Design for Transfer
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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 authenticity, and real-world relevance. Results we collected data on perceived realistic-similarity and social work. In several pilot studies, varying backgrounds in health innovation education. Primarily physical and functional fidelity are associated with authenticity, resulting in the pursuit of a real-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 of 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-
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 realism is concerned with the degree of similarity with the real world, realism can be seen as perceived realism. 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 realism 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 realism 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 consists of transfer types that advocate 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 mindset aspects of health professionals. The artifact can achieve this with a low fidelity simulation game, which with minimal means evokes a lifelike world, in which 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.

**Problem Space**
- Design Principles (DP)
- Supporting Theories (ST)
- Working Theory (WT)

**Design Space**
- Design Choices (DC)
- Intervention
- Artafact

**Solution Space**
- Pattern of Use
- Effect

**Artafacts**
- Artefact (a): Assess needs, analyze content & context
- Artefact (b): Construct prototypes (design)
- Artefact v.1.0: Utilize prototypes (research)

Social system development

Evidence based Practice

Set Objectives

Design Research

Practice based Evidence
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 were 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.
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’ vigorosity 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
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.

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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

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

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.
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’s good, but it will also take time.”

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

<table>
<thead>
<tr>
<th>Pilot</th>
<th>N</th>
<th>Characteristics</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design - viewed a prototype</td>
<td>5 field experts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preview - tested a scenario</td>
<td>7 bachelor students social work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 group questionnaire and interview</td>
<td></td>
<td>- perceived realism/ness</td>
<td>4.34 / 5</td>
</tr>
<tr>
<td>1 group questionnaire and group-interview</td>
<td>10 bachelor students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 group questionnaire and group-interview</td>
<td>9 social work professionals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- perceived realism/ness</td>
<td></td>
<td>3.87 / 5</td>
<td></td>
</tr>
<tr>
<td>- motivation / engagement</td>
<td></td>
<td>3.05 / 5</td>
<td></td>
</tr>
<tr>
<td>- perceived usefulness</td>
<td></td>
<td>3.25 / 5</td>
<td></td>
</tr>
<tr>
<td>- expected learning effect</td>
<td></td>
<td>3.39 / 5</td>
<td></td>
</tr>
<tr>
<td>Users - participated in a trial</td>
<td></td>
<td>3.87 / 5</td>
<td></td>
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</tbody>
</table>
Perceived realismness

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 “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 realismness, 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...
Acknowledgments

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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.
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