Design for Transfer

Kuipers, Derek

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2019

[Link to publication in University of Groningen/UMCG research database](#)

H6: Maximizing Authentic Learning and Real-world Problem Solving in Health Curricula through Psychological Fidelity in a Game-like intervention: Development, Feasibility and Pilot Studies

Abstract

High fidelity is regarded as a hallmark of educational games and simulations for health education. Primarily physical and functional fidelity are associated with authenticity, resulting in the pursuit of a real-to-life simulation and suggesting the imposition of a generally accepted and often unconscious design rationale that assumes that the greater fidelity of a game or simulation to the real world, the more authentic the intervention is perceived.

Psychological fidelity receives significantly less attention, although it is correlated strongly to credibility, suspension of disbelief, and engagement. The BABLR simulator reduces physical and functional fidelity to a minimum and explores the use of psychological fidelity as the main carrier of an authentic learning experience. BABLR was assessed using 26 participants with varying backgrounds in health innovation and social work. In several pilot studies, we collected data on perceived realisticness and real-world relevance. Results show that experts, as well as participants, acknowledge BABLR for its engagement, immersiveness, and motivational qualities. Practical implications of these findings for future research into developing low-fidelity simulations with high psychological fidelity will be discussed.

1 Introduction

Growing interest in game-like interventions to educate and train health professionals is apparent from the number of serious games and simulations that are used in medical education [1]. In the literature, many studies have evaluated game-like interventions developed and used explicitly for health education and training. However, the use of games in medical education is relatively new, and the full potential of serious game applications in medical education should be explored further [2]. Similar to the development of pharmaceutical therapies, serious games are held to the same rigorous scientific standards as those in randomized trials [3], but the design rationale of serious games or game-like interventions are rarely explored [4]. In regards to the development of therapeutic drugs or medical procedures, the quest for efficacy is necessary and justified. Without diminishing the importance of effect studies, in the case of designing game-like interventions for health education, it is too early to state whether specific approaches do or do not work. Thus, it is necessary to create space for experimenting with different forms of games and simulations. In particular, when it comes to fidelity, there seems to be limited scope as to the appearance of game-like interventions. Studies on game-like interventions for medical education do not investigate the specific design choices made and rarely provide design principles used to create the intervention. The consensus is that games for health education should aim to achieve a true-to-life, high fidelity representation [5].

In the following chapters, we will describe: 1) the reasons for the exploration of a low-fidelity simulator, 2) the way in which the design research process was carried out, and 3) the first results obtained with the simulator. Terminology originating from disciplines other than medicine will be briefly explained. BABLR, the name of the simulator, is not an abbreviation, but a corrupted Dutch word that shares common ground with English terms such as chatterbox or babbler. This name seems appropriate because the simulator provides text-based scenarios, focused on communication. The term artifact, as used in this article, refers to the simulator in the prototypical phase.

We describe supporting theories in the problem space, in the design space, we examine the formulation of design choices and how these choices shaped the artifact. Here, the simulator itself is also briefly described. Finally, in the solution space, we discuss the preliminary results obtained from the first assessments.

1.1 Problem Space

The field of health innovation education encompasses socio-technological issues, including technology acceptance [6], user-centeredness [7] and a learners' mindset towards design science research [8]. Attitudes and mindsets are important components of this competencies, especially within health innovation curricula and in so-called 21st-century skills [9,10] on a broader scale. In traditional health curricula, these tacit elements of competencies are hard to teach, train and measure in concrete, literal form [11].

It might be useful to elaborate briefly on the reason why design research is needed in health. Current health curricula teach natural or analytical sciences that are appropriate for the study of inductive and deductive phenomena, with a focus on reconstruction the past [12], in other words: studying what already exists. On the other hand, design research focuses on shaping the future by addressing so-called wicked problems, that require creative and innovative solu-

tions [13]. To deal with these wicked design issues, health curricula should, therefore, teach forms of abductive reasoning [14]. The literature describes the application of abductive research methods imperative to deal with unstable requirements and constraints, to be flexible in case of unforeseen interactions among problem and suggested solution, and a dependency on creativity and teamwork [15], all properties that do not have an explicit place in health education. Therefore, health curricula should emphasize a designer's mindset amongst students and equip them with skills such as prototyping, concept visualization and new strategies to engage problems as design opportunities for innovation [16].

A possible starting point to make the above possible can be found in the problem-based learning paradigm, well known and adopted in the current health education system [17–20]. Problem-based-learning in health curricula produces the "desired habits of mind, behavior, and action to become competent, caring, and ethical health care professionals" [21]. Defined as "learning that results from the process of working toward the understanding or resolution of a problem" [20,22], it forms a match with what we are expecting to achieve with the BABLR simulator. Exposing health students

to authentic and ill-defined activities with real-world relevance [23] connects problem-based-learning principles to design research. The goal of the BABLR simulator is to offer (as low-fidelity as possible) authentic scenarios, in which students solve wicked design problems. In this sense, BABLR is a training tool for using, training and explicating the tacit elements of a designer's mindset.

1.2 Design Principles

The reason for labeling the BABLR simulator as a low-fidelity game-like intervention stems from the ideas on design for transfer [24] and zero-fidelity [25]. The elaboration of these principles goes beyond the scope of this article, but the main idea is that where realisticness is concerned with the degree of similarity with the real world, realism can be seen as perceived realisticness. Relevant in this respect is that realism can be perceived as long as the player experiences coherence in the design of the simulator, and forgets that a simulator is being played on [26]. The latter is called suspension of disbelief [27] and is the desired working ingredient for the performance of the simulator itself. In research, to some extent, the degree of realism is held to be conditional for transfer to occur.

Fidelity is believed to be of importance in terms of relevance for learning and transfer [28], denoting the degree of similarity between the training situation and the operational situation, which is simulated [29]. According to Alexander [30], fidelity has dimensions beyond the visual design of a game. Notions of simulation fidelity include physical, functional and psychological fidelity [31]. Physical fidelity is the fidelity of the simulated physical elements in a simulated representation, e.g., virtual intestines that resemble those in a real body in a laparoscopic surgery simulator.

The same goes for functional fidelity: how are the functions from the source environment translated into a virtual environment? A simulation of a rat should react identically as a laboratory animal to interventions from outside. Both types of fidelity are about the realisticness of simulated reality. Psychological fidelity, however, can be seen as the degree of similarity between the mental experience in a simulator and the simulated reality. Does a simulation evoke the desired degree of stress or urgency, are the experienced feelings of pain, inability or joy true to reality?

This theoretical starting point forms the basis for the exploration of the BABLR simulator, reducing physical and functional fidelity

to a minimum and using psychological fidelity as the main carrier of an authentic learning experience.

1.3 Supporting Theories

A first supporting theory (ST) that informs the design of the artifact is that of double-loop learning [32]. In short, the concept of double-loop learning demands for tacit knowledge to become explicit. Initial actions of players arise from their mental models with regard to how to act in presented situations. Double-loop learning occurs when an error is detected and corrected in ways that involve the modification of one's underlying norms, beliefs, and objectives, rather than just adapting to the situation.

Further substantiation is found in the narrative transportation theory [33]. Narrative transportation occurs whenever the player experiences a feeling of entering a world evoked by the narrative because of empathy for the story characters and imagination of the story plot [34]. This theory actually shows that suspension of disbelief can be achieved by means of a strong narrative, or scenario. This offers possibilities for the intended low-fidelity character of the BABLR simulator. Narrative transportation is held to be more unintentionally affective than intentionally cognitive in nature. To enable

double-loop learning (tapping into and explicate tacit knowledge), the design of the BABLR artifact must, therefore, implement dedicated feedback loops that facilitate reflection-in-action [35]. These built-in feedback loops must be an integral part of the experience, to avoid disturbing the experienced realisticness of the simulation.

In early simulations, psychological fidelity was considered as a byproduct of high fidelity [36]. This way of thinking implies that low fidelity does not have any psychological value, although there are also studies that argue for low fidelity simulations, provided that they maintain a direct connection with real-world tasks [37]. In research, to some extent, the degree of realism is held to be conditional for transfer to occur.

The literature describes the difference between first class transfer types and second class transfer types. The first class consists of transfer types that advocate a literal method of transfer. The second class contains figural, sometimes more difficult to explain, forms of transfer. Our previous research [38] on second class of transfer [39] types showed that low fidelity is rarely consciously applied as a design rationale for the development of game-like interventions for health education and is usually associated with physical or functional fidelity alone. Cost saving is by far the most com-

mon reason to choose low fidelity over high fidelity. Where we found low fidelity as a conscious basis for the design, the objective always was the reduction of cognitive load [40] or the assumption that reduced fidelity is most suitable for learning motor and spatial skills. One study coined the concept of zero fidelity in a game without concrete elements of the simulated environment [25] and is consequently almost the only study of a game-like artifact where a substantive reason is put forward in favor of the use of low fidelity.

There are certainly examples of research into game-like artifacts that deliberately bring physical and functional fidelity back to the minimum, especially in the field of employee selection [41]. As mentioned earlier, Psychological fidelity is an important design parameter in serious games and simulations [25]; [42–45]. In addition, these studies all claim that representing the real world as literal as possible is less important for learning. The definition of psychological fidelity in this studies varies slightly, e.g. cognitive fidelity [46], but all studies mention the abstraction of certain real-world concepts and a process of recontextualization. Suspension of disbelief as an important characteristic of psychological fidelity: oneself's temporarily allowance to believe in something that is not true-to-life. Despite

the second class of transfer is not explicitly stated in those studies, they do utilize second class transfer in serious game design. The above provides sufficient support to assume that when it comes to acquiring attitude and mindset aspects of health curricula competences, this can be achieved by a simulator specifically designed to achieve its goals by means of second class of transfer.

1.4 Working Theory

The working theory is the above theories captured in one design hypothesis, bridging the problem space with the design space (see the left side of Figure 1), laying out the contours of the first version of the artifact. The design hypothesis here states that the artifact to be designed should contribute to the acquisition and explicitation of attitudes and mindsets belonging to a new generation of innovative health professionals. The artifact can achieve this with a low fidelity simulation game, which with minimal means evokes a lifelike world, in where the players are enticed to perform meaningful actions.
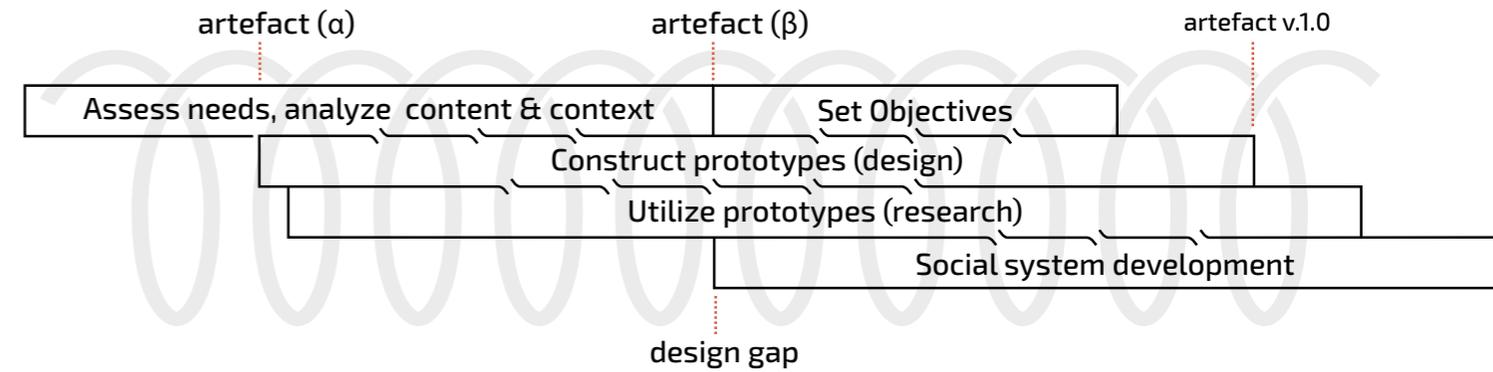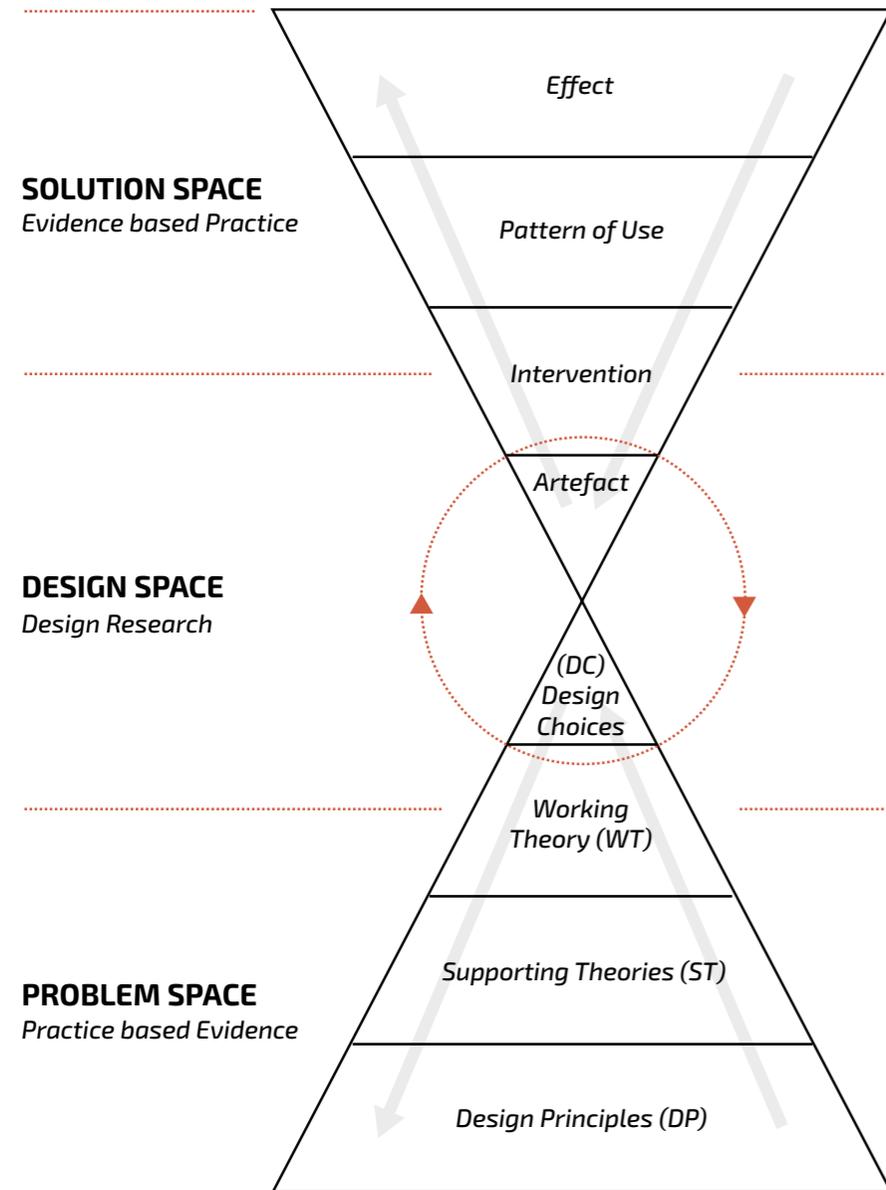
2 Methods

This chapter describes the way in which design research is applied, with the main

focus on the substantiation and justification of design choices. The research and development of the BABLR artifact are structured around spaces laid out in the layers in serious media design model (LiSMD), depicted in the left side of Figure 1. The term artifact refers to the prototype of the simulator in this specific phase. Common to design research practice, the prototypical instance of the artifact itself is regarded as an emergent boundary object [47], endeavoring towards a befitting answer to the problem-solution binary. The artifact is placed, as it were, between the problem situation and the desired situation to see if and in which form it can be a solution. This process of appropriation is facilitated by a design research framework as shown on the right half of Figure 1.

2.1 Design Space

Within the design space, we adopted a design science research approach [13] for articulating the design choices for building the BABLR artifact. This framework [48] is adapted from the rapid prototyping ISD model [49] and facilitates the development of the BABLR artifact through an iterative-incremental process. The focus of the iterations shifted during the process along to non-linear design steps [50], including ideation, prototype development, and prototype testing. The first step involved the

Figure 1: Layers in serious media design

(LiSMD) & Design Research Framework.

SOLUTION SPACE
Evidence based Practice

Effect

Pattern of Use

Intervention

Artefact

DESIGN SPACE
Design Research

(DC)
Design
Choices

Working
Theory (WT)

PROBLEM SPACE
Practice based Evidence

Supporting Theories (ST)

Design Principles (DP)

artefact (α)   artefact (β)   artefact v.1.0

Assess needs, analyze content & context   Set Objectives

Construct prototypes (design)

Utilize prototypes (research)

Social system development

design gap

development of the LiSMD-model (left side of Figure 1). The initial version of the model was constructed through a synthesis of various concepts and best practices, aligned with the main findings from DPs and STs as mentioned in Sections 1.2 and 1.3.

2.2 Procedure and Participants

Expert Panel

Five field experts were selected on the basis of a variety of expertise, such as specific knowledge about the practice of health and social work, knowledge about serious games and simulations or knowledge about education in the field of healthcare. BABLR uses text-based scenarios, tailored to the target group, each with its own internal trajectory and objectives. A potential scenario that would be playable with BABLR was presented during panel sessions, in which the entire scenario in full detail was presented in a walkthrough of the storyline. The experts were then invited to share their initial reactions and findings on the scenario in question. In a final, semi-structured questionnaire the field experts we asked about their reactions to, respectively, the perceived realisticness of the scenarios, the expected learning effect, and engagement.

Pilot 1

A first 8 day-pilot in which 6 students participated from the bachelor of social work, all attending an eSocialwork specialization course. Afterward, all participants were invited to partake in an evaluation session. A questionnaire was used to ask the players about the perceived realisticness of the scenarios, the expected learning effect, and engagement. Conditional for participating in the evaluation was a minimum of 2 interactions every 24 hours. All participants were rewarded with a cinema voucher. In addition to the participants' gaming experience, the aim of this pilot was also to verify the overall system performance, to test playability and the lead time of the given scenario.

Pilot 2

Ten bachelor students from different study programmes at the NHL Stenden University of Applied Sciences, The Netherlands, participated in the second pilot. A shortened scenario concerning communication styles had been developed for this pilot in order to introduce students to BABLR. For one week the students played the role of a junior communications officer, who just started a new job. During the game, however, the various contacts with the virtual opponents showed that there was a lot going on within the communication agency. The aim of this scenario was to find and interpret the communication problems, and then successfully use a communication model to guide the situation in the right direction. During a joint debrief, the experiences were discussed and shared.

Pilot 3

During the third pilot project, 9 social work professionals played a dedicated BABLR scenario for 4 weeks. These professionals were employees of the Tinten Welfare Group, a large social work organization (550 employees), located in the North-East of the Netherlands. The participants were part of a district team in the city of Emmen, and had different specializations within the social domain, such as youth worker, social worker or community worker. The district team participated as a whole in this pilot and was appointed by the Tinten Welfare Group's head of education. All participants were informed beforehand that the pilot was part of a study. A formative evaluation was conducted after two weeks and an extensive debrief took place at the end of the session. Again, the purpose of the third pilot was to gather information about the perceived realisticness of the scenarios, expected learning effects, and engagement.

In addition to acquiring early indicators of success of the overall functioning of the scenarios (perceived realisticness, expected learning effects, and engagement), each session gave the designers of BABLR insight into how to improve the artifact itself. The low-fidelity character of the simulator is characterized by the fact that BABLR's front end is actually nothing more than the respondent's mail client. Most of the changes are done to the back-end of the prototype, not visible to the players. In particular, the manageability of the various storylines in which individual players can find themselves in a scenario proved to be a real challenge. Following the experiences with the pilot studies, far-reaching changes have been made to the initial versions of BABLR. The design choices, the final prototype, and the early indicators of success are presented in the following chapter as a result of the design research process.

3 Results

3.1 Design Choices

As described in the introduction, BABLR is designed as a low-fidelity simulation game (DC). In order to optimize accessibility, the starting point was to be able to play the simulation without third-party software

(DC). The player plays the simulation from his or her own mail account. The text-based nature of communicating via email makes it possible to establish narrative transportation through scenarios (DC) which pre-selects on psychological fidelity alone. The scenarios are carefully crafted and based on authentic practical situations engaging players in real-to-life affairs (DC). All scenarios are set in the context of health and social work and place the player in a key position of a change agent (DC). In this capacity, the player must solve complex problems in the areas of project management, communication skills, and innovative design-based research projects.

3.2 The BABLR prototype

BABLR is designed to provide an authentic experience in a role-playing environment for students. A total of 26 players from different disciplinary backgrounds have used this learning tool with tailored scenarios to collaborate with others on authentic problems in the field of health innovation. All scenarios contain elements from project management, personal leadership, uncertainties and resistance in change processes and change agency through design research techniques.

The implemented BABLR scenarios provide complex socio-technological quests that give utterance to authentic decision-making, promoting collaboration, technology acceptance and leadership skills, all needed to be successful practitioners in the field of health innovation.

The prototype was evaluated in playtest sessions with end-users, including an immersion study, again providing input for the design and development of the prototype. After each session, observational data and players feedback were analyzed and led to a partial redesign or reconfiguration of the scenarios and back-end of the artifact.

BABLR front-end

Each scenario starts with a short introduction email, wherein the player is welcomed as a new team member. The mail email explains the task to be tackled and presents the virtual team members and their job profiles. The scenario starts to unfold when the player contacts the virtual team members, again by email. Each character holds specific information, which the player has to retrieve, combine and interpret, leading to the next move. Ideally, a golden path should be followed that leads to solving the wicked problem, but the scenario is that complex that it is imminent that this ideal line will

be difficult to find. In this search, players' actions become more tangible. The players' vigorousness towards virtual opponents, the quickness of establishing connections, seeing through motives, keeping key figures on-board and ultimately completing the scenario, are regarded as indicators of proven competent behavior.

BABLR back-end

The emails with responses from virtual team members are sent from the BABLR mail client. The game moderators can log in to the back-end via a web browser. Players can be added to BABLR, players can be divided into groups and players can be admitted in a specific scenario. In addition, the moderators can monitor and influence the course of a scenario from this back-end. The content of the reactions of the virtual team members is partly automatically provided by BABLR, but also augmented and refined by a moderator. This is primarily to ensure that the players experience the highest possible degree of authenticity in the conversations, but also to sometimes lead players back to the golden path in the scenario. The system knows where in the timeline of the scenario the player is situated and, based on that information, predicts the most appropriate response of a virtual character to an email from the player.

Moderators will modify and agree to these proposed responses as appropriate. Each player develops a certain understanding with his or her virtual opponents. For example, opponents can be happy or irritated and react from this state of mind. It is up to the player to recognize these emotions and respond accordingly.

Scenarios

The scenarios are separate entities that can be embedded in the BABLR environment. This way BABLR can host multiple scenarios, which can also be played simultaneously with multiple teams. It is beyond the scope of this article to discuss the design and origin of the scenarios in detail, but it suffices to rapport that each is divided into five parts, or acts [51], which some refer to as a dramatic arc: exposition, rising action, climax, falling action, and dénouement. The scenario developed for pilot 1, called FOCUS, is about a health care institution, for which a digital innovation (serious game) has to be developed. Whereas the health care institution itself seemingly has strong ideas about the artifact to be, during the scenario the player has to find out that end-users of this serious game have totally different needs. The solution to this scenario lies in reframing the problem, resulting

Figure 2: The sphere display, depicting in-game interactions between the player and virtual team members.

in a totally different solution. The scenario in pilot 2 is named BABEL, and deals with misunderstandings within a communication agency. The key to playing this scenario can be found in addressing mutual disputes and applying a communication model provided by a specific virtual character.

The TINTEN scenario used in pilot 3 can be completed by informing each other about an ongoing case as social workers. The aim of this scenario is to illustrate that operating from a too one-sided perspective on a case can be counterproductive and even dangerous and that the complete picture is necessary to provide the right care in complex social situations. After obtaining this overall picture, it is possible to work towards the end by choosing a collective, coordinated method.

Sphere Display

A final part of the system is the sphere display (Figure 2). On an additional monitor, the BABLR back-end projects the individual timelines of a group of players in horizontally distributed vertical lines. A single line represents one player. Colored spheres are shown on this line, corresponding with the email traffic flow. Each virtual team member has its own sphere color. With several successive interactions in short order, a sphere increases in size. The last send email is shown as a pulsating sphere, which indicates a required action by the moderator. The spherical display ensures that moderators have an overview at a glance of the progression of a group of players, where obstacles arise, and to whom they should send a message on behalf of a virtual team member. The sphere display is the only graphical component of BABLR, but it is not visible to players. The only thing players see of BABLR is the email traffic. After the completion of a scenario, or on a set end date, players and moderators will evaluate and reflect on the course of the simulation, critical incidents and personal experiences in a debriefing session.

3.3 Intervention

This paragraph describes the early indicators of success, which preface final statements on the effect of the BABLR simulator. The LiSMD-model intervention layer (see the left side of Figure 1) bridges the design space and the solution space. At this point, only statements can be made about demonstrated appropriateness and effect, based on the pilots as described in Chapter 2. The artifact transcends its prototypical status and can, therefore, be seen as an intervention from this phase on.

Perceived usefulness

In response to the scenario, the experts indicated that it appeared to be very recognizable and lifelike, that the issue to be solved was relevant, and that a number of characters from the storyline could be linked to people they actually knew. In addition, they underlined the importance of the possibility of training extra-curricular skills in a safe environment. The ability to evoke real-life learning situations that are difficult to recreate in existing health curricula was identified as a strength of the BABLR concept. After the concept has been submitted to the experts, they were asked to give an initial response to the design. During the questioning, the

strengths and weaknesses of the artifact were examined until a clear argumentation was given. Expert 1 was the first to mention that the prototype mainly deals with the relational aspect of such projects. In addition, expert 4 mentions the replayability as a major plus point, as well as "the ability to travel several routes, make different choices, the feedback mechanisms that ensure that there are consequences for the choices and the ability to gain experience with such projects." As a possible weakness, expert 1 mentions that the system or the scenarios can steer too much: "If there is too much steering, it is tricky (…) that really has to be taken into account." Also, expert 3 mentions the lack of actual visual designs to respond to: "I am of course also a designer, I think it would be very nice if students could also respond to visual designs in terms of content (…) you could, of course, put that into a scenario."

Expert 2 comments: "This is really very recognizable from my practice". The similarities with practice and the degree of realism are regarded as strengths. "I also think that gaining experience is a very strong point, very well done." In addition, expert 2 recognizes the phases of design thinking principles as well as their application within the prototype. Expert 2 sees a possible risk in the construction of the scenario "because

it may be quickly over the top." "Of course you try to let the important moments and escalations happen, but that can easily become too much (…) or maybe it becomes too difficult."

Motivation / engagement

Within the expert group the main reaction focuses on the player's experience: "In this simulation you really engage the student in a unique experience within a vivid scenario", and "We [expert 5's association] have realistic-looking simulations and they work well, but as soon as they [students] get out again, it [the experience] is over. That's just for a brief moment, but in this simulation, you can really keep them [the players] involved for a longer period of time…" The flexibility of the scenarios and storylines were also mentioned as a strong point. The time-consuming role of the facilitator as part of the simulation was identified as a weakness: "In order to keep it [the simulation experience] realistic, you [the facilitator] have to respond to the content and respond to what the player says. That is good, but it will also take time."

Table 1. Average scores for artifact scoring conditions, both from experts and students

Pilot	N	Characteristics	Mean
Design - viewed a prototype			
Expert Panel	5	field experts	
Preview - tested a scenario			
1 group	7	bachelor students social work	
questionnaire and interview			
- perceived realisticness			4.34 / 5
- motivation / engagement			3.75 / 5
- perceived usefulness			4.01 / 5
- expected learning effect			3.42 / 5
Users - participated in a trial			
1 group	10	bachelor students	
group-interview			
1 group	9	social work professionals	
questionnaire and group-interview			
- perceived realisticness			3.87 / 5
- motivation / engagement			3.05 / 5
- perceived usefulness			3.25 / 5
- expected learning effect			3.39 / 5

Perceived realisticness

When asked: "Do you expect the students will experience the simulation as realistic and authentic?", all the experts responded affirmatively. Expert 1 said: "Yes, very realistic. On several levels, both social and in terms of routes, there are many possibilities." Expert 3 added: "Yes, this is very realistic. Also in the scenario, the persons [virtual team members] are very recognizable and also their behavior is very true to life (...) a behavioral therapist [virtual character] who is critical, yes, I experienced that so often myself." In addition, the expert 4 suggested that the relationship between players and the virtual team members could differ per session, while these relationships might be one of the most important parts of the simulation: "Yes, you have to approach such

a policy advisor [virtual character] with conviction, otherwise you will lose him. At least, that would be the case in real life. It would be nice if different approaches could have a different effect", and: "I think that insight into the status of relations would be of added value."

Expected learning effects

When asked about expected learning effects, the experts confirmed the principle of learning through an immersive experience "because you can really keep them involved for a longer period of time, they can gain a lot of experience." Expert 5 also mentions the aspect of gaining experience as an important point for learning. Expert 2 adds that

Figure 3: Boundary spanning as the core of learning.

"they are really forced into the role of project manager, they have to be proactive (...) that is very valuable." Expert 1 notes: "You have to discuss and reflect on the choices you have made in order to create a good learning experience". A consensus was found on the importance of a real-life debrief, because "physical contact moments and reflection are also important for learning."

The three pilots generated both practical and substantive results. The scenarios proved to be generic enough to engage the players from different studies and vocational backgrounds. During the debrief, individual progress was shown and the players shared their strategies. In a few occasions, the participants found the scenarios hard to play but were curious about the outcome when they were not able to finish the scenario. Furthermore, the participants indicated that sometimes they would prefer to be able to meet or call the virtual team members from the scenario in person in order to be able to talk to them directly. At the time of the debrief, it only became clear to some players that they were dealing with virtual opponents. Table 1 shows the gathered feedback in debrief sessions after finishing the playing periods.

4 Discussion

From the start of this design research project, the pre-set goal was to examine if it was possible to design a game-like intervention with psychological fidelity as the main carrier of an authentic learning experience. In the artifact, any tangible form, either in functions or physical elements, was avoided. The LiSMD-model was used to support the design choices, the theoretical basis is described in sections 1.1, 1.2 and 1.3. For a series of three pilot studies with different target groups, tailored scenarios have been developed, all around hard-to-train tacit elements of so-called 21st-century skills. Five content experts and 26 players responded to four test items after playtests and scenario-walkthroughs. The BABLR prototype is currently in the intervention phase of the LiSMD, showing promising results in terms of perceived realisticness, motivation & engagement, perceived usefulness and expected learning effects.

A point of discussion may be whether the proven early indicators of success will actually feed through into final measurements. Here we can state on the basis of the first results, that the artifact in this line of growth will meet the set objectives. This design study shows that it is possible to achieve authentic learning in real-world issues by using purely high psychological fidelity as the main carrier. What cannot be demonstrated
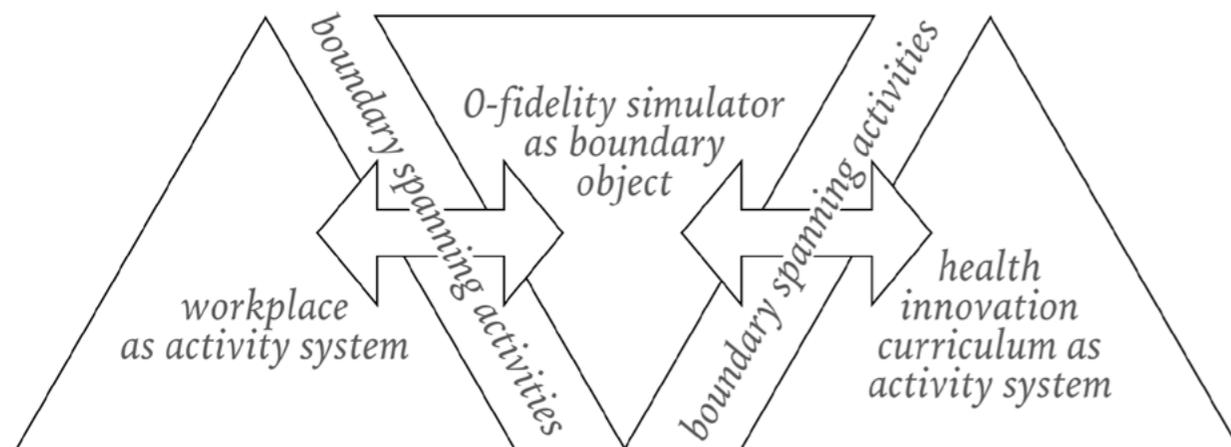
at this stage of development is whether the use of BABLR will lead to transfer or lasting learning effects, mainly because the artifact is not yet ready to generate data in the upper 2 layers of the LiSMD-model.

Drawing from the work on transportation [52], it can be argued that players' experience within the BABLR artifact in the case of high-transportation influences existing beliefs, even though the player knows that the story is fictional. Transportation defined as immersion into a text or drawing into a different place corresponds to the immersion and perceived realisticness properties shown in BABLR. In this uptake, we found BABLR to act as a boundary object, providing ongoing, two-sided actions and interactions between activity systems, even when the inserted narrative (scenario) is a meaningful, but recontextualized rhetoric. We learned that the BABLR simulator acts as a boundary object, as depicted in Figure 3, where the act of boundary spanning facilitates the actual learning. The literature describes this type of learning activities as dialogical learning mechanisms, triggering identification, coordination, reflection, and transformation [53]. It is this process of dialogical learning that to a large extent ties in with attitudes and mindsets sought after in 21st-century skills, as described in section 1.1.

One final comment concerns the role of the facilitator in BABLR. During the pilots, the facilitators were the same people who developed and investigated the artifact. Despite the fact that the field experts indicated that the scenarios approached reality adequately, it seems advisable to assign the role of the facilitator from the perspective of both health innovation education and the professional field. In this way, BABLR will be able to function even more clearly as a boundary object.

For the generalization of these findings, it will be necessary to further explore the concept of psychological fidelity as the main carrier of learning of tacit concepts of cognition in game-like interventions in other contexts and guises. When doing so, the LiSMD-model can provide a cross-domain perspective, combining medical contexts to educational and design theories. The model can be used to create space for experimenting with different manifestations of game-like interventions and other serious media and offers a generic design research approach for future work. The LiSMD-model might even be a boundary object in itself, bridging the strict separation between medical science and design [54].

Compliance with Ethical Standards

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

1. Durkin K. Videogames and young people with developmental disorders. Rev Gen Psychol. psycnet.apa.org; 2010; Available: http://psycnet.apa.org/journals/gpr/14/2/122/

2. Kato PM. Video games in health care: Closing the gap. Rev Gen Psychol. psycnet.apa.org; 2010; Available: http://psycnet.apa.org/journals/gpr/14/2/113/

3. Kato PM, Cole SW, Bradlyn AS, Pollock BH. A video game improves behavioral outcomes in adolescents and young adults with cancer: a randomized trial. Pediatrics. 2008;122: e305–17.

4. Fleming TM, Cheek C, Merry SN, Thabrew H, Bridgman H, Stasiak K, et al. Juegos serios para el tratamiento o la prevención de la depresión: una revisión sistemática. RPPC. 2015;19: 227.

5. Barry Issenberg S, Mcgaghie WC, Petrusa ER, Lee Gordon D, Scalese RJ. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teach. Taylor & Francis; 2005;27: 10–28.

6. Bagozzi RP, Davis FD, Warshaw PR. Development and Test of a Theory of Technological Learning and Usage. Hum Relat. 1992;45: 659–686.

7. Norman DA, Draper SW. User Centered System Design: New Perspectives on Human-computer Interaction. CRC Press; 1986.

8. Badwan B, Bothara R, Latijnhouwers M, Smithies A, Sandars J. The importance of design thinking in medical education. Med Teach. 2017; 1–2.

9. Trilling B, Fadel C. 21st Century Skills: Learning for Life in Our Times. John Wiley & Sons; 2012.

10. Frenk J, Chen L, Bhutta ZA, Cohen J, Crisp N, Evans T, et al. Health professionals for a new century: trans forming education to strengthen health systems in an interdependent world. Lancet. thelancet.com; 2010;376: 1923–1958.

11. Frank JR, Snell LS, Cate OT, Holmboe ES, Carraccio C, Swing SR, et al. Competency-based medical education: theory to practice. Med Teach. Taylor & Francis; 2010;32: 638–645.

12. Klabbers JHG. A framework for artifact assessment and theory testing. Simul Gaming. 2006;37: 155–173.

13. Hevner A, Chatterjee S. Design Research in Information Systems: Theory and Practice. Springer Science & Business Media; 2010.

14. Dorst K. The core of "design thinking" and its application. Design Studies. 2011;32: 521–532.

15. Hevner AR, March ST, Park J, Ram S. Design Science in Information Systems Research. Miss Q. Minneapolis, MN, USA: Society for Information Management and The Management Information Systems Research Center; 2004;28: 75–105.

16. Evans M. Empathizing with the Future: Creating Next-Next Generation Products and Services. The Design Journal. 2011;14: 231–251.

17. Davis MH. AMEE Medical Education Guide No. 15: Problem-based learning: a practical guide. Med Teach. Taylor & Francis; 1999;21: 130–140.

18. Taylor D, Miflin B. Problem-based learning: Where are we now? Med Teach. Taylor & Francis; 2008; 30: 742–763.

19. Savery JR, Duffy TM. Problem based learning: An instructional model and its constructivist framework. Educ Technol Res Dev. books.google.com; 1995;35: 31–38.

20. Savery JR. Overview of problem-based learning: Definitions and distinctions. Essential readings in problem-based learning: Exploring and extending the legacy of Howard S Barrows. books.google.com; 2015;9: 5–15.

21. Gwee MC-E. Problem-based learning: a strategic learning system design for the education of healthcare professionals in the 21st century. Kaohsiung J Med Sci. 2009;25: 231–239.

22. Barrows HS, Robyn M. Tamblyn B. Problem-Based Learning: An Approach to Medical Education. Springer Publishing Company; 1980.

23. Herrington J, Oliver R, Reeves TC. Patterns of engagement in authentic online learning environments. Australasian Journal of Educational Technology. 2003;19. doi:10.14742/ajet.1701

24. Kuipers DA, Wartena BO, Dijkstra A, Prins JT, Pierie J-PEN. Design for Transfer. Lecture Notes in Computer Science. 2013. pp. 239–246.

25. Toups ZO, Kerne A, Hamilton WA. The Team Coordination Game: Zero-fidelity Simulation Abstracted from Fire Emergency Response Practice. ACM Trans Comput -Hum Interact. New York, NY, USA: ACM; 2011;18: 23:1–23:37.

26. Huizinga J. Homo Ludens Ils 86. 2014.

27. Coleridge ST. Biographia literaria, or Biographical sketches of my life and opinions. 1847.

28. Noble C. The Relationship Between Fidelity and Learning in Aviation Training and Assessment. 2002; Available: https://ntrs.nasa.gov/search.jsp?R=20020074981

29. Hays RT, Singer MJ. Simulation Fidelity in Training System Design: Bridging the Gap Between Reality and Training. Springer Science & Business Media; 2012.

30. Alexander AL, Brunyé T, Sidman J. From gaming to training: A review of studies on fidelity, immersion, presence, and buy-in and their effects on transfer in pc-based simulations and games. Training Impact Group. academia.edu; 2005; Available: http://www.academia.edu/download/30709818/2005_Alexander_Brunye_Sidman_Weil.pdf

31. Lukosch H, van Bussel R, Meijer SA. Hybrid Instructional Design for Serious Gaming. Journal of Communication and. academia.edu; 2013; Available: http://www.academia.edu/download/32435668/Journal_of_Communication_and_ComputerIssue_12013.pdf#page=5

32. Argyris C. Double-Loop Learning, Teaching, and Research. Academy of Management Learning & Education. 2002;1: 206–218.

33. Green MC, Brock TC, Kaufman GF. Understanding Media Enjoyment: The Role of Transportation Into Narrative Worlds. Commun Theory. 2004;14: 311–327.

34. van Laer T, de Ruyter K, Visconti LM, Wetzels M. The Extended Transportation-Imagery Model: A Meta-Analysis of the Antecedents and Consequences of Consumers' Narrative Transportation. J Consum Res. 2014; 40: 797–817.

35. Schon DA, DeSanctis V. The Reflective Practitioner: How Professionals Think in Action. The Journal of Continuing Higher Education. 1986;34: 29–30.

36. Hays RT, Singer MJ. Definitions and Problems in Training System Design. Simulation Fidelity in Training System Design. Springer, New York, NY; 1989. pp. 4–22.

37. Kozlowski S, DeShon - Scaled worlds: Development RP, 2004. A psychological fidelity approach to simulation-based training: Theory, research and principles. researchgate.net. 2004; Available: https://www.researchgate.net/profile/Steve_Kozlowski/publication/267562279_A_Psychologi cal_Fidelity_Approach_to_Simulation-Based_Training_Theory_Research_and_Principles/links/546e11370cf2b5fc17603831/A-Psychological-Fidelity-Approach-to-Simulation-Based-Training-Theo ry-Research-and-Principles.pdf

38. Kuipers DA, Terlouw G, Wartena BO, van 't Veer JT, Prins JT, Pierie JPE. The Role of Transfer in Designing Games and Simulations for Health: Systematic Review. JMIR Serious Games. 2017;5: e23.

39. Royer JM. Theories of the transfer of learning. Educ Psychol. Routledge; 1979;14: 53–69. Sweller J. Cognitive load theory, learning difficulty, and instructional design. Learning and Instruction. 1994;4: 295–312.

40. Motowidlo SJ, Dunnette - Journal of Applied … MD, 1990. An alternative selection procedure: The low-fidelity simulation. psycnet.apa.org. 1990; Available: http://psycnet.apa.org/journals/ apl/75/6/640/

41. Dankbaar MEW, Alsma J, Jansen EEH, van Merrienboer JJG, van Saase JLCM, Schuit SCE. An experimental study on the effects of a simulation game on students' clinical cognitive skills and motivation. Adv Health Sci Educ Theory Pract. 2015;21: 505–521.

42. Rooney P. A Theoretical Framework for Serious Game Design. International Journal of Game-Based Learning. 2012;2: 41–60.

43. Gopher D, Well M, Bareket T. Transfer of Skill from a Computer Game Trainer to Flight. Hum Factors. SAGE Publications Inc; 1994;36: 387–405.

44. Salas E, Wilson KA, Burke CS, Priest HA. Using simulation-based training to improve patient safety: what does it take? Jt Comm J Qual Patient Saf. jointcommissionjournal.com; 2005;31: 363–371.

45. Hochmitz I, Yuviler-Gavish N. Physical fidelity versus cognitive fidelity training in procedural skills acquisition. Hum Factors. 2011;53: 489–501.

46. Carlile PR. A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development. Organization Science. 2002;13: 442–455.

47. Kuipers DA, Wartena BO, Dijkstra BH, Terlouw G, van T Veer JTB, van Dijk HW, et al. iLift: A health behavior change support system for lifting and transfer techniques to prevent lower-back injuries in healthcare. Int J Med Inform. 2016;96: 11–23.

48. Tripp SD, Bichelmeyer B. Rapid prototyping: An alternative instructional design strategy. Educ Technol Res Dev. 1990;38: 31–44.

49. Warner B, Simon HA. The Sciences of the Artificial. OR. 1969;20: 509.

50. Freytag G. Freytag's Technique of the Drama: An Exposition of Dramatic Composition and Art. 1900.

51. Green MC, Brock TC. The role of transportation in the persuasiveness of public narratives. J Pers Soc Psychol. 2000;79: 701–721.

52. Akkerman SF, Bakker A. Boundary Crossing and Boundary Objects. Rev Educ Res. 2011;81: 132–169.

53. Verkerke GJ, van der Houwen EB, Broekhuis AA, Bursa J, Catapano G, McCullagh P, et al. Science versus design; comparable, contrastive or conducive? J Mech Behav Biomed Mater. 2013;21: 195–201.