verbal and visual communication are the preferred type of construction and exchange of ideas, each possessing its advantages. Verbal communication is advantageous when **inspiring, sharing experiences and questioning**. Dreaming is a process where participants close their eyes and imagine. This is especially beneficial to **reconcile, visualize** the past or the future to retrieve information or construct future scenarios. Last, visual communication in the means of drawing, is especially effective when the transition is done from verbal communication to visual communication. Participants draw on the paper for others to see it and react to it. Therefore, **individuals change from thinking and talking mode to the mode of doing and combining ideas**.

During the design process in the creative sessions, the focus should be on stating and **revealing the questions,** picking and **mixing the questions to develop an idea** and **work out an idea in the concept**. The core challenge appears during the ideation process when participants try to **pick individual questions, make associations, build connections between different ideas, frame it and visually present it**.

After the discussion with facilitator Marjolijn de Graaf, additional tool' requirement was defined - "*it must bring some extra humour, fun with competition and impulse (call to action) into your session*".

Participant – problem identification - quantitative

Quantitative research has been conducted during the FutureLAB session with its participants to investigate their communication types, identify challenges during different design phases and their needs considering those. Twelve participants answered an online questionnaire on the dates between 15th of October and 4th of November 2019. At the end of the online questionnaire, five of twelve participants shown interest in the further developments of the game and design tool by entering their email.

Main conclusions of the participants' quantitative research are:

1. Majority of participants prefer **verbal** (8/12), **written** (8/12) and **visual language** (8/12) to express and communicate their ideas and thoughts during the session.
2. Majority of participants have **challenges with understanding design challenge** (11/12), as well as **ideating** (10/12) and **prototyping** (10/12) the solutions. Almost a half (5/12) positively responded when asked if they require new ways to express their ideas.
3. Other identified needs of participants are
    a. Support at decision making
    b. More **interaction between participants for co-creation**
    c. **Visualization of different perspectives to understand the design challenge and participant' perspectives**
    d. **Visualization of solution' purpose, its position in the environment, as well as a strategic whole**
    e. **Working with various intuitive prototyping tools** to make complicated technical concepts easy to understand for non-specialists.

Client – problem identification - qualitative

Qualitative client research has been carried out with one of the FutureLAB clients, namely Stan Kerkhofs, project manager of Reconnaissance Living Lab Infrastructure. On the 3rd of December, an online questionnaire was filled by him which lead to an interview on 9th of December to discuss the answers and further investigate specifics.

Main conclusions of the client's quantitative research are:

1. Innovation push – The main goal of the project *Tankstation of the Future* is innovation push on the themes of Sustainable mobility, Energy and Climate and Circular Economy in the Field Lab Brainport. The motivation behind the realisation of the *Tankstation*' project is to prove the innovation is necessary to apply today and learn upon to achieve big transitions in 2030 and 2050. Thus, inspire and attract new partners for future projects, as well as examine new transition laws and regulations in practice.
2. Envision and imagine – Reason to collaborate with FutureLAB is to envision and imagine the Future. When the future solution is visualized, involved stakeholders get more attached and motivated while they can imagine the big picture.
3. Visualize – The tool should represent how the solution could look like, and which steps needed to be taken. Digital visualization helps a person to envision the solution in a safe environment, which insights can be used to project into reality. Digital media is better, while is it easier to reproduce, it is 3-dimensional and faster compared to physical prototyping. A person is capable of walking through a visualized solution and reshape it in a required way. Through this experience, human senses should be stimulated, such as sound, smell and vibrations.
4. Inclusive process – The session should be inclusive, consisting of three main parties – (1) people living and working in the project area, (2) people which only work in the project area, and (3) entrepreneurs and other stakeholders which carry out the innovation project.
5. Visual communication – A preferred type of communication is visual with interaction, while verbal and written communication is commonly used.
6. Commitment and misalignment – The challenges restricting the Tankstation of the Future project to not be realised yet are in first place lack of commitment and misalignment of dominant RWS and other key stakeholders, and secondly gathering finance for prototyping of innovations. Additionally, people are scared when it comes to transitions, while they are not sure what to expect.

Project manager and business developer – problem identification – quantitative

The qualitative research conducted on 28th of November including project manager Marith Meijer and business developer Mohammad Alkhan revealed the following:

The main target group are client pioneers, which bring innovative infrastructure-related project into the Future Center. They are usually the initiators of the innovation projects and are characterized as early adopters, innovators and fast adapters.

The main pain is that they need to pull the rest of the project's key stakeholders from other domains, which are late adopters and slow adapters. The process of their collaboration is restricted due to communication gaps due to different perspectives and languages they use.

Elaborative description of the project manager's qualitative research:

1. The project's key stakeholders, consisting internal development team, are **Directors and Project managers as decision-makers; Auditors, Law regulation and financial officers; Procurement and purchase officers; Portfolio and service managers; Software architects and developers; and last Domain expert**s. **Directors** are usually pushing the innovation project and carry concerns about budget and **responsibility** of the project team, as well as **its value**. Similar to directors, also **project managers** are usually promotors of innovation projects and their problem is **operational overload**. **Auditors, law regulation and financial officers** are guided and usually restricted by law regulation, but concerned also by **budget and responsibility**. **Procurement and purchase officers** are often limited and pressured by time, therefore their concerns are about **time for preparation and team commitment to the project**. **Portfolio and service managers** face a challenge while trying to **effectively connect internal projects and required people** due to the complexity of the organisation. Trying to include all necessary people, in their perspective information manager especially are difficult to involve and connect. Software architects and developers are **restricted by standard development procedures and building blocks. Domain experts** are often **afraid of innovation** while they bring disruption to their normal operations. Most of them are senior experts on their specific domains, often possessing the belief in their superiority and have a **lack of effective communication skills** with development teams.
2. Client pioneers have difficulties to bring the required network together, beyond their network circle. Therefore, they expressed the wish **to network more and involve different suspects** in the FutureLAB process. The reason for that is department cross-learning, sharing good practices and establish a base for future common projects. Moreover**, breaking the development team "tunnel vision"** of the internal project team by **involving unusual suspects and building social networks** with externals for further development of current projects and any potential in the future.
3. Clients desire to receive a quick visually represented proof-of-concept (POC) to check its viability. By using the produced visualized solution, it would help them to **communicate the project and convince the rest of the project's key stakeholders to join.** Moreover, **achieve common agreement upon the project baseline** and **point individuals in the same direction**. And last, **stimulate key stakeholders to take ownership**.
4. Clients are struggling to bring the produces concept towards product development and/or its implementation.
5. Management of the pioneer' organisation wants to test and validate the idea of clients pioneers with the support of the expertise brought by the external party.

Account manager – problem identification - quantitative

The qualitative research with account manager Nur Kara-Atakan was performed on 28th of November and brought the following key insights:

Clients decide for the Future Center session to receive an **experience they cannot predict or imagine** with the factor of mysteriously, exceeding their initial expectations. The experience

inspires them by showing the possibilities though solution visualization and prototyping, as well as simulation and testing.

Clients pioneers are pulling new innovative project into their organisation, but the rest of the organisation is not ready yet or slow in response. The underlying problem is to convince and inspire the rest of the organisation the innovative project is valuable to execute. Looking from a project team perspective, prepare the organisation and its project team for a change. The unbelievers in the project teams are hard to change and adapt, therefore they should be inspired to shift to believers. On the other hand, it happens that innovation project which is ideated outside of the organisation is accepted by management level, but get stuck after they enter the organisation and the work returns to daily operational flow.

At the end of the FutureLAB session, clients expect to see the solution which communicates:

1. If the solutions are feasible – technically, socially, environmentally, economically, law and regulations, etc.
2. If the key stakeholders are actively involved in the project and willing to continue the development process
3. The value for the client

Appendix B

Description of case study Tankstation of the Future

Tankstation of the Future (TOFT) is part of a bigger project called InnovA58, lead by Rijkswaterstaat (RWS). The goal of InnovA58 is to expand the road and implement innovations, lead by three main themes stated below, between the area of Tilburg and Eindhoven. In the scope of this project, the realisation of the project TOFT should fulfil the future needs of the road user and local visitors, while being aligned to RWS goal of being fully energy-neutral by 2030 (Campus, 2018; Ilmer, Martín, Brandhof, Kruithof, & Broeze, 2018).

TOFT concept provides and operates an experimental playground, using Living Lab framework, for testing small-scale prototypes and concepts to achieve required social innovations. Different parties should be included to collaborate and co-create during concept development, such as knowledge institutions, government, companies, care housing and welfare institutions, as well as local authorities and citizen. However that the primary TOFT concept represents a strong vision, it still lacks practical answers on the questions about how the solution should look like, function and interact with the environment from various perspectives. Three main perspectives, namely technical and functional perspective, environmental and social perspective. Those three perspectives of TOFT has been individually ideated, but not conceptualized and integrated into one coherent concept (Figure 1).

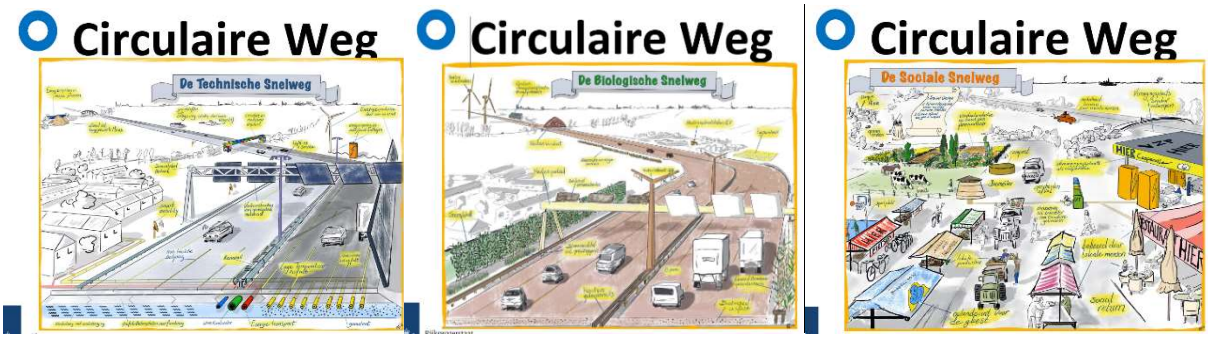

Figure 1: Tankstation of the Future - Technical and functional, environmental and social perspective

From a technical and functional view, the client was questioning:

- which are new services that fit the function of the TOFT users?
- which information about the region are needed at the location?
- how do a safe resting place and relaxation facilities for trucks look like?

The questions from the social perspective were:

- what would the people want to do at TOFT?
- what do you, as a visitor, want to see there?

- why would you go there and stay there?
- what are the future needs of the visitors, commuter and local communities?
- which social and technological innovations should be tested and implemented in TOFT?

Those answers on the individual perspectives should be described in a holistic Tankstation concept model, representing its looks and feelings, functions, as well as value and impact on the perspective domains and stakeholders.

Appendix C

Physical and digital tools for ideation and conceptualization

Five person-to-person experiments with participants were carried out at Dutch Design Week 2019 between the 21st and 23rd of October in Eindhoven. On those days, LEF Future Center facilitated an interactive exhibition with participants of Mobility Pavilion at the Dutch Design Week (Figure 1).

Figure 1: Interactive exhibition during the Dutch Design Week 2019

The goal was to test if simple-to-understand physical and digital prototyping tools and technologies help participants to understand the design challenge, support participants to imagine, ideate and build concepts. During this process, participants applied imagination and scenario making, paper sketching and drawing on existing maps and concepts, ideating using Collaboard software on Microsoft Surface Pro tablet by inserting keywords and, sticky notes and pictures (Figure 2, 3).

Figure 2: Ideation and conceptualization using Microsoft Surface Pro tablet and software Collaboard

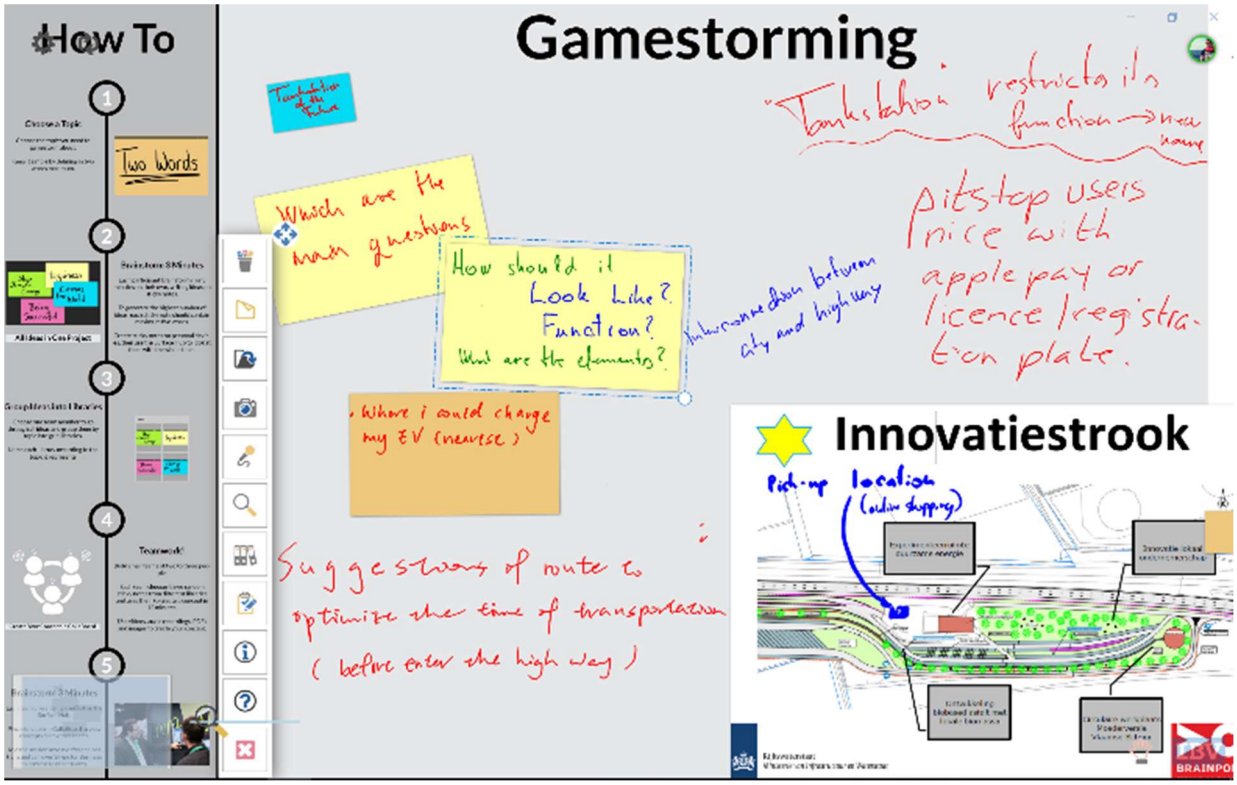

Figure 4: Outcomes of the ideation and conceptualization using Microsoft Surface Pro tablet and software Collaboard

The outcomes of the experiments were based on the observation and interaction with participants:

1. Participants are curious about trying new digital design tools and approaches to express their ideas, especially using Microsoft Surface Pro tablet and CollaBoard application to sketch their ideas, capture voice recordings and add pictures
2. Participants are highly cooperative when full attention is given to them and have the feeling of being heard and valued
3. The visual material provided to explain context information was not effective enough for participants to imagine the Tankstation‘ challenge
4. By using physical and digital designing tools, more information-rich and diverse concepts are produced. This can be achieved for the price of extra effort and time necessary to show and explain participants how to use new tools, which can expose the question when is it beneficial to introduce new physical and digital prototyping tools. Nevertheless, Microsoft tablet and CollaBoard application were found simple to use for a typical student, but not simple enough for an average visitor of Dutch Design Week with the average age of 35 years. The motivation of the majority decreased after 5 minutes of using it, while the tool was not intuitive enough and too slow learning curve.

Appendix D

Facilitators adopting new technology applications

An experiment with 21 facilitator participants was carried out during the session Community of Practice (CoP) in LEF Future Center by me, between 13th of December in Utrecht (Figure 1). In the experiment, two online digital tools have been introduced to the participants and examined their motivation to construct concepts by applying online digital tools. The experiment aimed to identify the difference between the expectation of the participants towards how digital tools should function and how do they perceive it after its utilization.

The experiment shown that facilitators and participants are interested and inspired to try new digital technologies for designing, but can often take too much time to learn, are impractical and not intuitive enough.

Figure 1: Test during the CoP session

During the session, an experiment was conducted in a group of eight participants. They were given an option to express their ideas and thoughts by using two online software program before unknown to them. Those were Miro, online whiteboard for collaboration, and Kumu, online network-based graph tool. Three participants from eight joined the experiment from curiosity and interest in new online design tools. While starting to interact with a new tool, one immediately discontinue the interaction and join the physical prototype group (Figure 2). The reason for that was too difficult operation of the Kumu, perceived by that participant.

Figure 2: User interacting with the new digital tool – Miro board

On the other hand, the two persons continued with. With the facilitator support, participants were capable of first built physical prototypes, took pictures of those, upload them in Miro and enhance those with extra symbols and word descriptions (Figure 3).

Figure 3: Outcomes of the utilization of the digital tool Miro

Nevertheless, both participants clearly stated that they are inspired by new technologies, and like to experiment, but most of them take too much time to learn, are impractical and not intuitive enough. As such, introducing the new skill to a person is similar to introduce a new technology or product and underlying behaviour needed to use it. Before the new product can be introduced, the person's present skill level and its product acceptance level needs to be discovered (Dam, 2020).