Sneak Teaching Bridge

from learning domain to game mechanics

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Abstract

This thesis describes the study Sneak Teaching Bridge, which addresses the curiosity for games that have the intention to teach without the player noticing. These type of games were named Sneak Teaching Games and formed the subject of the main research question 'how can a digital learning application be shaped as a Sneak Teaching Game?'

In order to answer this question, a literature survey on Learning Games was carried out, of which the findings were used to design a prototype of the mobile Sneak Teaching Game *Britz!*

The literature survey revealed that one of the most difficult things for Learning Game designers is to find a balance between the learning domain and the game world: a Learning Game should be educational, but at the same time fun to play. This was pointed out as the area in which Sneak Teaching Games should try to go one step further, by creating a Sneak Teaching dimension.

During the design of *Britz!*, it was discovered that this Sneak Teaching dimension can be created by realising a tight bond between the game mechanics and the educational content. The results from heuristic test and user tests showed that this can be done by smart modelling of the learning domain and embodying learning elements by game elements.

The design process of the prototype of *Britz!* can be seen as an example of how a learning domain can be shaped as a Sneak Teaching Game.

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1 Oh! That is Sneaky!

> *An elderly lady at the local Bridge club in Antigonish, Canada, was interested in what I am actually writing about in my master thesis. I explained to her that I am trying to design a game that teaches people Bridge, without them even noticing it. Directly she responded: "Oh! That is Sneaky!". When I told her that my thesis is called 'Sneak Teaching Bridge', she laughed and said that she believes it is an excellent idea.*

Lately the commercial digital Learning Game DragonBox[1] made headlines in the international press (Eaton, 2013; Kühl, 2012) because of its fun and smart way of teaching young children how to solve equations, without them realising that they are doing mathematics. The children are playing an engaging game, which at the same time offers them a head start for when they will learn to solve equations in school. In fact, there are schools that are using Dragonbox in math classes[2].

There is no scientific term describing games that have the intention to teach without the players noticing. This thesis introduces the term 'Sneak Teaching Games' to describe such games. The overall main question in this thesis is "How does one design a Sneak Teaching Game?". To find an answer to this question a prototype of a mobile Sneak Teaching Game will be developed. This game, called *Britz!*, has the intention to teach concepts of card play used in the card game Bridge[3], without the players realising it, of course.

During the design of the prototype, the focus was on finding ways in which didactical and pedagogical methods can be used to support the intended learning goals with a minimal interference to the game play.

1.1 problem area & research questions

Although much research has been carried out in the area of digital game based learning, the niche of Sneak Teaching Games has been fairly unexplored. Most scientific research on developing digital Learning Games is focussed on integrating fun to make difficult or boring ma-

[1] www.dragonboxapp.com

[2] http://rootsoftheequation.wordpress.com/2012/12/19/dragonbox-in-the-classroom/ & https://www.youtube.com/watch?v=espOwMZYbQ8

[3] The word Bridge is spelled with a capital letter throughout the whole thesis, for readability issues.

terial easier to learn. Although Sneak Teaching Games also strive to combine fun and learning, they have an even more detailed focus: they try to hide the learning material within the game so that the learner will not realise during the play that he or she is learning a specific topic. The aim is that learners, or maybe better, players, perceive the game as an entertainment game, while in fact it is an Educational Game, with explicit learning goals.

Due to this more detailed focus, Sneak Teaching Games can be seen as a type of Educational Game, that brings a new angle to digital game based learning, and therefore a new area to explore.

Reasons behind wanting a concept like sneak teaching can have different origins, from as straight forward as pulling learning out of the classroom to more deeper intentions like letting people get acquaintance with a subject that otherwise would not appeal to them. It is presumable that developing a Sneak Teaching Game might even be more challenging than developing a regular Educational Game (in which it is not a high priority to hide the teaching intention), since it might involve a deeper relationship between the learning domain and the game world. Based on this presumption, the main research question of this master thesis is:

> **How can a digital learning application be shaped as a Sneak Teaching Game?**

The search to find an answer to this main research question was divided into two stages. The first stage places Sneak Teaching Games within the field of Learning Games and seeks towards a definition. In the second stage, a prototype of a mobile Sneak Teaching Game was designed and developed. In order to ultimately give an answer to the main research question, the following questions were used as guides throughout both stages.

- What are the most important characteristics of Sneak Teaching Games?
- How can scaffolding support the intended learning goals, without interfering with the game flow?

1.2 sneak teaching Bridge

As mentioned before, the subject that is chosen for the Sneak Teaching Game that was designed during this research is the card game 'Bridge'. This might seem like an interesting or odd choice since it is a game by itself, but looking at the number of academic articles referring to Bridge, there must be something interesting about this game. Also, Bridge is facing some challenges that make the subject suitable for sneak teaching, and has proven to be an interesting domain for academic researchers.

about Bridge

Bridge may seem like any other card game since it is played by four players at a table with a standard deck of 52 cards, but actually, Bridge is quite unique. When comparing Bridge to a popular card game like Go Fish, there are quite some differences concerning the rules, tactics, and seriousness as a game (or sport).

The rules of Go Fish can be explained in less than five minutes, and usually the players do not struggle a long time with finding a suitable tactic to increase their chances of winning the game. For Bridge this is different; learning just the technical rules of Bridge might take up to several hours, and in order to find and apply a winning tactic at Bridge, much more effort is required. People that have played Bridge every week for up to three years are still considered beginners.

Bridge has a worldwide network of national federations. The World Bridge Federation[4] has almost 700.000 individual members from 123 different countries. In some of these countries (e.g. The Netherlands) Bridge is even seen as a 'real' sport and falls under the same regulations as Olympic sports such as swimming and skiing.

attracting new players

Over the last years, the number of young people that play Bridge has declined. Many national federations try to change this, but with little success.

Unfortunately for Bridge the circumstance in which Bridge is played (sitting still at a table, not much talking and playing cards at an interme-

[4]World Bridge Federation: http://www.worldbridge.org/

Figure 1: People enjoying their weekly Bridge match at Bergen Academic Bridge Club

diate speed, see picture 1) does not make a great marketing start point. Neither does the way in which Bridge is taught these days: a number of live theory classes with several study books as a guide. Luckily, once the first step of learning Bridge is taken, many players enjoy the game, and keep playing it regularly.

Bridge could benefit from a way to acquaint young people with the game, without them having to overcome the threshold of going to a course, and an engaging mobile game could be the solution.

complexity

The reason why Bridge is usually taught with the old-fashioned methods of classes and books, is that in the beginning stages there are many rules to remember and basic skills to master. These skills involve understanding and applying theories and strategies that are also used in mathematics, economics, and statistics. The website of the American Contract Bridge League offers a synopsis that gives some insight in the rules and tactics of Bridge[5].

[5]"How to Play Bridge" at the website of the American Contract Bridge League: http://www.acbl.org/learn/howToPlay.html

The profoundness of Bridge as a game is recognised by the World Mind Sports Association[6], which labeled Bridge, together with Chess, Draughts, Go and Xiangqi, as a 'mind sport'. When compared to the beginning stages of the other mind sports, Bridge, however, has a high threshold. A five year old can play a recreational game of Chess, but for Bridge this is almost unthinkable.

Breaking Bridge down into smaller parts and modelling it into a Sneak Teaching Game could lower the threshold to try out Bridge. It could make it easier to master and understand the underlying theories and basic skills. On top of that it might help to improve the image of Bridge, and make it more approachable for youngsters.

research field

The connections that Bridge has to intellectual domains such as mathematics, economics and statistics, make it an interesting area for academic research. Some researchers choose Bridge as a tool to illustrate theories (Eriksson et al., 2001; Gillman, 1992), while others create tools specifically focussing on the Bridge domain (Ginsberg, 1999; Moriyon, 2012).

Sorting a Bridge Hand

Eriksson et al. (2001) state that the first task a Bridge player has to overcome before playing a game is to sort their cards. They were determined to find the optimal algorithm to complete this task in a minimum amount of moves. The sorting algorithm (used in mathematics and computer science to put elements in a certain order) that they created for this purpose takes into account that "professional card players never sort by rank, only by suit". Applying the proposed algorithm each time a Bridge hand is played will save a very high cumulative amount of sorting moves. Unfortunately, the algorithm is meant for computer use, so it seems unlikely that there will be any Bridge players applying this algorithm each time they pick up thirteen cards.

Bayes' rule

Gillman (1992) illustrates how Bayes' rule (concerning conditional probabilities) applies to Bridge. By applying Bayes' mathematical formula to a Bridge situation where one of the defending players drops the Queen or Jack in a certain suit, Gillman calculates that it is much more likely

[6] more information at: http://www.imsaworld.com/

that the other card (Queen or Jack) is placed with the other defender. In Bridge, this argument is called “principle of restricted choice”.

Bridge-playing programs

There are many computer programs available that allow a person to compete with and against the computer. One of these programs is GIB (Goren In a Box), a program designed by Matthew Ginsberg. In his paper “GIB: Steps Toward an Expert-Level Bridge-Playing Program”, Ginsberg (1999) enlightens the reader about the algorithms he chose for GIB’s card play and defence. As Bridge is a game of so-called ‘imperfect information’, Ginsberg chose to let GIB use “brute-force search to analyse the situation in which it finds itself, while Monte Carlo techniques are used to suggest plays by combining the results of the analysis.” Ginsberg acknowledges weaknesses of computer steered analysis. He mentions: “Human experts often choose not to make bids that will convey too much information to the opponents in order to make the defenders’ task as difficult as possible. This consideration is missing from the above algorithm. Ginsberg (1999, p. 587)”

Today, GIB is also used for real time double dummy analysis (knowing all 52 cards) in the online internet Bridge club ‘Bridge Base Online[7]’.

Bridge Teaching Table

A recent project that emerged is the Bridge Teaching Table, which proposes a solution on how to achieve collaborative Bridge learning (Moriyon, 2012). Moriyon recognises the limitations of traditional Bridge teaching methods, and created a web-based tool that can be used during Bridge classes. His aim is to achieve a Guided Collaborative Learning environment suitable for Bridge teaching. While using Microsoft Powerpoint gives the teacher linear possibilities of showing material, the Bridge Teaching Table gives the teacher the possibility to show, hide, and change selected elements on the spot. This gives the teacher flexibility to follow the thoughts of students by making changes to the shown examples, such as switching a card from one hand to another.

Moriyon’s believes that giving flexibility to the teacher about which elements of a Bridge problem to show to the students, will in particular “simplify the analysis by students of their conceptual mistakes” (Moriyon, 2012, p. 231).

[7] Bridge Base Online: http://www.bridgebase.com/

1.3 organisation of the thesis

This thesis is organised in nine chapters, with this first chapter featuring the introduction *Oh! That is Sneaky!*

2. Learning Games
Chapter 2 explores literature and theories that are relevant for Learning Games. It discusses how researchers arrived to wanting to design Learning Games, how designers try to merge game design and didactic design, which challenges can appear when using Learning Games in educational settings, and important aspects of mobile learning.

3. Exploring Sneak Teaching Games
The third chapter introduces the methodologies that are used in this thesis. It explains how the Creation & Design research strategy was applied and lists, and mentions other techniques and methods that were used. It also describes the heuristic test and user tests.

4. Sneak Teaching Games
Chapter 4 gives a description of Sneak Teaching Games, proposes a definition, and suggests a design approach for Britz!

5. Iteration 1 - Design prototype domain model
Chapter 5 describes the design of the domain model, the interview with the experts, and an evaluation of the findings.

6. Iteration 2 - Design paper prototype game environment
The sixth chapter describes the design of the paper prototype, the user experience test, and an evaluation of the test results.

7. Iteration 3 - Design Digital prototype game environment
Chapter 7 describes the design of the digital game environment, the user test, and an evaluation of the test results.

8. Discussion
The discussion gives an overview of the most important findings of Sneak Teaching Bridge and gives answers to the research questions.

9. Conclusion
The conclusion features a brief summary of the work done for this thesis, including the research contribution and suggestions for further research.

2 Learning Games

Simon Egenfeldt-Nielsen, computer game designer and expert in the field of Educational Games, recognises three forms of formal educational use of games: learning by making games, learning through games, and learning with games (Egenfeldt-Nielsen, 2010).

In *learning by making games* develop students their own games. In in the process of doing that, they learn about the contents of the game. *Learning with games* uses already existing games to teach relevant terms, concepts and methods. Playing entertainment games can contribute to the development of higher order thinking skills (McFarlane et al., 2002). In *learning through games* make educators use of games that are specifically developed with the purpose of being educational and focus on teaching specific skills or knowledge. These type of games will further be called **Educational Games** or **Learning Games**, and form the focus of this overview.

Sneak Teaching Games are similar to Learning Games, but have an important extra dimension in that they must appear to be an entertainment game. To get an overview of important aspects for Sneak Teaching Games, this chapter outlines aspects of Learning Games that can be relevant for Sneak Teaching Games.

The section 'from play to Learning Game' elaborates the interest in creating digital Learning Games. After that, challenges are discussed that occur when 'merging games & learning', this includes discussing how domain modelling can be of aid and which engagement strategies can be used. Also 'integration challenges' that can occur when wanting to bring games in educational environments are discussed. Finally, the section 'mobile learning' addresses considerations about Learning Games for mobile platforms.

2.1 from play to Learning Game

'Play' is often associated with recreational pleasure and enjoyment (Garvey, 1990). The Oxford Dictionary of English describes 'play' as "Engage in activity for enjoyment and recreation rather than a serious or practical purpose".

But 'play' has also been connected to more serious contexts. Play, for example, is believed to be of great significance for child development

in areas such as communication, language, creativity, and emotional well-being (Frost et al., 2008; Ginsburg et al., 2007). Play has also been connected with human culture. Dutch historian Johan Huizinga characterises play as a 'serious business', while he elaborates about the importance of play and play elements for the human culture and society (Huizinga, 1949).

Playing is fun, yet important and useful, thus the idea of using games in education seems very fitting. Physical toys such as Lego have been brought into educational settings to teach engineering to students (Rogers and Portsmore, 2004), but with the rising popularity and possibilities of technology, the use of digital games becomes very attractive.

Digital Learning Games originated out of the wish to combine fun and learning. Marc Prensky, expert in the use of games in education and author of the book 'Digital Game Based Learning' (Prensky, 2004), is very enthusiastic about the possibilities that Learning Games can offer education. His main idea is that the 'fun' element in games creates relaxation and motivation; being calm helps the learner to take in the material easily, and being motivated helps him to do this without resistance.

technology enhanced learning

Since the sixties researchers have been exploring ways in which learners and teachers can be aided by technology. In Europe, this field is referred to as Technology Enhanced Learning (TEL). The European Commission of Research and Innovation describes the research being done in the field of TEL as follows: "European research on technology-enhanced learning investigates how information and communication technologies can be used to support learning and teaching, and competence development throughout life.[8]" As TEL is a broad area with researchers from different disciplines, the STELLAR (Sustaining Technology Enhanced Learning at a LARge scale) Network of Excellence functioned as a hub to unify the researchers, developers, teachers, industry and other people interested in Technology Enhanced Learning[9]. The STELLAR network was setup "to provide a strategic direction for TEL research that explicitly relates to improving learning and education systems" (Sutherland et al., 2012).

[8] description at: http://cordis.europa.eu/fp7/ict/telearn-digicult/telearn_en.html

[9] see: http://www.stellarnet.eu

Table 1: Development of TEL since the 1960s (based on figure 1, Wasson and Morgan 2014)

	Genres of TEL	Pedagogical concepts	Learning Theory	Technology enabler
1960s	- Computer Aided Instruction (CAI) - Computer Based Learning (CBL)	Communication of subject matter	behaviourism	- if-then-else
1970s	- Constructionist Environments - Microworlds	Remediation of incomplete or incorrect knowledge	constructionism	- Artificial Intelligence - Microworlds
1980s	- Intelligent Tutoring Systems (ITS) - Computer Supported Intentional Learning Environment (CSILE)	Facilitation of knowledge construction	cognitivism / constructivism	- Construction kits
1990s	- Computer Supported Collaborative Learning (CSCL) - Telelearning Environments	Facilitation of communication / Transfer of skills and knowledge	social constructivism / sociocultural theories / situated cognition	- Groupware - Networks - Online learning - Distance Learning
2000s	- Mobile Learning	Facilitation of communication	contextualised learning	- Internet - Mobile technologies
2010s	- Participatory Environments	Facilitation of participation	participatory learning	- Web 2.0 - Semantic Web

Throughout the years TEL has been focusing on a wide range of different uses of technology. Table 1 summarises Wasson and Morgan's (2014) overview of the development of TEL since the 1960s. In the sixties most research was focused around Computer Aided Instruction (CAI) where the main idea was to communicate subject matter by the computer. Now in 2014, research has advanced to trying to facilitate learning by making use of web 2.0 technologies (Alexander, 2006). Questions such as 'can social media be integrated into the learning experience of students? (Grosseck and Holotescu, 2008)' and 'which issues could arise when mixing formal and informal learning? (Trinder et al., 2008)' are asked.

Digital Learning Games have had a place in TEL since the mid seventies, when Thomas W. Malone addressed the motivational factors of games and related these factors to learning (Malone, 1981; Malone and Lepper, 1987). He developed a theory on how *challenge*, *fantasy*, and *curiosity* could be used for intrinsically motivating instruction.

'How the West was Won' (WEST) (Burton and Brown, 1976) is seen as the first digital Learning Game. Originally, WEST is designed as a

computer board game, to give students drill and practice in arithmetic. By adding a tutoring system to this game, Burton and Brown wanted to show how automatically provided feedback and hints in a game environment could be accomplished. The project showed great results; students that played WEST with the inbuilt tutoring system made better choices in the game and on top of that showed much more variety in their choices. By implementing this tutoring system within a game, Burton and Brown gained insight in how complex it is and how much knowledge is "required to construct a coaching system that is robust, friendly and intelligent enough to survive in home or classroom use" (Burton and Brown, 1979, p. 5).

Following the study of Burton and Brown, many more studies have been and are being conducted on the subject of digital Learning Games.

what's in a name

In the beginning of this chapter, *Learning Games* and *Educational Games* have been set as terms that will be used in this thesis for games that embody the *learning through games* principle as defined by Egenfeldt-Nielsen (2010). However, when it comes to games and learning a diversity of terms is used in academical research.

'*Serious games*' is a term that often related to games and learning. Although experts do not fully agree on a precise definition of the term, a common understanding seems to be that *serious games* have a deeper intention than just being for leisure, fun or entertainment (Susi et al., 2007). This common understanding is broad and does not exclude games that have been made for marketing or sales purposes (Cook, 2005).

'*Edutainment*', a contraction of the words education and entertainment, is another term that often is used in relation to games and learning. *Edutainment* is a broad term covering the combination of educational and entertainment use of different media, including video games (Egenfeldt-Nielsen, 2006). Edutainment games are often seen as the predecessor of Serious Games (Charsky, 2010), but are characterised as being more drill oriented (Van Eck, 2006) and similar to school assignments, except with pretty graphics (Prensky, 2005).

What this thesis calls a *Learning Game* or *Educational Game* can be seen as a part of the domain of *serious games*, but the terms are not interchangeable.

2.2 merging games & learning

The design of an Educational Game, or as Schwarz and Stoecker (2012) call it *Learning Game Design*, is about merging game design with didactic design. The tricky part in this is to find a good balance between the two: on one hand the Educational Game should have game elements that make it 'fun' to play, and on the other hand the game should have substantial educational content.

In game design developers try to create a certain flow in their games, which makes the games easy to play. Psychologist Mihaly Csikszentmihalyi introduced this term in the seventies to describe a 'state in which people are so involved in an activity that nothing else seems to matter' (Csikszentmihalyi, 1990). In a perfect flow, the challenges presented and the ability of the user to solve them are in perfect balance, and this gives great satisfaction and pleasure. Marc Prensky states that a well thought-out game plan will help to reach this good flow. This includes introducing the player step by step to the rules of the game, or in other words: familiarise the player with the game mechanics.

In education, the concept of flow can be related to the zone of proximal development (ZPD), a term introduced by psychologist Lev Vygotsky (Vygotsky, 1978). The zone of proximal development presents the difference between what a learner can accomplish all by himself and what this same learner can accomplish with some help from a slightly knowledgable peer or tutor. This help is given in the form of instructional scaffolding, a method to provide sufficient support to the learners to achieve the next competence level. This means that the learner receives, for example, advice or coaching while doing an assignment.

Creating a well thought-out game plan for an Educational Game, includes keeping the flow during the whole game. On one hand developers try to engage the learner by increasing the difficulty of the game itself, while on the other hand they increase the difficulty of the educational content, keeping in mind the presumed zone of proximal development.

A well thought-out game plan should also include a way to involve the learning domain in the game mechanics. According to Egenfeldt-Nielsen et al. (2008) the lack to do so may result in games that are not very playable. Egenfeldt-Nielsen explains that difficulties may occur when the learning goals are somehow in contradiction to the game's goals, for example if speed is more important than accuracy of the an-

swer. In such a case, students will often tend to focus on achieving the game goals while neglecting the learning (Egenfeldt-Nielsen, 2006).

Creating a Learning Game this way, keeping in mind both the game aspects as well as the educational content, and interconnecting the two, requires creative minds, and a narrow cooperation between game designers and the didactic experts of the particular learning domain.

instructional design

When creating educational material, designers are always looking for a good way to present the domain to the learners. They try to make materials that keep in mind the zone of proximal development, and order the theory or assignments in a logical and smart way. For Learning Games, this is not any different; the secret of successful Learning Games lie in a foundation of good learning principles (Gee, 2003). The technology, or method, to accomplish this is called instructional design (ID). Merrill et al. (1996) describe instructional design as follows:

> "Instructional design is a technology for the development of learning experiences and environments which promote the acquisition of specific knowledge and skill by students." (p. 2)

Bloom's Taxonomy Bloom and Krathwohl (1956), dating from the 1950s can be seen as one of the most influential theories for instructional design. This framework classifies educational goals and is, in a revised version (Airasian et al., 2001), still used as a foundation for designing learning material.

Bloom and Krathwohl (1956) believed that by creating a framework that gives more insight in how people learn, educators can have an advantage when designing effective material. This taxonomy of educational objectives, or "Bloom's Taxonomy" divides educational objectives into three areas: cognitive (focus on knowledge & comprehension), affective (focus on emotion & attitude), and psychomotor (focus on physically using a tool). By outlining these three areas, Bloom and Krathwohl (1956) tried to motivate educators to focus on all three areas in their teachings, promoting a holistic form of learning. The nowadays best known application of Bloom's Taxonomy is in the cognitive area. To fully master a cognitive skill, one moves through six different stages: knowledge, comprehension, application, analysis, synthesis, and evaluation. The revised version of Bloom's Taxonomy (Airasian et al., 2001) uses verbs

instead of nouns to refer to the stages. Figure 2 shows a visual presentation of the stages to master a cognitive skill as presented by Airasian et al. (2001).

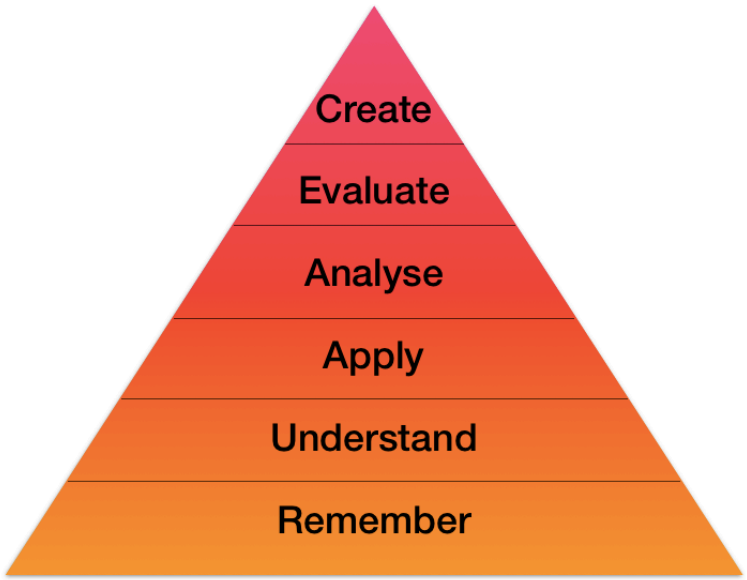


Figure 2: Bloom's Taxonomy: stages to master a cognitive skill based on (Airasian et al., 2001)

4C/ID

An interesting approach to the design of instructional environments is the Four Components Instructional Design model (4C/ID) by Van Merriënboer and Kirschner (2012), which focusses on how to teach complex skills. Van Merriënboer et al. define complex skills as skills that require the integration of knowledge, skills, and attitudes, creating an holistic approach, just as Bloom and Krathwohl (1956). According to Kirschner and Van Merriënboer (2008) holistic design approaches to learning "deal with complexity without losing sight of the separate elements and the interconnections between them" (p. 245).

Van Merriënboer and Kirschner (2012) designed the 4C/ID method for the development of training programs of substantial durations. The central message of the method is that environments for complex learning can always be described by four components: *Learning Tasks*, *Supportive Information*, *Procedural Information*, and *Part-Task Practice*. To make the 4C/ID practicable for teachers, domain experts, and instructional designers, Van Merriënboer and Kirschner introduce a ten

step design process (The Ten Steps), see table 2, that cover the four main areas. They stress that it is not always necessary to go through all steps; it differs from project to project. They also mention that the steps are not meant as a purely linear process, and that iterations may occur. The flexibility and practicability of the ten steps, make that this method could also very usable in the design of a Learning Game.

Table 2: The components of 4C/ID and the ten steps (based on table 1.1, Van Merriënboer and Kirschner 2012)

Components of 4C/ID	Ten Steps to Complex Learning
Learning Tasks	1. Design Learning Tasks
	2. Develop assessment instruments
	3. Sequence learning tasks
Supportive Information	4. Design supportive information
	5. Analyse cognitive strategies
	6. Analyse mental models
Procedural Information	7. Design procedural Information
	8. Analyse cognitive rules
	9. Analyse prerequisite knowledge
Part-Task Practice	10. Design part-task practice

Learning Tasks

In 4C/ID, the learning domain gets analysed and *divided into learning tasks* (step 1). This helps to make clear from the start what the program or course that is being designed aims to achieve. Step 2, the *development of assessment instruments*, is used to set an aim to what level the learners must reach. These assessment instruments are used to determine whether the standards have been met and make it possible to give feedback on the performance. Step 3 aims to *sequence the learning tasks* in a way so that the learning process is optimised. This is done by ordering the tasks by difficulty, as well as decreasing the amount of support and guidance. Learning tasks with similar difficulty get grouped into task classes.

Supportive Information

The *design of supportive information* (step 4) is meant to help the learners get tasks done. It focusses on information that learners need to complete the tasks, in the beginning stages of Bridge this could be, for example, knowledge on the order of the cards. Van Merriënboer and Kirschner (2012) explain that it may be helpful to *analyse cognitive strategies* (step 5) that skilled task performers use to solve problems, especially if there are no existing instructional materials available. Step 6, the *analysis of mental models* is also optional. This step is used to analyse the mental models that describe how the domain is organised.

Procedural Information

The *design of the procedural information* (step 7) is also aimed to help the learners get tasks done, but it focusses on reoccurring aspects, and is preferably presented at the precise moment that it is needed. In a mobile card game this could be the instruction on how to select and play a card. Step 8, the *analysis of the cognitive rules* provides the basis of the design of the procedural information, but is (just like step 9) only necessary if the procedural information needs to be designed from scratch. By constructing if-then-else models and/or procedures of how experts perform tasks, cognitive rules are visualised. The ninth step, *analysing prerequisite information*, focuses on finding what knowledge the learners need in order to be able to perform the reoccurring aspects of a task. This step also tries to identify misconceptions learners may have.

Part-Task Practice

Van Merriënboer and Kirschner (2012) recognise that it can be necessary to *design parts-tasks practice*, especially in cases where the content is very complicated or very critical.

ID/ for Learning Games

While the 4C/ID method is suitable for the development of all types of learning materials and courses, including Learning Games, there has also been research relating instructional design specifically for Learning Games. Most research in this area focuses on finding a balance between learning and game elements. Moreno-Ger et al. (2008) looked specifically at how Learning Games are developed, Dickey (2005) researched how engagement strategies in entertainment games can inform instructional design, Amory et al. (1999) found out which game

elements appeal to students, and Foley and Yildirim (2011) researched how Educational Game designers achieved the balance between entertainment and instructional design.

Moreno-Ger et al. (2008) noticed that many initiatives for the development of Learning Games fail or are rejected at an early stage due to high development costs and the risks involved with that. A solution to this problem could be to use commercial games that already have proven to sell, and adjust these games to improve the educational value, which would reduce the development costs significantly. Still, Moreno-Ger et al. do not see this as an optimal solution; they would prefer to see specifically designed Educational Game engines. They believe that such a game engine will reduce costs, help to lower technical requirements, and let educators produce and maintain the games themselves. Even though creating a game engine is not within the objectives of Sneak Teaching Bridge, Moreno-Ger et al. do point out some interesting key pedagogical assets. They believe that a Learning Game that can *adapt* to learners of different levels of initial knowledge, will have a higher quality educational experience than games that are not adaptive. Moreno-Ger et al. also believe that games as a rich, interactive medium are ultimately suitable as an *assessment* tool. By saving logs of student activity, educators can interpret how the students are progressing.

Popular computer and video games make use of engagement strategies. Dickey (2005) researched what these strategies nowadays are, and how they can be used in instructional design. Dickey came up with a list of questions (see table 3) that designers can go through to set up an architecture for interactive learning environments.

The main game areas that Dickey identifies as engaging are *player positioning*, *narrative*, and *interaction*. Player positioning, or in game terms *perspective*, is relevant in order to draw the player into the game. Dickey mentions that traditional board games take place in a single two-dimensional space, which the player manipulates from the outside. By creating a game space in which the player can move through the graphical environment while encountering new events, actions, and activities, the game would become more engaging and thus, more fun. Narrative, the second area Dickey identifies, is a controversial subject in game design (Juul, 2001; Ryan, 2006). Proponents of narrative in game design believe that it plays an important role in engaging game-

Table 3: Design questions for integrating game design strategies to support learning activities (based on table 2, Dickey 2005)

Area in game design	Associated questions
Narrative	What is the primary obstacle or conflict that must be overcome?
	Who are the main characters and how are they constructed?
	How will the backstory be conveyed?
	Who is telling the back(story)?
	What is the purpose of a cut? (if used)
Perspective	Where is the learner positioned in the environment?
	How will information be revealed to the learner?
Interactive Design	What are the physical dimensions?
	What are the temporal dimensions?
	What are the environmental dimensions?
	What is the emotion that this activity hopes to evoke?
	What are the ethical dimensions or moral aspects of this activity?
	What type of hooks will help support the learning activity?

play (Bringsjord, 2001; Jenkins, 2004), while the opposition argues that it is interaction what makes a game engaging (Juul, 1998). Regardless of one's opinion, narrative has long been used in game design. To integrate narrative into games, designers often use a *back story* and *cut scenes*. A backstory provides a context in which the game takes place, while cut-scenes are often used as intermezzi during the game. According to Dickey having a story around the game enables the element of fantasy, which is indicated by Malone (1981) as one of the key areas that can lead to intrinsically motivating instruction. The last game area that Dickey identifies as engaging is *interaction*. Dickey distinguishes three ways in which an interactive design can be created: *setting*, *roles & characters*, and *game play hooks*. By creating a *setting* that includes physical, temporal, and environmental dimensions, designers can provide players with a sense of immersive game game play. Dickey mentions that *roles & characters* could be used to benefit from role playing techniques that are often used in education, such as role reversal between students and teachers. *Game play hooks* are anything that requires the player to make a decision in the game. The actions of the player will generate feedback from the game. This way of thinking can give interesting opportunities for instructional designers if they manage to fit the learning domain into this model.

Also Amory et al. (1999) researched engaging game elements, however they approached it completely from the student's perspective. Amory et al. wanted to know which game elements students found interesting when playing entertainment games for educational purposes. Amory et al. let the students play a couple of entertainment games and gave them a questionnaire to evaluate aspects related to the game enjoyment (sound, graphics, type, story-line and technology), skills (logic, memory, visualisation, mathematics, reflexes and problem solving), and game play (addictive, boring, too difficult or illogical). The students identified graphics, sound, and story line as important game aspects that make the games fun. Visualisation, logic, and memory were identified as the most important skills to be able to play the games successfully. The evaluation by the students gave the researchers good insight into which aspects of the games the students perceived best. It also brought ideas about which game elements should be focused on during the development of Educational Games to make them appeal to learners.

Foley and Yildirim (2011) researched the paradoxical relationship between the entertainment value of Educational Games and their instructional design. They reviewed existing literature and found that Educational Game designers use both strategies that support entertainment value of Educational Games, and strategies that support the instructional value of Educational Games.

The strategies that Foley and Yildirim found that are meant to support the entertainment value of Educational Games are: a fantasy environment; a sense of control and challenge; and, collaboration & social interaction. In particular the fantasy environment stood out as paradoxical to Foley and Yildirim, as they state that in most educational settings it is preferred that learners encounter situations that reflect real life, as studied by Herrington et al. (2014).

Strategies that support the instructional value of Educational Games, according to Foley and Yildirim, include the incorporation of meta-cognitive strategies such as reflective quests and self-evaluation elements, the availability of external support, the allowance of teacher involvement, and scaffolding through dialogue.

Foley and Yildirim believe that a certain harmony can be achieved by employing strategies that are supporting the entertainment value, as well as strategies that support the instructional design.

scaffolding & feedback

Instructional scaffolding is closely related to Vygotsky's zone of proximal development (Vygotsky, 1978), and could be seen as the assistance given to students in order to fulfil tasks that are new or above their ability. Scaffolding is also used in game design, for example, to teach the player game mechanics or give new information to players.

Possibly, the game interface can be used to scaffold and give feedback related to educational issues to the players through game elements. Dickey (2006) promotes narrative scaffolding by providing clues and resources through the game environment by using inventory such as documents, diaries, or objects.

Warren et al. (2008) suggests character dialogue as a form of embedded scaffolding. Also enhancements to game elements can be used to scaffold; drawing the attention of the learner to a certain object, may induce ideas about how to proceed. For example they can be used as embedded tips.

If it is possible to scaffold and give feedback through the game, with or without a minimal separation between the learning and the game, this could benefit the flow of the Learning Game. It could help to create a balanced learning curve while at the same time help the player to understand the game mechanics.

monitoring & assessment

An important task of educators is to keep track of how students are progressing in their learning. As pointed out by Moreno-Ger et al. (2008) the rich, interactive environment of games can be exploited as an assessment tool.

Shute (2011) provides a method she calls *stealth assessment*, which is developed to assess students, while at the same time maintaining the game flow.

Shute points out that when assessing it might be necessary to look at a sequence of interactions of the player with the game, and not just at the product. This provides problems for traditional assessment methods that usually treat each question as an independent datapoint. According to Shute, games that include stealth assessment must be able to evoke behaviour in the students that shows evidence of their skills and knowledge, and additionally, the game must be able to interpret this

evidence in such a way that it suits the purpose of the assessment. This is not an easy task, but Shute believes that Evidence-Centered Design (Mislevy et al., 2003) and Bayesian networks (Pearl, 1988) can be of help in accomplishing such a system.

Shute looked at Evidence-Centered Design and applied it to games with stealth assessment. As with an intelligent tutoring system, she believes that games with stealth assessment need: *student models* to represent beliefs about the targeted aspects of the assessed skills; *evidence models* to identify what actions or behaviour of the student provide evidence about the assessed skills; and *task/action models* to indicate which situations are likely evoke such behaviour. To create these type of models, Shute proposes to use Bayesian networks to map the the different variables that occur in the game and visualise their dependencies on each other. By using such a map, the system can identify, based on the learners current state, how good a decision was in that particular situation.

Stealth assessment alines very well with the idea behind sneak teaching. It could also be a great option for student's with performance anxiety.

2.3 integration challenges

As if developing a high quality Learning Game isn't challenging enough, there are often challenges to overcome concerning the integration of the games into an educational environment. Many people can make or break a successful integration, and developers also face a range of equipment, financial, and procedural challenges. It is important for developers to keep these aspects in mind, to make the chances of success as high as possible.

stakeholders

John Kirriemuir et al. comprised a list of stakeholders, see table 4, that they believe should be considered during the development of games for use in schools. They consider all the people mentioned in this list as influential in the decision making about the integration of games in the classroom. The list shows, among other things, that: the school children are important since they are the ones playing the games; the teacher plays an important role in fitting games into the curriculum; and several stakeholders are connected to the funding of the games.

Table 4: Stakeholders to consider in the development of games for use in schools (Kirriemuir et al., 2004, p. 35)

Actor	Affect
School child	Plays the game
Friends of school child	Peer pressure and group social behaviour can alter a school child's perception or use of the game
Teacher	Needs to know how to use the game to best effect. Will examine the game critically
Parent	Keen to see that their child receives the best and most appropriate education and teaching
Governor	Approves or oversees teaching practice within the school
Head teacher	Approves financial spending on items such as technology and software within the school
Technician	Can determine, or enable, what technologies and software can work within the classroom
Local funding body	Affects funds that the school receives
National educational body	Indirectly affects funds that the school receives; prescribes curriculum that the school follows
Media	Reports on school and education matters, which can affect the attitude of the various actors

It is often assumed that the children or students will enjoy to play games in the classroom or as homework. Kurt Squire questions this (Squire, 2005). Squire studied several educational uses of the entertainment game Sid Meier's Civilization III (Firaxis Games & Westlake Interactive, 2001) and noticed that students who do well in school seemed more hesitant about playing games in educational settings. Squire believes that possibly, learning through games might be more appealing to children for whom learning in the traditional way is not working optimal. He concludes that when games become compulsory, at the minimum, educators need to be careful that bringing entertainment games into schools does not rob the games of precisely those qualities that make them so engaging.

Kirriemuir et al. (2004) consider the teacher as an important factor in the process of introducing games in the classroom. Of course, teachers will need to feel comfortable with using technology, and games in their classes, but they also have to convince the school board, head teacher and parents that using games is a good idea. Teachers have to find games, become familiar with them, look for methods of getting the best results from their use, and figure out which skills the games teach, all

in order to know how if a particular game is suitable for the curriculum. Sometimes getting acceptance for using games in the classroom is not an easy task, especially not when there are still (pre)conceptions about games that associate them with violence or addiction (Anderson and Bushman, 2001; Gentile et al., 2004).

Another point brought to the attention by Kirriemuir et al. (2004), is the equipment of schools. Sometimes, schools make use of old fashioned technology; in some cases even commonly accepted features like flash player and java are not available at the computers in the schools. This limits the teachers choice, as well as it can be a limit for projects that develop Educational Games. There are cases in which government funding will be withdrawn when the developers do not meet the provided technical limitations. Dr. Janice Gobert from the department of learning sciences and psychology at Worcester Polytechnic Institute, encountered this problem with her research group that develops interactive simulation games for science learning. Even though her research group would love to make use of advanced technology and platforms, they are bound to keep the games low-tech.

The development of entertainment games can run into the hundreds of thousands of dollars, since the creators are expecting to sell the games to thousands of people. It is safe to say that the sales expectancy for Educational Games is a lot smaller than that expectancy for entertainment games, which makes it more risky for the industry to invest money in the development of Educational Games (Moreno-Ger et al., 2008). Luckily, games such as DragonBox prove that it is possible to create a high-tech *and* high quality Learning Game that reaches a wide range of people and schools.

evaluation

De Freitas and Oliver (2006) provide a four dimensional framework to evaluate Learning Games. A thorough evaluation can facilitate educators with a good profile for the game, and thus make it easier to recognise if a game suit the curriculum requirements and integrate it into the classroom. Figure 3 shows a visual representation of the framework.

By answering questions about the game during the evaluation process, De Freitas and Oliver (2006) try to create a profile for the game. The first dimension that they mention is about the context in which the game will be played. This includes the physical location (e.g., at school or at

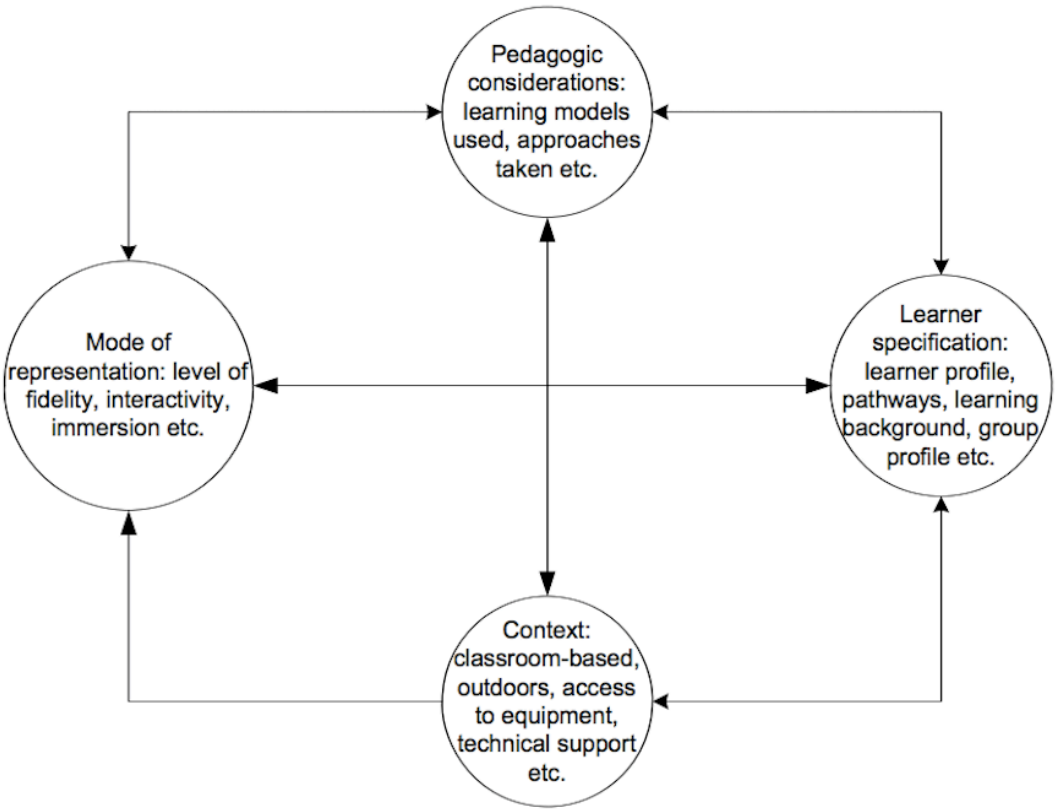


Figure 3: A representation of the four dimensional framework for evaluating games- and simulation-based education. (taken from figure 1, De Freitas and Oliver 2006)

home), but also how the game fits in the curriculum of the school. The second dimension addresses the target group, and tries to identify for which kind of learners the game is suitable, by answering questions about the preferred learning style, learning background, etc. The third aspect of the model describes which pedagogic considerations the game encompasses. Evaluators describe how they used the game, which learning activities the game offers, and which learning outcomes they found on the way. The fourth and last aspect that de Freitas and Oliver mention is the mode of representation. There the software tools should be evaluated, and questions about what kind of immersion is needed from the learners to get good outcomes, what links can be made between the game world, and a reflection upon learning should be answered.

The approach of de Freitas and Oliver seems to be a good way to assess the educational content of games. It seems to be relevant that

evaluators receive good documentation in clear language about precisely which questions they should try to answer about the games and which aspects of the game they should describe. However, De Freitas and Oliver do not mention, game elements, flow or fun in their framework, thus it could be an idea to add a dimension that evaluates how and if students are enjoying the game itself.

Developers of Educational Games can benefit from keeping in mind the way their game will be evaluated. To create a stronger starting point for their game, developers can, and should, anticipate the evaluation by providing easily accessible and understandable documentation for educators.

2.4 mobile learning

Today, many games are developed on mobile platforms. This offers interesting opportunities both for educators as well as for learners. Although the 'mobile' in mobile learning can be interpreted in multiple ways (Sharples et al., 2009), the main reason to develop *Britz!* as a mobile game is popularity.

The popularity of smartphones and tablets is continuously growing, which gives applications developed for this medium the possibility to reach a wide range of people. Downloading new games onto a tablet or phone has a low threshold, which makes it easy to distribute *Britz!* through channels that are already known by the target group. Also the already existing possibilities to connect people through for instance Apple's game centre, might be of use.

Combining learning with use of mobile devices can also be of use to enhance life-long learning, as it allows individuals and groups to learn anytime, anywhere (Sharples et al., 2002).

Mobile devices are nowadays hi-tech products that have graphical possibilities and processing power that are often powerful enough to display advanced graphics and animations. Although probably not relevant for *Britz!*, the built in functionality such as GPS, compass and SMS can be integrated in games to create interesting mixed environments, where aspects from the digital and the physical world are combined; one can even create an augmented reality.

designing for mobile learning

Designing for mobile devices can be challenging. Ally (2005) have specifically looked at the design of mobile learning materials and believe they require a careful design. Taking into account the limited screen sizes, Ally suggests to chunk down the displayed information into small pieces and order these chunks into meaningful sequences. Ally also advocates a shift from textual writing to the use of visuals, photos, videos, and audio.

Churchill and Hedberg (2008) add that scrolling should be avoided and that learning objects should be designed for a full screen presentation.

It might also be useful for designers to storyboard their prototypes on small pieces of paper that reassemble the real size of the device they are developing for (Rettig 2002, recalled from Churchill and Hedberg 2008).

success of mobile games

Learning Game designers are advised to look into aspects that make commercial video games attractive (Amory et al., 1999; Dickey, 2005). These aspects,in general, also apply to mobile games, but are there other elements that contribute to the success of mobile games?

The success of one of the most popular mobile games, Candy Crush[10], is attributed to the *social side* of the game (Stern, 2013). The game connects to Facebook and shows which levels friends are playing. It triggers social interaction by a feature that allows Facebook friends to donate lives to each other, which adds a sort of excitement for players.

According to Icaza (2011) one of the secrets to the success of Angry Birds[11] is that the concept is *expandable*. The makers of Angry Birds keep their players interested by offering them changes of scenes. Also the possibilities of extra level packs can keep the attention of players.

Another aspect that can lead to the success of a mobile game is *recognisability* (d'Arc Taylor, 2013). Some of the most successful mobile games are games that have been transferred from offline to online, such as Wordfeud[12]. New players were already familiar with the rules, which made the game mechanics easy to master.

[10]Candy Crush: www.candycrushsaga.com

[11]Angry Birds: www.angrybirds.com

[12]Wordfeud: www.wordfeud.com

mobile Bridge applications

Google Play as well as Apple's app store offer a number of Bridge applications, but none of them are a *game* to learn Bridge, or even an application that helps with the initial learning stage. Searching for 'learn Bridge' gave few results and the applications that appear are meant for people that have already started a course. Three categories can be distinguished: playing Bridge, (learning) Bridge conventions, and Bridge calculators. A review of seven of the existing applications can be found in the Appendix A.

3 Exploring Sneak Teaching Games

This study on Sneak Teaching Games uses the Design & Creation research strategy (Oates, 2005) as a guide throughout the whole research. The Design & Creation research strategy is often used for projects that that focus on developing new IT products, while connecting it to literature and making a contribution to the knowledge base (Oates, 2005).

Sneak Teaching Bridge uses the development of a prototype to illustrate assumptions made about the development of Sneak Teaching Games. Thus, the Design & Creation research strategy helps to formalise the process of creating and designing a Sneak Teaching Game.

After the discussion about how the Design & Creation research strategy is used in this thesis, this chapter gives some special attention to how test participants are selected and how design decisions are documented.

3.1 design & creation research

A Design & Creation Research usually contains five major steps: *awareness*, *suggestion*, *development*, *evaluation* and *conclusion*, which are often used in the form of an iterative cycle (Oates, 2005). These steps were also taken during this research. This chapter describes how the Design & Creation research strategy was used in Sneak Teaching Bridge, and which additional methods were used during the different steps.

Because Sneak Teaching Games are introduced in this thesis, desk research was used to analyse what characteristics these type of games can have and what should be taken into account during their development. This theory was illustrated by a prototype, which was developed making use of an iterative design that included domain expert evaluation and user testing. This process was used as an example of how a mobile Sneak Teaching Game could be developed.

awareness

In Design & Creation Research, the *awareness* step is used for the 'recognition and articulation of a problem' (Oates, 2005). This step was used to address the phenomenon Sneak Teaching Games as presented in the introduction.

Interest for learning and making learning fun, together with seeing games appearing like DragonBox, led to the question in which way these games differ from 'normal' Learning Games and what should be taken into account during their development. The term Sneak Teaching Games came to mind and the subject of the research was settled.

suggestion

The *suggestion* step in Design & Creation Research indicates the transition from interest in the problem towards a possible solution (Oates, 2005). In Sneak Teaching Bridge, this step involved a two-phased desk research.

In the first phase, a literature survey was conducted, with the aim to give an overview on how Learning Games are designed. It features parts of the history of Learning Games and key issues, background information on the modelling of the learning domain, game studies and mobile learning.

The second phase was used to describe the most important elements of Sneak Teaching Games and to suggest a possible design approach. The description of Sneak Teaching Game elements included their characteristics, a working definition, and points of interest to take into account during the development. In addition, two games that could be seen as Sneak Teaching Games, DragonBox and Fingu[13], were reviewed.

development & evaluation

Development stands for the step in Design & Creation Research where the previously generated ideas get implemented in an artefact (Oates, 2005). The *evaluation* step is used to examine the artefact, and value its worth (Oates, 2005).

By developing a prototype of the mobile Sneak Teaching Game '*Britz!*', the theoretical ideas about developing Sneak Teaching Games were used in practice. The prototype was evaluated by domain experts as well as possible future users.

Sneak Teaching Bridge made use of iterative user interface design (Nielsen, 1993) for the development of the prototype. Each iteration aimed to develop a new version of the prototype, and emphasised on how the

[13] http://www.ipkl.gu.se/english/Research/research$_{p}rojects/codac/fingu$

learning aspects and game elements come together. At the end of each iteration the prototype was evaluated. Figure 4 shows a visual representation of these iterations and table 5 shows the objectives by iteration.

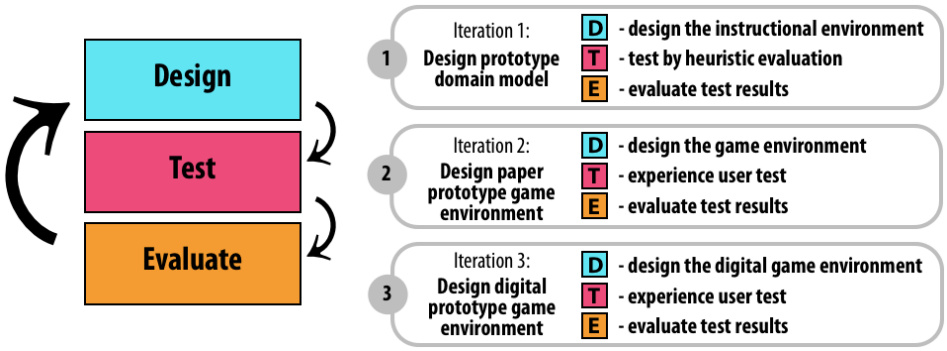


Figure 4: Visual representation of the iterative design process of Britz!

Iteration 1: learning domain prototype

The first iteration was about designing the instructional environment of Britz and included consulting domain experts for a heuristic evaluation. The learning domain was analysed and subsequently structured by making use of the 4C/ID instructional design method (Van Merriënboer and Kirschner, 2012). A qualitative analysis of the learning tasks by two experienced Bridge teachers gave insight into whether the proposed structure was approved by domain experts.

Iteration 2: paper experience prototype

The second iteration aimed to develop a paper prototype (Snyder, 2003) and made use of experience prototyping. This iteration had basically two objectives: design of game environment, and testing how users perceive the game.

The method of experience prototyping (Buchenau and Suri, 2000) was used to create the prototype and set up the user test. The focus was on recreating the situation of using the *Britz!*, so the participants could experience what it would feel like to use the 'real' game.

Iteration 3: digital prototype

During the third iteration a digital prototype was developed which included the formalising of supportive information & scaffolding, the design of a feedback model, and a user test which focussed on game interface and possible improvements.

Table 5: Overview of the objectives and used methods & techniques by iteration

	Objectives	Methods / Techniques
Iteration 1	- structuring the learning domain to appropriate format for gaming - testing if decisions made during the structuring are approved by domain experts	- 4C/ID - Paper Prototyping
Iteration 2	- creating a game environment (mechanics, context & user interface) that involves the learning domain - testing how users perceive the game	- Storyboard Sketching - Experience Prototyping - Paper Prototyping
Iteration 3	- digitising the prototype - illustrate supportive information & scaffolding - testing the users opinion on game and interface	- Wire-framing - programming in HTML5 / javascript

The digitising of the prototype was done by using HTML 5 and Javascript and was made available by access to a website; the focus was on making the game for iPad. This is a temporary solution that is meant to speed up the time needed to construct the prototype, and is not advised for further development of *Britz!*. This digital version of *Britz!* has special focus on user interface, scaffolding and feedback. Wireframes and Storyboards were used during the design to support a smooth development. Users were asked to play around with the game and suggest possible improvements.

conclusion

The findings of this research are written up in the *discussion*. This chapter highlights interesting findings and gives answers to the research questions. The chapter *conclusion* includes a brief summary of the research and suggests possible directions for further research.

3.2 selecting test participants

During the prototype development of Sneak Teaching Bridge there were three test moments. One of these tests was a heuristic test with domain experts and two of these tests were user oriented.

heuristic test

The heuristic test was used to guarantee the quality of the the prototype from the perspective of domain experts. Two renowned Bridge teachers were asked about their impressions of the learning domain structure of *Britz!*

These people were interviewed (Oates, 2005) about the learning domain structure.

user tests

The user tests were used to evaluate the prototype from the user's point of view. To get realistic feedback, the participants were selected to fit the intention of *Britz!*: attract young players.

The profile for the test participants was based on the demographic variable age, the psychographic variable of attitudes toward games and mobile games, and the possession of a smartphone or tablet.

> A typical player of *Britz!* is between 15 and 35 years old[14], gender is irrelevant. The player enjoys games, puzzles and mobile games, and has access to a smartphone or tablet.

Based on the advice to use five test participants for each user test Nielsen (2012), five people that fit the user profile were chosen to participate in each user test. All participants were asked to play the game and afterwards asked to reflect on this during an open interview.

3.3 data collection

During the heuristic test and the two user tests data was collected. Table 6 gives an overview of collected data, how it was collected, and for what purpose it was used.

heuristic test in iteration 1

The heuristic test was used to make a qualitative analysis of the domain model by consulting two experts in the Bridge learning domain. Specifically, they were asked for their opinion on:

- the possible usefulness of the material for Bridge learning
- the structure and level of the learning tasks

The opinion of the experts was collected by a semi-structured interview about the feasibility of the progress and difficulty of the tasks. The semi-structured interview-style was used to ensure flexibility to explore particular answers further (Toolbox, 2014).

First, the learning tasks and the context in which they would be used

[14] Youth players are by definition under the age of 26 (http://worldbridge.org/age-criteria.aspx). Players up to 35 are usually still seen as young.

Table 6: Brief overview of collected data, how it was collected, and what it was used for.

	What data?	How was it collected?	What was it used for?
Heuristic test in iteration 1	*experts opinion* on the learning tasks	Semi-structured interview *(taping & field notes)*	re-evaluation of the learning tasks and their order
User test in iteration 2	*player's attitude* towards games, card games, mobile games	Semi-structured interview *(field notes)*	determining if user fits the description of a *Britz!* player
	player's performance in *Britz!*	observation *(video taped)*	determining if ZPD is fitting
	player's opinion on *Britz!*	Semi-structured interview *(field notes)*	re-evaluation of game elements & mechanics
	player's experience of *Britz!* as a learning application or game	Semi-structured interview *(field notes)*	evaluating the Sneak Teaching dimension
User test 2 in iteration 3	*player's opinion* on looks & game elements	Semi-structured interview & observation *(field notes)*	re-design of game elements and graphical user interface

were presented to the experts. After that, the experts were asked to answer specific questions about the material, after which they were asked to enlighten their answers.

The answers of the experts were carefully recorded; one of the interviews was taped with a voice recorder and the other one was recorded by taking field notes. This last method was used because the interview was held over the phone, which complicated digital recording.

The answers of the two experts were used to re-evaluate if the learning tasks and their order were ready for use in the user test, or that changes would have to be made.

user test 1

The first user test was a combination of a usability test and a qualitative evaluation of the first prototype of *Britz!* Specific subjects of interest were:

- the entertainment value of the game
- the flow of the game and zone of proximal development
- the functionality of the game elements

Five participants were selected to take part in the user test. An open-interview was used to determine if the participants fit the profile of a *Britz!* player.

To allow for flexibility, the usability test in which the participants were asked to play *Britz!* making use of the experience prototype, was set up with pre determined elements as well as optional elements. The order in which the learning tasks followed each other up formed the blueprint for the usability test was, while scaffolding was used to adapt to what was going on during the play. This open test setup allowed for flexibility in the test, and facilitates the possibility to evolve the testing based on what is going on at that moment as well as results from previous usability tests.

The performance of the participants was recorded by camera, and used to evaluate if the used Zone of Proximal Development was fitting for the user, and if extra scaffolding was in order.

In the last step of this user test, the participants reflected during a semi-structured interview on how they experienced the difficulty of the levels, the game elements of *Britz!*, and playing *Britz!* in general. Field notes were used to record the answers. The data was used to re-evaluate the game elements, the game mechanics, and evaluate if the players experienced *Britz!* as an entertainment game.

user test 2

The second user test was used to make a qualitative evaluation of the user interface and scaffolding of the digital prototype. Special attention went to:

- the visuals
- game elements

The test participants were asked to try out *Britz!* on an iPad, during and after which they were asked to reflect on their experience with the game. Their suggestions were evaluated and used to generate ideas about how to improve the prototype. Field notes were made to write down observations and comments of the participants.

3.4 design decisions

To be able to give a substantive contribution to the knowledge base, design decisions that were made during the development of the prototype were carefully documented. To formalise the decision making process, important decisions were guided by the Question Options Criteria (QOC) method (MacLean et al., 1991).

The QOC method is used to provide grounded reasoning for design decisions. For every important decision that has to be made a couple of options are listed and related to criteria. In this way is made clear why a certain option has been chosen, and what value lays in this option.

Figure 5 shows a visual representation of an example of a design decision that is made during this research. The figure shows the decision process for the choice of development platform for the digital prototype of *Britz!*.

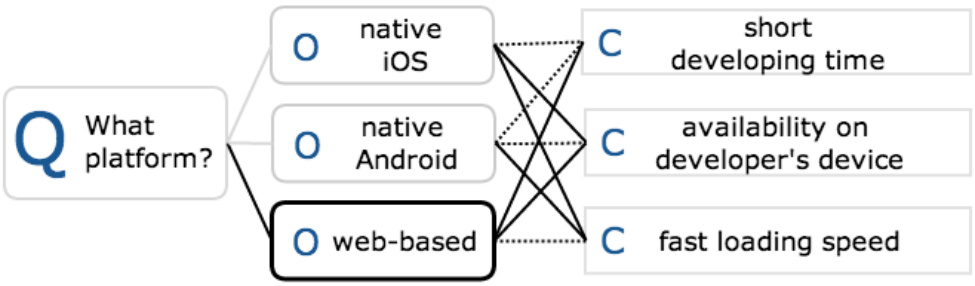


Figure 5: Decision process for the choice of development platform for the prototype of Britz!

The considered options for the development platform of the prototype were native iOs, native Android, and web-based development. The criteria on which the decision was made were short development time, availability on developer's device, and fast loading speed. Solid lines from the options to the criteria visualise a positive evaluation, while dotted lines represent a negative evaluation. Even though both native iOs and web-based development have two compatible criteria, web-based development was chosen because short development time is a vital part of the development of prototypes. Note that if this were the decision on the development of the 'real' version of *Britz!*, this decision might have had a different outcome.

4 Sneak Teaching Games

The literature review on Learning Games identified some key aspects that play a role when designing and developing (mobile) Learning Games. These aspects are used to construct a more detailed description of Sneak Teaching Games and what designers should specifically focus on when designing such games. This chapter reflects on two mobile Learning Games that have features of Sneak Teaching Games and concludes with a plan on how to develop Sneak Teaching Games, illustrated through *Britz!*.

4.1 Sneak Teaching Games Defined

The idea behind Sneak Teaching Games is that the learner will not realise during the playing of the game that he or she is learning. Taking this as a starting point, Sneak Teaching Games can be described as:

> A Sneak Teaching Game is a type of Learning Game where the learning is hidden within the games mechanics, so that players perceive the game as an entertainment game.

Much of the literature reviewed in the literature survey on Learning Games mentions or addresses the issue of finding a balance between the educational value and entertainment value (Dickey, 2005; Egenfeldt-Nielsen et al., 2008; Foley and Yildirim, 2011; Schwarz and Stoecker, 2012). This balance, or merge is the essence of Sneak Teaching Games.

The development of Sneak Teaching Games can be seen as three dimensional: the learning dimension includes the educational foundation, the game dimension makes the application attractive as a game, and the sneak teaching dimension blends these two together.

learning dimension

The learning dimension addresses the need for a solid educational foundation. Key aspects of this dimension are: domain modelling, adaptability, assessment, and integration.

The learning domain should be modelled to suit game design. An instructional design method such as The Ten Steps in 4C/ID (Van Merriënboer and Kirschner, 2012) can guide instructional designers through the process of designing the instructional environment.

During the development of the instructional environment should be considered whether the domain content should adapt to the learner. Designers should investigate how this can be achieved. An adaptive environment will benefit the zone of proximal development, as well as contribute to the game flow (Moreno-Ger et al., 2008).

The back end of the instructional design should offer teachers the possibility to assess the progress of the students. Stealth assessment (Shute, 2011) might be an option, however, it should be investigated if this method is suitable for mobile Learning Games or that another solution should be found. An assessment function can help to quantify the educational value of Sneak Teaching Games and play a positive role when trying to integrate them into educational settings.

In addition to an assessment function, an evaluation report of the game make will make it easier for educators to evaluate how the game could fit into their curriculum (De Freitas and Oliver, 2006).

game dimension

The game dimension focusses on creating an engaging game environment that suits the learning domain.

When designing an engaging game environment, developers can try to make use of tactics used in game design. Player positioning, narrative, interaction, a fantasy environment, giving the player a sense of control and challenge, and collaboration and social interaction are strategies that can support the entertainment value of Learning Games (Dickey, 2005; Foley and Yildirim, 2011).

Depending on what type of games fit the learning domain, a development platform has to be chosen. The mobile platform can be a good option if the learning domain allows for chunked down parts (Ally, 2005) or has other aspects that suit well with mobile gaming. In that case, developers could try to integrate mobile game success factors such as a social side, expandability, and recognisability (d'Arc Taylor, 2013). During the development real size paper prototyping (Rettig 2002, recalled from Churchill and Hedberg 2008) can be used.

The game dimension includes the design of a user interface with elements that make the game visually and audibly attractive, while making use of usability guidelines.

sneak teaching dimension

Designing an optimal Sneak Teaching experience includes trying to establish a seamless merge between the game design and didactic design. Designers have to investigate how to make optimal use of the game environment, so that the educational scaffolding gets translated by game elements and game mechanics.

Strategies such as the incorporation of reflective quests, self-evaluation elements, offering external support, allowance of teacher involvement, and scaffolding through dialogue, can be used to support the educational value of Learning Games (Foley and Yildirim, 2011). Sneak Teaching designers should investigate the extent to which these strategies can be incorporated into the game environment without interfering with game play and without the player realising that they are meant for instruction while at the same time maintaining a high educational value of the Learning Game.

It is very well possible that there are many possibilities to achieve a Sneak Teaching dimension. Developers will need to think out of the box and make smart use of the learning domain structure. It will be a challenge to make optimal use of game elements to provide instructional scaffolding and feedback. This creative process forms the core of Sneak Teaching Game design.

4.2 examples

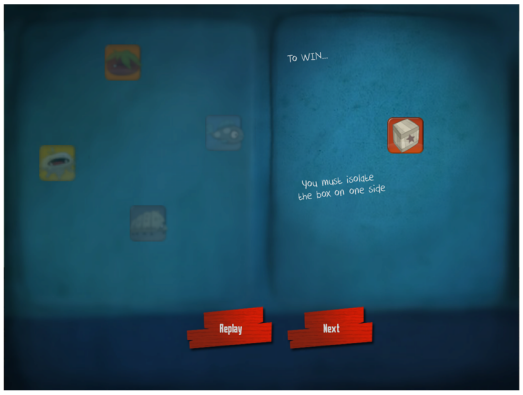
Although there are no Learning Games yet that have the literal stamp "Sneak Teaching Game", there are games that can be seen as such. Two mobile Learning Games, DragonBox Algebra 5+ and Fingu, have been reviewed to illustrate the Sneak Teaching dimensions.

DragonBox

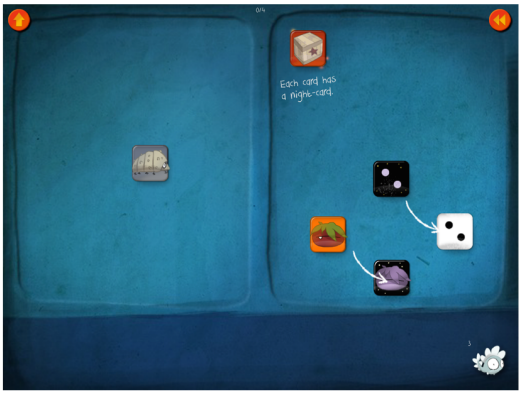
DragonBox Algebra 5+, see figure 6, is an Educational Game that claims to secretly teach young children the basics of algebra, and in specific the solving of equations (finding '*x*'). The game is commercially developed by WeWantToKnow AS in a cooperation between a game developer and a domain expert who is a teacher. The game targets children from five to ten years old and is for five euros available for PC, Mac, Android, and iOS[15]. (DragonBox also has a version for older children.)

[15] This review is based on the iOS version, displayed on iPad.

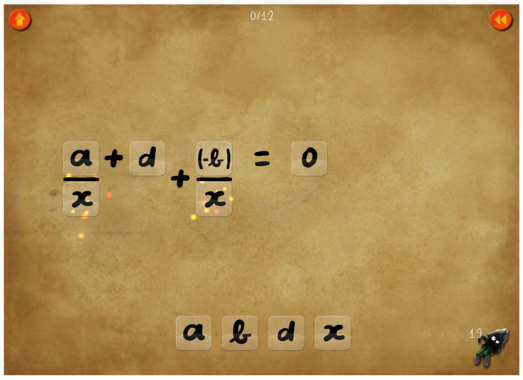
(a) welcome screen



(b) scaffolding



(c) one of the first levels



(d) an advanced level

Figure 6: Screenshots of Dragonbox Algebra 5+

The designers of DragonBox Algebra 5+ tried to find ways in which the learning domain, algebra, could be transformed into game elements. They came up with substituting the 'x' by a mysterious box and the numbers and letters in equations were substituted with images of cute animals. The negative value of the numbers and letters is presented by a 'night' version (see figure 6c).

At the beginning of the game, the players are told that in order to win the game, the box wants to be alone. By matching a night and day version of the same animal the children can remove them from the playing field, see figure 6c.

DragonBox makes use of scaffolding by game elements; when an animal, for example, is added to the left side of the field, a place holder appears on the right side, indicating that something should happen there.

In DragonBox the number of stars the player collects is the only indication about the progress of the learner and possibly the understanding of the subject. However, these stars are very neutral; it is not specified which stars stand for which level of solving equations.

Reviews of users of DragonBox Algebra 5+ indicate that there are many children that love the game so much, that they treat it as an entertainment game.

Sneak Teaching evaluation

Even though the name of DragonBox Algebra 5+ might be a giveaway, the game embodies the idea behind sneak teaching; the children do not realise that they are learning equations and treat the game as an entertainment game. The success of the game indicates that the learning domain has been modelled to fit the zone proximal development of players, so that they keep in game flow.

The designers made excellent use of game elements to embody the elements of the learning domain, by replacing the the mathematical letters by images. Thus in the beginning of the game it is virtually impossible to realise the game is about solving equations. After a short period of inactivity, the game lights up elements to draw the attention of the player. Scaffolding is also done by short text and arrows.

DragonBox shows the minimum number of moves needed to solve the puzzle, but does not give too much insight into what went wrong if this number is exceeded. When one uses too few moves, the game even indicates that the right number of moves was used.

It could be a good idea for DragonBox Algebra 5+ to offer an overview of the different skills that are taught and, for example, show the number of stars collected on each specific skill, the time used, and the number of retries.[16]

Fingu

Fingu, see figure 7, is an iPad game developed as a part of the research project CoDAC (Conditions and tools for Development of Arithmetic Competencies) and is freely available in Apple's AppStore. The game targets children from four to eight years old and aims to improve their

[16] After this review was conducted, the 12+ version of DragonBox added a detailed teacher manual and an evaluation tool. Due to time restrictions this funtionality has not been reviewed in this thesis.

basic arithmetic competencies.

The idea is that the children tap the screen with as many fingers as there are fruits visible. By doing this, the children, according to the developers, are trained in: 'seeing' numbers of objects without counting them; 'feeling' a representation of the numbers up to 10 in their hands; coordinating the seeing the number of objects with showing it with their fingers; and, the ability to add two numbers with sums up to 10.[17]

The concept that the designers of Fingu present is very nicely executed. The game helps children master 'number concepts' without actually using any numbers; the arithmetic skills and number concepts are embodied through the game (Barendregt et al., 2012).

There is little scaffolding to help the children understand that they have to touch the screen at once with all the necessary fingers at the same time.

Fingu offers an extended set of settings that make the game adaptive, the available response time can for example be reduced. The game also offers statistics in which the progress of the learners can be tracked, see figure 7d.

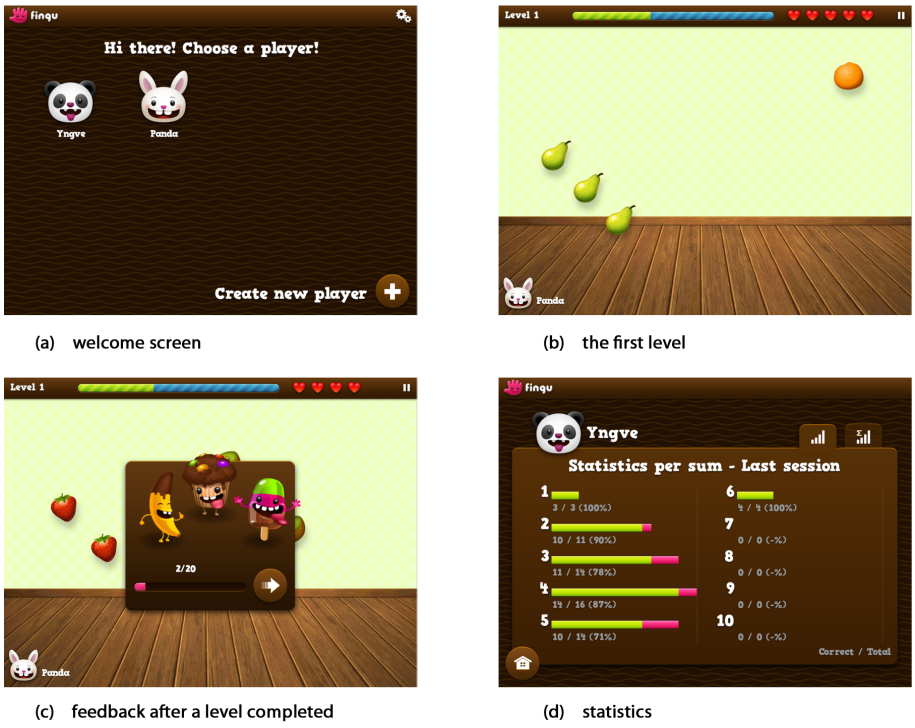
Sneak Teaching evaluation

The idea behind Fingu lines very well with Sneak Teaching ideas; children playing the game will not realise that they are actually improving their arithmetic competencies, and the conceptual aspects are embodied by game elements.

The game could possibly benefit from a little more scaffolding, especially in the beginning to help the children understand the game mechanics. The designers could also have made more use of the possibilities of the visual environment. The time left to fulfil a level is displayed by an indicator bar in the top of the screen. This bar could be replaced, or at least reinforced, by for example letting the fruit turn bad over time.

The statistics that Fingu offers, give a good indication to parents or educators on the performance of the child over time. The information on the Fingu website states clear learning goals and an extended overview on how to interpret the statistics of the game.

[17] http://www.ipkl.gu.se/english/Research/research_projects/codac/fingu



(a) welcome screen

(b) the first level

(c) feedback after a level completed

(d) statistics

Figure 7: Screenshots of Fingu

4.3 design approach for *Britz!*

Based on the three dimensions of Sneak Teaching, the following suggestion is made for how to approach the development of the prototype of *Britz!*

- iteration 1: design prototype domain model
- iteration 2: design paper prototype game environment
- iteration 3: design digital prototype game environment

The three iterations cover different aspects of the development of a Sneak Teaching Game. The first iteration focusses on guaranteeing a high standard learning application, which is tested by consulting domain experts. The second iteration presents the instructional game environment and is used to assess the entertainment value of the game for players. The third iteration focusses on the visual presentation and is used to test how players would perceive the game at first sight.

The red thread during all iterations the Sneak Teaching dimension: *Britz!* should appear as an entertainment game.

5 Iteration 1 - Design prototype domain model

The first iteration in the design process of *Britz!* aimed to design a prototype of the domain model, and test this model by consulting two domain experts.

Figure 8 shows the visual representation of the design process in this iteration. The main objectives were:

- structuring the learning domain to appropriate format for gaming
- testing if decisions made during the structuring are approved by domain experts

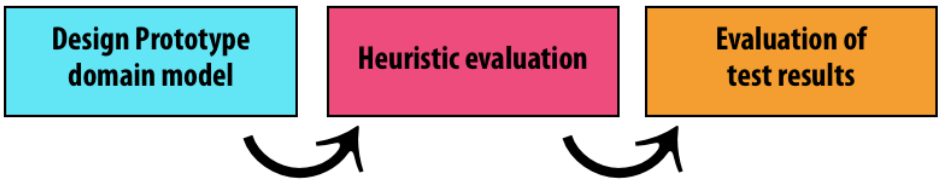


Figure 8: Visual representation of iteration 1

5.1 prototype domain model

The prototype of the domain model forms the underlying structure of *Britz!* The intention was to create a model that presents Bridge in a suitable way to players with no prior Bridge knowledge, and allows for mobile game play. On top of that was sought ways in which the structuring of the learning domain by itself can contribute to the Sneak Teaching dimension of *Britz!*.

The 4C/ID method was used as a guideline during the design of the prototype domain model.

brief analysis of the learning domain

As shown in figure 9, Bridge consists of a bidding stage and a playing stage. Bidding is mainly used to communicate about the cards in the possession of a player. The card play is about how to make smart use of those cards when trying to establish tricks. Even though the card play stage can be divided into defence and declarers play (offence), both sides have the same goal: trying to make as many tricks as possible.

The basic rules and skills in card play techniques form the focus of the beginning stages of *Britz!* Bidding can be introduced in later stadia of the game, but this is out of the scope of this *Britz!* prototype.

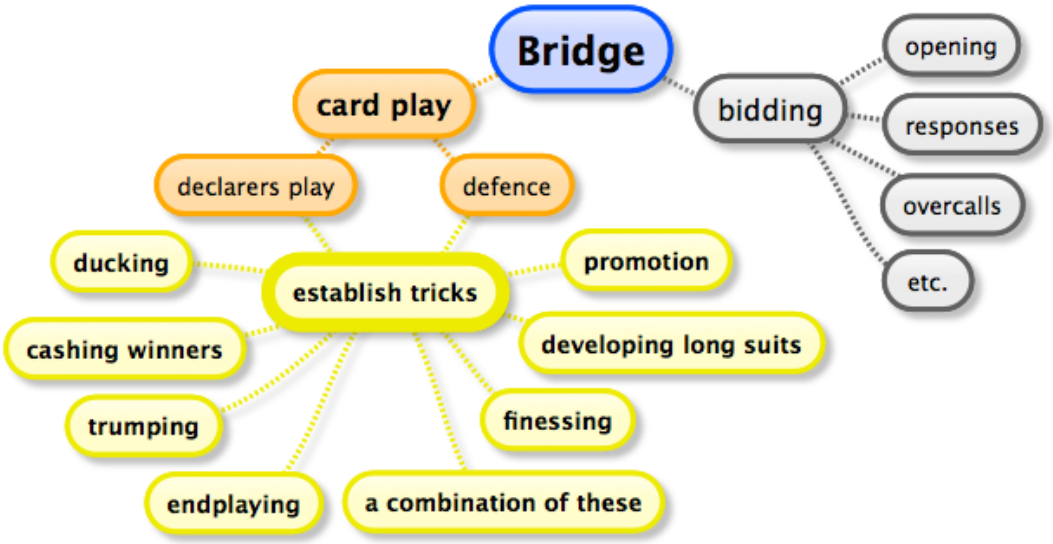


Figure 9: Simplified overview of the structure of the Bridge game

'Spill bridge' is the main teaching method used in Norway. The first chapter of the first book, 'what is bridge', introduces the readers to Bridge by exposing them to a number of facts and basic rules such as 'there are 52 cards in a deck' and 'players have to follow suit'. Even though these rules and facts are absolutely relevant when playing Bridge, this type of information transfer is not suitable for *Britz!*. The following six rules from this first chapter were selected for use in the domain model. Following sections will illustrate how these rules are introduced to the players of *Britz!*

- the order of cards: AKQT98765432
- what is a trick
- main idea: get as many tricks as possible
- the one who makes the trick leads in the next trick
- players have to follow suit
- if players can't follow suit, they can play what they want

learning tasks

The main goal of the card play in Bridge is to get as many tricks as possible. To create learning tasks that embody this goal and suit beginners, the idea was to transform the learning domain into playable mini puzzles. By designing mini puzzles, information can be presented to players in small chunks and thus suit presentation on mobile devices.

In the carefully designed mini puzzles players have to establish tricks, making use of the techniques shown in figure 9: promotion; developing long suits; cashing winners; ducking; finessing; trumping; endplaying; and a combination of these. An explanation of the different techniques can be found in Appendix B.

For every technique were several mini puzzles designed, in different difficulty levels. The mini puzzles of all techniques with similar difficulty level were collected into a chapter and within the chapter ordered from easy to hard. By connecting the techniques and the mini puzzles, the completion rate of the puzzles can give teachers an overview of how the players are doing.

Relating this to 4C/ID, the mini puzzles form the learning tasks, the chapters form task classes, and the completion rate of the puzzles connected to the different techniques form the assessment instruments.

example puzzle

Figure 10 illustrates an example of a mini puzzle that players can encounter.

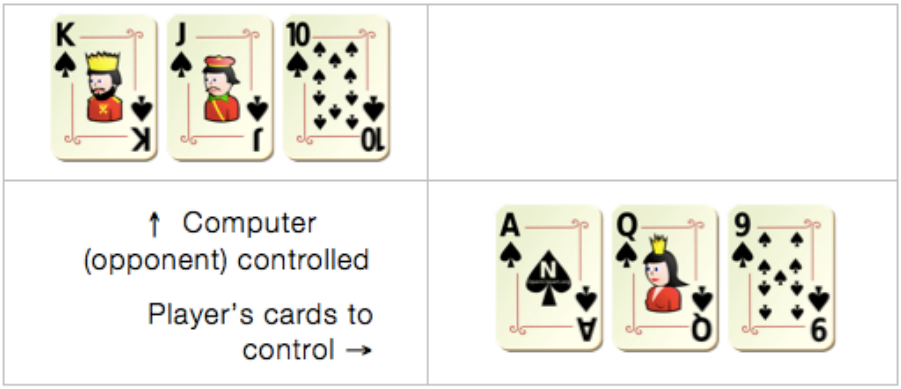


Figure 10: Example puzzle: begin position, player starts

In order to get the maximum number of tricks, and thus solve the puzzle optimally, it is crucial in this example that the player starts with his lowest

card, the ♠9. This will make the opponent win the trick, and play first in the next trick. Now the player has the ♠Ace and ♠Queen left to make the remaining two tricks. Depending on which card the opponent plays in the second trick, the player will take it with the ♠Ace or ♠Queen, see figure 11. This will result in score of 2 tricks for the player and 1 for the opponent.

If the player would decide to start with playing the ♠Ace in the first trick, a similar situation would appear, only then resulting in 2-1 tricks in favour of the opponent.

To complete this puzzle successfully, the player makes first use of the endplay technique, and afterwards of the finessing technique.

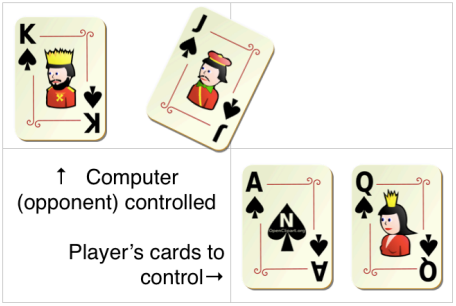


Figure 11: Example puzzle: when the opponent plays the Jack, the player will take with the Queen

chapter 1

The first chapter that players encounter contains the easiest puzzles connected to the techniques. Figure 12 gives an overview of the puzzles (levels) in this chapter and their order. The letters and numbers on the left side of each level present the cards of the computer controlled opponent, and the cards on the bottom/middle present the cards that the player controls.[18] The suits (♠, ♡, ♢, & ♣) have not been indicated because they are irrelevant to the puzzle. The suit indication will be added when the puzzles are presented to players. The asterisk in each level indicates who will play the first card in the level. The colours indicate difficulty from easy (green) to intermediate (blue) to red (difficult).

The levels in this chapter have been designed and ordered in a way that allows new players to learn new rules and skills by playing, instead of reading. By introducing, for example, new cards during the first couple of levels, the idea is that the player will understand their order without a literal explanation; the domain structuring facilitates the scaffolding.

During the design of the levels was tried to create variation by using different combinations of cards, sometimes small cards were used, other times high cards. When ordering the levels within the chapter was variation created by mixing the levels connected to the different techniques.

[18] This way of presenting problems is common for Bridge players and authors.

Level 1 T2 98 *	**Level 2** JT3 875 *	**Level 3** J3 * QT	**Level 4** J97 QT5 *	**Level 5** AKQ4 6532 *
Level 6 AK9 JT7 *	**Level 7** KJT AQ5 *	**Level 8** KQT * AJ6	**Level 9** AK6 973 *	**Level 10** QJ8 * A92
Level 11 KJ98 * AQ102	**Level 12** 854 4 32 * T3	**Level 13** 4 * 854 T3 32	**Level 14** T76 Q K * JT9	**Level 15** KQ A A * 43
Level 16 KT K AQ * 2	**Level 17** KJ KJ AQ * A3	**Level 18** KQ5 K AT4 * 5	**Level 19** 543 AK AK * 543	**Level 20** AK K3 4 * AQ7
Level 21 AK5 3 Q9 * 54	**Level 22** KQ4 3 AJ8 * A	**Level 23** KQ94 - J87 * 4	**Level 24** QJ KQ8 A8 * AJ7	**Level 25** 43 42 52 * 53
Level 26 A8 64 Q972 * -	**Level 27** T9 KJ6 KQ AQ3 *	**Level 28** K4 QJT AQJT A	**Level 29** K3 8 2 AQ * 6 6	**Level 30** 642 * 6 - - 75 AK

Figure 12: Chapter 1 of Britz!. The colours indicate difficulty: green = easy, blue = intermediate and red = difficult

The levels in this chapter introduce the player to the following general principles and rules:

- what is a trick (level 1+)
- the order of cards: AKQT98765432 (level 1, 2, 3, 4, 5)
- get as many tricks as possible (level 1+)
- the one who makes the trick leads in the next trick (level 1+)
- following suit is obligatory & when not able to follow suit, any card is allowed (level 12 & 13)
- small cards are important (level 5, 12, 15, 23, 25, 29, 30)

This chapter contains puzzles connected to the following card play techniques:

- promotion (level 1, 2, 5, 6, 9, 26 & 28)
- ducking (level 4, 7, 8, 10, 18 & 24)
- endplay (level 11, 16, 17, 18, 20, 22, 24, 25, 27 & 29)
- developing long suits (level 14, 15 & 19)
- cashing winners (level 12, 17, 21, 22, 23, 24, 25, 27 & 29)
- finessing (level 3, 4, 7, 8, 11, 16, 18, 20, 22, 24, 25, 27 & 29)

puzzle evolvement

The puzzles connected to each technique will evolve when the player progresses in the game. It is possible to do this by adding cards, suits, and combining different techniques, as done in chapter one. It is also possible, for example, to involve more players and hide the opponents cards, so that the player has imperfect information.

Figure 13 shows an example of an early stage finesse puzzle. When the computer plays the ♠Jack, the player can ensure two tricks by playing the ♠Queen. If the computer plays the ♠King, the player can play the ♠Ace to take two tricks.

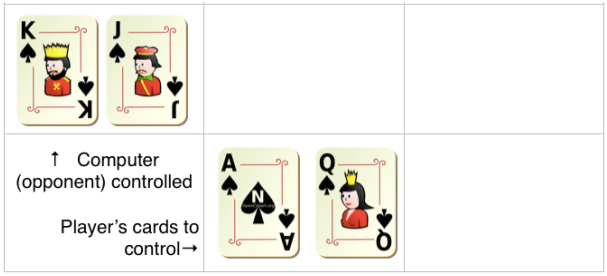


Figure 13: Finesse in stage 1

In a later stage of finesse puzzles, the player receives another set of cards to control, simulating a situation that in Bridge is called declaring. Figure 14 shows an example. By starting with a small card towards the ♠Ace Queen, a similar situation is created. The computer's Jack will be taken with the Queen, while the King should be taken with the Ace.

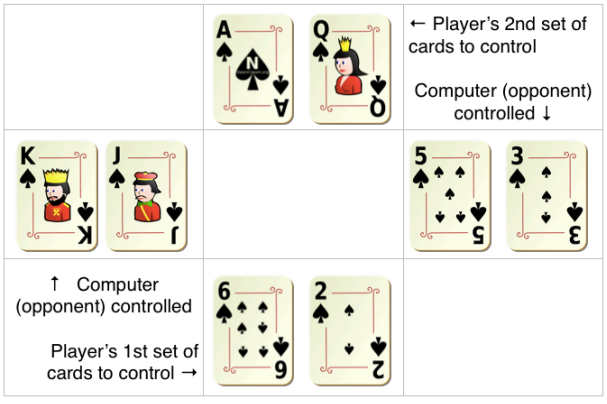


Figure 14: Finesse in stage 2

In the second stage the placement of the opponent's cards is

known to the player. The third stage, see figure 15, only provides information on which cards are in play, but does not reveal where each individual card is located. The player has to choose a line of play, based on imperfect information, making use of chances.

The best chance for the player to score two tricks is to start by playing the ♠6. When the right-hand opponent plays a small card or the Jack, the ♠Queen should be played, taking the chance that the right-hand opponent's remaining card is the ♠King. This gives the player a 50% chance of getting two tricks. Playing the ♠Ace instead of the ♠Queen gives the player (in this fixed example) a 0% chance on two tricks.

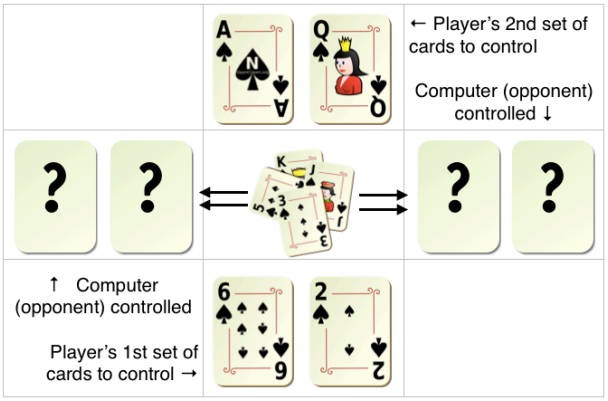


Figure 15: Finesse in stage 3

5.2 heuristic test

The main purpose of the heuristic test was to get expert feedback on the structuring and quality of the prototype of the learning domain. It was also used to evaluate which possibilities the material presented as a mobile game would mean for Bridge teaching.

Two domain experts were asked to participate in a semi-structured interview. This chapter introduces the participating experts and describes the opinions of the domain experts as collected during the interviews.

the experts

The two consulted domain experts were Sven-Olai Høyland from Norway and Jacques Barendregt from the Netherlands. They were asked to participate in the test based on their background and reputation in Bridge teaching.

Sven-Olai Høyland is one of Norway's best known Bridge teachers. He has taught Bridge for over twenty years and is involved in the Norwegian junior education and Bridge development.

Jacques Barendregt has written one of The Netherlands most used

Bridge learning methods for beginners. He also gives workshops and courses to players from the beginner level to advanced, and is one of the leading educators of Dutch Bridge teachers.

the interviews

At the start of each interview the domain expert was presented the first chapter as shown in figure 12, explanation about the context in which it would be used, and how the levels and chapters would evolve over time. The interview guide can be found in Appendix C.

The interview with Høyland was taped (22min) and the interview with Barendregt was recorded by making field notes.

While scoping the levels in chapter 1, Barendregt already commented on the structuring: “Ah, I can see they are learning by doing it”.

suitability for beginners

The first couple of questions in the interview aimed to gather a general opinion on puzzles of this kind, displayed on mobile phones or tablets in game form.

Høyland believes that beginning bridge players can certainly benefit from puzzles like those presented in chapter 1. He mentions: “One of the problems we have seen lately when teaching courses, is that people are not used to play cards anymore. Earlier there were more people that played cards at home, they knew how to take tricks. This kind of puzzles [*points at chapter 1*] teach card play.”

Barendregt believes that these kind of puzzles will “definitely make beginners better players”. He enjoys the idea to not present the puzzles on paper, but to use the possibilities of a mobile device to really allow players to play and see the consequences of their choices. Barendregt added that he believes these kind of puzzles are likely to stimulate certain cerebral functions, even if the player will never actually play Bridge. He mentions: “This type of material has to do with thinking ahead. I know people that have played bridge for ten years but still don’t manage to do it”.

zone of proximal development

The experts were asked to evaluate the learning curve within the chapter.

Barendregt noted that the puzzles gradually get more difficult, but he

predicted that players will need to think quite hard to accomplish the chapter.

Høyland went into more details and pointed out that in his opinion there was a huge gap between level 3 and 4, and suggested to place level 6 before level 4.

variation

The experts were asked to evaluate the variation of the puzzles within this chapter.

Barendregt noted the transition from using one suit to three suits and the variation in use of high cards and low cards, and believes that the variation in this first chapter will probably manage to keep the attention of the players. He was intrigued by the extra challenge and variation that the small cards can present to players, and points level 29 out as 'fun'.

Høyland noted that some of the problems are actually the same, only with different cards, like level 6 and 9, he comments: "For me they look the same, but for beginners they probably seem very different. They probably won't recognise that the problem is the same, but when they do recognise it... they are ready for the next level!"

additional comments

Barendregt wondered if players are able to retry a level (if they wronged it) and if so other cards will be used to present the same problem.

Høyland sees the possibility for these type of puzzles for advanced players, and advises, in the case the game will go that far, to take a look at full board double dummy problems.

5.3 evaluation

The input of the experts was valuable for the further course of the development of *Britz!*.

on track

Both experts were positive about the idea of *Britz!*. They confirmed that these type of puzzles presented as a mobile game can be a valuable addition to bridge teaching, that the designed puzzles are suitable for beginners and pre-beginners, and that the levels more or less gradually increase in difficulty over the course of the chapter.

This positive attitude towards the idea of *Britz!*, indicated that the design of *Britz!* is on track, and that no drastic changes need to be made.

impact for next iterations

The switch in levels that Høyland suggested (place level 6 before level 4) will be carried out in the prototype of iteration 2.

The possibility to retry levels, brought under the attention by Barendregt, will be subject of research in the next iteration. Questions that arise around this subject are: 'does a player have to retry when failing the chapter?', 'when can a player retry?', and 'should different cards be used when retrying a level?'.

6 Iteration 2 - Design paper prototype game environment

During the design of the prototype domain model it was already taken into account that the learning material would be used for mobile gaming. In this second iteration, a game interface was added to the domain model, realising a paper prototype that was tested by five people. The method of experience prototyping (Buchenau and Suri, 2000) was used to create the prototype and set up the user test.

Figure 16 shows the visual representation of the design process in this iteration. The main objectives of this iteration were:

- designing a game environment (mechanics, context & user interface) that includes the learning domain
- testing how users perceive *Britz!*

Figure 16: Visual representation of iteration 2

6.1 design of game environment

In the previous iteration it was decided that the learning domain would be presented as small puzzles, however, it was not decided how to present it to players. A game environment was designed for this purpose.

transforming the learning domain

When designing a Sneak Teaching Game, the designers need to seek ways to bind the learning domain and the game together. One way to do this, is to structure the learning domain, as shown in the first iteration. Another way is to transform aspects of the learning domain into game elements, like DragonBox did by replacing numbers with images of monsters.

Bridge might have an advantage over other learning domains because it involves playing cards, which are usually already associated with game play. Still, it might be possible to replace the playing cards with elements that have the same, or similar specifications. Cards have the attributes that they come in four different suits and have different ranks. For the numbered cards, the order is pretty straight forward, but players might not get the order of the honours, Ace, King, Queen, and Jack at once.

A solution for this could be to simply replace those cards by numbers, so the 13 cards in each suit will be numbered from 14 to 2. Another idea is, for example, to replace the cards of the opponent by cookies of different sizes, while the player holds cups in different sizes that can capture cookies of similar size or smaller. The goal would be not to 'make tricks', but to score cookies. Such a transformation of the learning domain seems unnecessary for the target group of *Britz!*, but could be worthy of further research, in case *Britz!* would get a light version for young children.

For *Britz!* it was decided to make use of standard playing cards for the following reasons:

- cards are usually seen game elements
- making use of ordinary cards can create a recognisability aspect, which might make the game easier to master
- replacing cards might make the application less attractive for use along the side of Bridge courses

The replacement of cards might be worthy of further research if a version of *Britz!* for young children were to be developed.

game elements

A couple of game elements used in popular mobile puzzle games like *Cut the Rope*[19] and *Where's my Water?*[20], were selected for use in this prototype of *Britz!*: vivid colours; sounds or music; short levels; awarding stars or other items; scoring points; the possibility to replay; and a 'cute' character with whom players can engage.

For the paper prototype the use of vivid colours, short levels (as already anticipated), awarding stars, and the possibility to replay were chosen.

[19] http://www.cuttherope.net/

[20] http://www.disney.co.uk/wheres-my-water/

Feedback in the form of stars can give players an indication of how they perform in the game, as well as that they can possibly serve as a form of educational feedback. The other elements in the list will be added in a later stage.

To see how a game level would be visually presented to the players a storyboard composed of playing cards and sketches on A4 sheets, was created visualise the level flow. Figure 17 shows steps 3, 4, and 7 of a level similar to level 1.

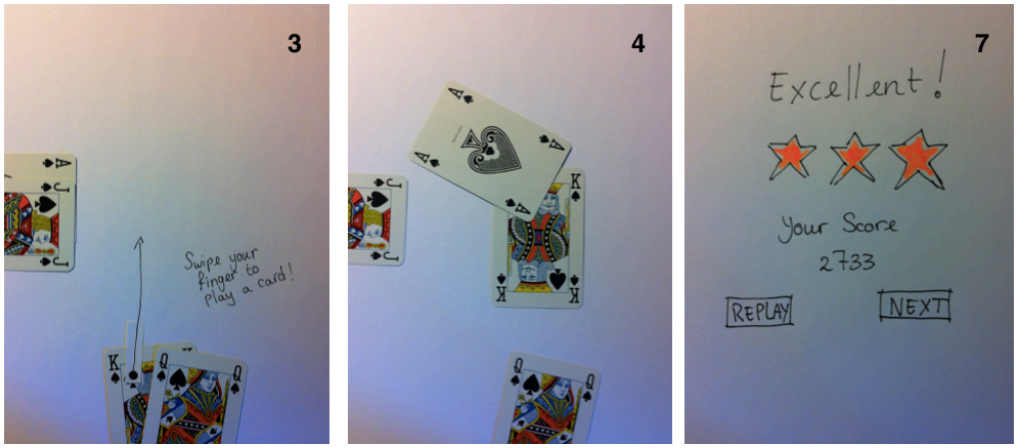


Figure 17: Step 3, 4, and 7 of the storyboard sketch. More images can be found in Appendix D.

the paper experience prototype

A paper prototype was designed for a user experience test in which the participants would be able to test the first chapter of *Britz!*. The aim of the prototype was to recreate the situation of using *Britz!* so that the participants could experience what it would feel like to play the 'real' *Britz!* on a mobile device. Paper prototyping gives flexibility during the tests because elements can almost instantly be changed, added, or removed.

The levels were prepared by selecting the needed playing cards from card decks, and organising them into separate pockets in a folder, as seen in figure 18.

The needed buttons and stars were designed in Photoshop, printed, and laminated, see figure 19.

Figure 18: The folder used to organise the levels.

To give the participants the feeling of playing a mobile game, an iPhone frame was printed (see figure 20) in a size that match the size of playing cards, so the proportions would be as viewed on an iPhone screen. The frame functioned to set boundaries to the game space and was intended to help participants conform to the game mechanics and restrictions of playing a mobile game.

Figure 19: Button and stars created.

6.2 user testing

The goal of this user test was to find out what possible future users will experience when playing *Britz!* and how they feel about the feedback and gameplay. Specific topics of interest were:

- the entertainment value of the game (sneak teaching dimension)
- the flow of the game and zone of proximal development
- the functionality of the game elements

test participants

Grace, Anna, Anders, Jahan, and Erik, five students of the University of Bergen, were asked to participate in the user test.[21]

To find out if these students fit the target group of *Britz!* a brief interview was conducted featuring questions about their age, experience with games, and access to smartphones and tablets. Field notes were used to record the answers during the interview.

Figure 20: The game space: a paper phone frame

age

The participants ranged in age from 20 to 30, which falls within the target group of *Britz!*

playing games

All students indicated that they enjoyed

[21] One name has been subsitituted for privacy reasons.

playing puzzles, games, and card games, although two of the students mentioned that they do not play card games very often.

smartphone/tablet use
All students were in possession of a smartphone or tablet, and indicated that they like to play mobile games. However, three of the students mentioned that they do not use much time on mobile gaming.

test setup *Britz!*

The playing of *Britz!* took place in a room that contained a table, camera, and the elements of the prototype (game space, game elements, and folder with levels). One person was supervising the test, taking the role of the opponent. Figure 21 shows the test setup.

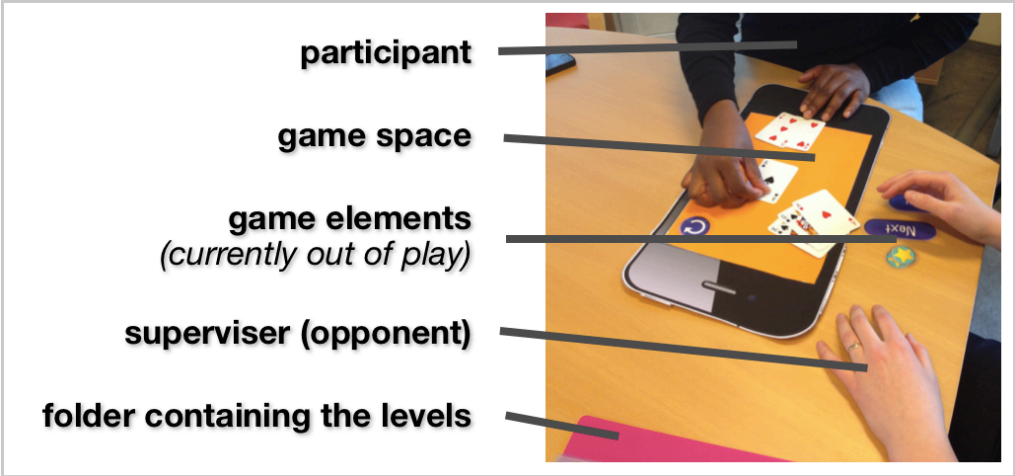


Figure 21: Overview of the setup of the user test. NB: a camera was placed outside the picture boundaries

When having participants play thirty puzzles on a paper prototype, there are many different situations that may occur. There are numerous ways in which the participants can go wrong during the solving of the puzzles, but also with conforming to the restrictions of the game mechanics. As it is practically impossible to have a scenario ready for all possible situations, this type of testing required improvising from the supervisor of the test (who had the role of opponent) who was controlling the game mechanics, and was in charge of giving feedback.

Before the start of the user test was decided that:

- the opponent will always play optimal
- the players will receive three stars for taking the optimal number of tricks, one star when playing the first card correct, and two stars when they make a small mistake
- feedback words like 'fantastic', 'awesome', 'almost', 'nice try', and 'could be better' would be used

It was anticipated that the last two points were open for improvisement by the opponent during the course of play.

This part of the user test was recorded on camera in case later review was required.

playing *Britz!*

During the playing of *Britz!* all participants seemed to be enjoying the game. One participant exclaimed after a couple of levels "I think I could really like such a game!".

level 1

In the first level, all participants had some trouble understanding that they had to take a card and put it in the middle of the play field.

excellent achievement

Erik managed to score three stars on all levels. He made frequent use of the replay button that was available during the play. When he noted that he went wrong, he directly restarted the level. A couple of times, when a new level came at the table, Erik happily commented that he knew 'how to do this one!'.

no replay button?

Grace completed only few levels with three stars during the first half of the play. After level 15 she noted that he had not noticed the replay button. During the second half of the play she performed better and made frequent use of the possibility to replay a level in an attempt to score more stars.

improvisation: hint button

Jahan was asking several times if he could get a hint. The flexibility of the paper prototyping allowed for instance response, and a hint but-

ton in the form of a paper with the word ‘hint’ on it was added to the game space. He used it frequently, so different types of hints had to be invented. One of the hints given was ‘try one of the red cards’ and another one was ‘there are x possible tricks’.

improvisation: stars during play
Erik had special difficulty with level 24, and retried it several times without success. Some of these tries would already have scored one star because the first move was correct, but he chose to not finish the level but replay instantly. In an attempt to help him a bit, an instant star was given to him after he made the first move correct.

reflection

After each participant finished playing the first chapter of *Britz!*, there was a short interview (see interview guide in Appendix E) in which the participant was asked to reflect on the game. The interview was recorded by taking field notes.

entertainment value
All participants indicated that they were enthusiastic about playing *Britz!*. Grace added: “If you have more cards and more time, I would like to play more!”, and Jahan wants to download the game when it is done.

On the question if they felt this was a game or training, the answers were as follows:

Erik: “It is like a solitaire game, as if you play against the computer! It felt like a game.”
Anna: “After a while it became a game to plan the strategy.”
Jahan: “Training for the mind. I was thinking ahead for the next move.”
Anders: “Mostly a game, but I can see the logical training in it.”
Grace: “Game.”

game flow / zone of proximal development
All participants indicated that they found the game challenging. Anna added that the first two levels were perhaps a bit too easy, and that she got a little impatient. Erik mentioned: “The challenges seemed to be well thought out.”

game elements
The *stars* were perceived by four participants as a reward. Only Erik, mentioned that he interpreted the stars as an indication of how well he

performed in the game. All players mentioned that not getting all stars made them want to retry the level.

The *replay buttons* were well received by everyone. Jahan and Anders suggested that the button that was available during the play could maybe only undo the last move, instead of starting the level from the beginning. Grace mentioned: “In the beginning I didn’t realise that the possibility of retrying was there, but when I understood, it made a big difference.”

The *hint button* was only used in Jahan’s prototype. He mentioned: “I liked the hint button! I want to get hints so that I can win.”

The knowledge about the *maximum number of tricks* made Jahan want to think harder in order to find the solution. Erik found the knowledge useful in some scenarios, and mentioned that he stopped thinking when he knew he had the maximum amount of tricks.

Erik suggested that a *time function* could be a nice addition to *Britz!*.

6.3 evaluation

The user experience test and the reflection afterwards gave many ideas for the further development of *Britz!*

entertainment value of the game

All players gave positive feedback to *Britz!*, and perceived it mostly as a game. This indicates that *Britz!* is on the right track to becoming a Sneak Teaching Game.

zone of proximal development

There was a large difference in performance between the participants. To keep the game attractive for players of different levels, a way should be found to allow the game to proceed quicker or slower, depending on the performance of the player. This would need an even more secure sequencing, possibly within a network of conditional statements, for example: if the player completed level a, b, and c correct, then skip to level x. Another solution, that requires less logic, could be to let the player select a play mode, for example easy, normal, or hard.

It is likely that the problem that the players encountered in the first level had to do with the game mechanics. The digital version of *Britz!* should aim to realise clear procedural scaffolding.

the functionality of the game elements

The participant that at first did not notice the replay buttons managed to score more stars after she started using it. Even though she performed better in the second half, it is possible that part of the training was lost by not replaying the levels. It might be an idea to include a clause that precludes players from proceeding without sufficient training, and possibly preventing premature quitting.

The participants seemed to be enjoying positive feedback, and most were eager to get all three stars on each level because they felt like they were getting rewards. This indicates that it might be a good idea to search for ways that allow the game to give even more positive feedback. Possible types of achievement feedback that could be used include: 'wow! you scored a total of 10 stars'; 'you completed 3 levels in a row flawlessly'; or 'you are a king catcher! you managed to capture 5 Kings with Aces'. The last example even subtly includes some educational scaffolding (Aces are higher than Kings) and might be worthy of further research.

The enthusiasm with which Jahan perceived the hint button, indicated further research could be carried out to see if other players will also perceive such a button positively, and how the functionality should be. Possibly it could be combined with the knowledge about the total number of tricks, which according to Erik was only useful in some levels. Maybe, the hint button could reveal the maximum number of tricks. Together with the timing function that Erik suggested, the hint button could be connected to a point score, next to the awarded stars.

7 Iteration 3 - Design digital prototype game environment

The third iteration was about creating a digital, playable prototype that has the looks and feels of a game. A user test was conducted to get feedback on the user interface and scaffolding.

Figure 22 shows the visual representation of the design process in iteration 3. The main objectives during this iteration were:

- digitising the prototype
- illustrating supportive information & scaffolding
- testing the users opinion on game and interface, searching for ways to improve

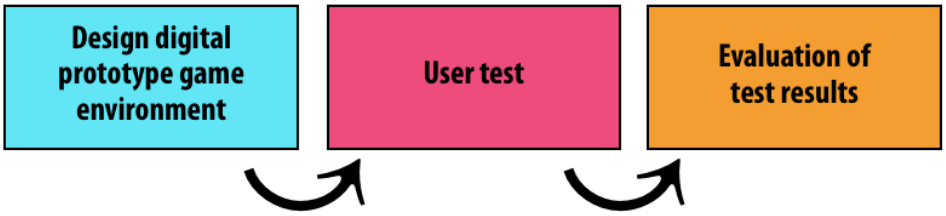


Figure 22: Visual representation of iteration 3

7.1 design of digital game environment

The digital game environment was used to visualise how *Britz!* could look on a mobile device. The intention was to create a playable prototype with a rich user interface, projected on two levels.

This digital game environment was designed during a creative process that included the sketching of wireframes, designing the user interface, and combining everything together using HTML5 and Javascript.

Note that it was not the intention to include the complete first chapter of Britz, nor to get all desired functions working perfectly. This prototype was merely to give an idea about how *Britz!* could be presented in digital form.

platform & programming

It was decided that the digital prototype of *Britz!* would be developed as

a web application, optimised for display on iPad. The most visual elements were designed in Photoshop, and were put together with HTML5 and Javascript.

choice of levels

The two levels, chosen for the digital prototype were level 1 and level 7, see figure <to be included>.

Level 1 was used because it would be interesting to see if the participants would understand the game mechanics, especially after the confusion during the first user test.

Level 7 was used because it represents a real challenge, and makes use of honours. The level was slightly adjusted to reduce the number of possible choices that can be made in the game. This made it easier to program the underlying model that the computer should follow to play optimal defence.

Procedural and supportive information was designed to help the users understand the game mechanics.

wireframes

The first step in the creative process was the design of wireframes. They served as a skeleton for the application and only showed where on the screen important elements should be placed, without paying attention to visual details.

The wireframes were sketched on paper sheets that were the same size as the iPad screen. This simplified the estimation of approximately how large the visual elements should be.

Figure 23, shows the wireframe of a level screen, placed on top of an iPad. More wireframes can be found in appendix F.

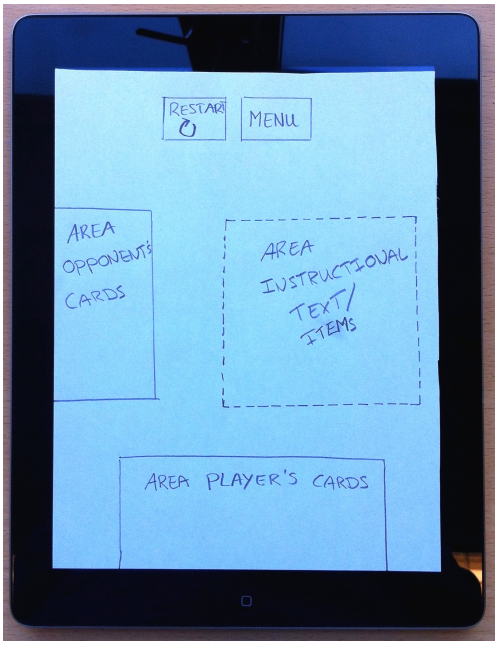


Figure 23: The wireframe of a Level, placed on an iPad, for real size comparison

user interface

The game elements that were selected in the previous chapter formed the core of the user interface. Vivid colours were used for the visuals, sounds, and music were added, and a character with whom the users can engage was designed.

visual elements

Photoshop was used to design all visual game elements, except the cards, which were found at the openclipart website[22].

Two backgrounds were designed with the aim of creating an interesting, yet non distracting stage. By varying structures and including suit symbols a setting that fits a card game was created.

Shadow was used to give the buttons a 3D effect. The buttons for sound and music were also created in grey version that was present when they were off.

A character in the form of a big happy Spade was designed to create a friendly setting for the user.

music & sounds

Sound effects and music were used to give *Britz!* the feeling of a real game. A click sound was chosen to give audio feedback when a card is played.[23]

The selected game music is called 'game music / mobile game 1'[24], and was chosen for the happy, yet suspenseful melody.

digital *Britz!*

The creative process resulted into the digital prototype of *Britz!* Screenshots of the home screen, Level 1, Level 2, and a result screen are described below. See Appendix G for more screenshots.

This prototype of *Britz!* can be accessed at SneakTeachingBridge.com. It should be noted that this version was developed for iPad (3rd generation), thus usability and functionality on other devices is not guaranteed.

[22]The cards are designed by user nicubunu, and can be found at: https://openclipart.org//tags/ornamental%20deck

[23]The selected sound is 'Chit' is a Freeware Sound Effect by Intermedia Design Graphics, and can be found at: http://www.flashkit.com/soundfx/Interfaces/Clicks/Chit-Intermed-466/index.php

[24]http://agenmusik.com/mp3/9/Game-music—mobile-game-1–CocoTown-/

Home screen

The home screen (see figure 24) is the first screen that players will see when starting *Britz!*. 'Play' will take them to start the first level and 'About' gives them some background information about why *Britz!* was developed. By tapping on the two smaller buttons, the player can switch the sounds (left button) and music (right button) on and off.

Figure 24: Screenshot of the home screen

Level 1

Figure 25 shows the starting situation of the first level. During this level, the player receives procedural information on how to use the game mechanics and supportive information to learn what a trick is and that the player who wins the trick can start the next round.

The information displayed to the player is: 1: "tap on one of your cards"+ an arrow, 2: "Well done! Now the opponent plays a card...", 3: "His card is higher, he won the trick.", 4: "That is why he can play now.", 6: an arrow, and "Nice! You won the 2nd trick".

Figure 25: Screenshot of level 1

During this level, the player can make use of the buttons on the top of the screen to restart the level or to see a menu displaying the options continue and main menu.

When the player is finished with the level, the results screen appears.

Result screen

On the reward screen, see figure 26, the player receives encouragement and gets an indication of the quality of the achievement by a number of stars. The replay button lets the user replay the level and maybe improve the score, the next button brings the user directly to the following level, and the main menu button brings the user back to the home screen.

Figure 26: Screenshot of the first results screen

Level 2

Figure 27 shows the starting position of level 2. The instruction in this level is limited to an arrow pointing at the player's cards, as an indicating that it is his turn.

When the level is finished, a results screen is displayed, this time without the next button.

Figure 27: Screenshot of level 2

7.2 user testing

The goal of testing the digital prototype was used to make a qualitative evaluation of the user interface. Five people were asked to play *Britz!* on an iPad, during and after which they were asked to answer questions about the visuals, feedback and game elements of *Britz!* in semi-structured interview-style.

participants

Five persons, Erik, Håkon, Thomas, Jahan, and Esther were asked to participate in the user test. A brief interview, similar to the one in the user test in iteration 2, was used to establish that all participants fell within the target group of bridge.

Two of the participants, Jahan and Erik, also participated in the first user test.

test setup digital *Britz!*

Data was collected by observation and an interview. The items that were used during this user test were an iPad displaying *Britz!* and a note block. Field notes were made to write down observations and comments of the participants.

users evaluation *Britz!*

During a short interview (see interview guide in Appendix H), the participants were questioned about what they thought of *Britz!*.

looks and feel

All participants expressed the opinion that *Britz!* looked like it could be a iPad game. Erik commented: "It looks like a typical app, quite intuitive also", and Thomas said: "One could probably play this game in trains, or when having to wait somewhere for 10 minutes."

Esther liked the background and commented "The images are very good!", she also reacted positively to the sound buttons turning grey: "Nice that you can *see* that there is no sound."

the levels

Håkon was a little confused about the game intention, he asked: "Is it the idea to collect the best cards? Should I go for the 9 or the 8?". Erik found it "clear" that he had to select a card by tapping it.

about button

Esther commented that she expected the 'About' section to include information on how to play the game. She suggested to rename the button credits.

suggestions

Thomas, a fan of card games, imagined about the possibilities that could come with more advanced stages of *Britz!*. He proposed “There could be a multi player mode in which both players get 13 cards and the one who makes 7 tricks wins!”

Jahan wondered how he could know that in the second level the Ace is higher than the King. When he remembered from the previous user test that there were more levels in between the specific levels, he suggested that “It could anyway be nice, if there would be a hint button on the top of the screen”.

7.3 evaluation

The user test gave some helpful feedback that can be used for the further development of *Britz!*

design

All participants reacted positive to the question if *Britz!* has the looks that could be of a real iPad game. This indicates that this prototype of *Britz!* succeeded in the mission to visually please the players as a game. The enthusiasm of Thomas for a possible multiplayer mode was very nice, and his idea should definitely be explored.

A next version should also search for a suitable name for the “about button”, to avoid confusion. Credits is an idea, but other options should be investigated.

Even though all participants were positive about the looks of *Britz!*, development of user interfaces should not be taken lightly. When designing a full version of *Britz!* different colour schemes and images should be tested, just like the size of buttons, the readability of text, and popularity of the character should be analysed.

procedural information

None of the participants commented on having difficulty with understanding the mechanical aspects of how to play the levels. This suggests that this kind of step by step guiding could be a possible solution for introducing game rules.

Håkon’s confusion about the game intention suggests that it might be a good idea to mention the goal (take as many tricks as possible) in the second level.

8 Discussion

This study on Sneak Teaching Games aimed to find answers to the following research questions:

- Main research question: How can a digital learning application be shaped as a Sneak Teaching Game?
- What are the most important characteristics of Sneak Teaching Games?
- How can scaffolding support the intended learning goals, without interfering with the game flow?

In order to answer these questions, a literature survey on Learning Games was carried out, of which the findings were used to design a prototype of a mobile Sneak Teaching Game, which was tested by domain experts and possible future users. This chapter discusses the findings of this process.

8.1 findings literature survey

The literature survey revealed that one of the most difficult things for Learning Game designers is to find a balance between the learning domain and the game world: a Learning Game should be educational, but at the same time fun to play.

This was pointed out as the main focus of Sneak Teaching Games and led to the following definition:

> A Sneak Teaching Game is a type of Learning Game where the learning is hidden within the games mechanics, so that players perceive the game as an entertainment game.

Based on the literature review and definition of Sneak Teaching Games it was suggested that the design of Sneak Teaching Games can be seen as three dimensional. The *learning dimension* addresses the need for a solid educational foundation and focusses on issues around domain modelling, adaptability, assessment, and integration. The *game dimension* makes the application attractive as a game. The *Sneak Teaching dimension* binds these two together by searching for ways in which the learning domain can be mould into the game mechanics.

Based on the three dimensions of Sneak Teaching Games a design approach was suggested for the design of the prototype, including aspects from all dimensions.

8.2 findings Sneak Teaching prototype

The design process of the mobile Sneak Teaching Game *Britz!* was carried out in three iterations. Each iteration included a design phase, a test phase, and an evaluation phase and strived to implement the suggested ideas in the prototype.

During the first iteration, the learning domain was modelled by carefully designing learning tasks in the form of small puzzles and ordering these within a chapter. This chapter was reviewed by two domain experts. During the second iteration, a game environment was added to the learning domain, realising a paper experienced prototype that was tested by five students. In the third iteration the prototype was designed for play on iPad, and was tested by five people.

The most notable results from the heuristic test and user tests showed that:

- the modelling of learning domain in small puzzles was approved by domain experts and can form a contribution to bridge teaching
- the paper *Britz!* experience prototype was perceived by most participants as a game
- the digital prototype of *Britz!* was perceived by all participants as a game
- the mobile platform proved suitable for the design of Sneak Teaching Games, since is allowed for the learning domain to be transformed into small pieces

Based on these results it can be concluded that a Sneak Teaching dimension can be created by transforming the domain model to fit gaming and to help with scaffolding.

It should be noted that all results were based on qualitative research and further research should be carried out to see the extent to which these findings are conclusive.

8.3 answers to research questions

Based on the findings of the literature survey and the process of designing the prototype, the research questions can be answered.

What are the most important characteristics of Sneak Teaching Games?
The most important characteristics of Sneak Teaching Games can be found in the proposed definition:

> A Sneak Teaching Game is a type of Learning Game where the learning is hidden within the games mechanics, so that players perceive the game as an entertainment game.

Also, it was found that designing a Sneak Teaching dimension can help to achieve such a game.

How can scaffolding support the intended learning goals, without interfering with the game flow?
This study found two methods that can be tried when finding ways to scaffold without interfering with the game flow:

- modelling the learning domain in such a way that it fits game play and contributes to the scaffolding
- embodying learning elements by game elements

Main research question: How can a digital learning application be shaped as a Sneak Teaching Game?
A digital learning application can be shaped as a Sneak Teaching Game by designing a Sneak Teaching dimension that manages to mould the learning domain with the game mechanics.

This can be done by smart modelling of the learning domain and embodying learning elements by game elements, and the design of the prototype of *Britz!* can be seen as an example of how to do this.

9 Conclusion

This study, Sneak Teaching Bridge, was conducted out of curiosity for games that have the intention to teach without the players noticing. The term Sneak Teaching Games was introduced in this thesis to describe this kind of game.

A literature survey on Learning Games was carried out with the aim of finding aspects that could be important during the design of Sneak Teaching Games. The literature survey revealed that one of the most difficult things for Learning Game designers is to find a balance between the learning domain and the game world: a Learning Game should be educational, but at the same time fun to play. This was pointed out as the area in which Sneak Teaching Games should try to go one step further, by creating a *Sneak Teaching dimension*.

During the development of the prototype of the mobile Sneak Teaching Game *Britz!*, this Sneak Teaching dimension was created by realising a tight bond between the game mechanics and the educational content. This was done by searching for ways to include the learning domain into the game mechanics.

One result of this research is that it can be concluded that during the design process of Sneak Teaching Games the designers should strive to model the learning domain to fit game play, contribute to the scaffolding, and embody learning elements by game elements.

9.1 research contributions

The research carried out in this thesis can be seen as an introduction to Sneak Teaching Games and contributes to the knowledge base by:

- pointing out, naming, and defining the concept of Sneak Teaching Games
- proposing solutions on how to mould the learning domain into the game mechanics
- testing these solutions by developing a prototype

These ideas proposed in this thesis can be used as stepping stones for further research in the area of Sneak Teaching Games, Learning Games, or Technology Enhanced Learning. That by itself can be seen as a contribution.

9.2 further *Britz!*

The idea of *Britz!* has already been well received in the Bridge community. The domain experts that were consulted during the heuristic test were very enthusiastic about the possible contribution that *Britz!* can add to Bridge teaching, and the Norwegian Bridge Federation wants to see *Britz!* developed and offered to help with this. The World Bridge Federation has already promised to invest in the project.

Knowing that within the Bridge community there is animo for a Sneak Teaching Game, makes it likely the findings and suggestions made in this thesis will develop further.

It will be fun to explore ways, for example, to transform the bidding stage of Bridge to fit Sneak Teaching, to see how trump can be introduced, and to design a multi player version, without letting the players actually play Bridge. The idea suggested by Thomas during the user test could be a great starting point for the multi player version, and could possibly be developed towards the situation where two players are both controlling two sets of cards, without knowing where the opponent's cards are. This has the potential to be a fun way to practice declarers play.

It will be exciting to see how the prototype of *Britz!* can transform into a full Sneak Teaching Game, that will teach people Bridge without them noticing.

9.3 further work

The work done during this thesis offers possibilities for further research.

The most difficult aspect of Sneak Teaching Games, seems to be finding suitable ways to model the learning domain to allow for replacement by game elements. It would be very interesting to see which kind of domains allow for this, and how this could be done. Since creativity seems to be of vital importance for this, maybe creative brainstorm sessions could be organised where domain experts with different backgrounds and designers try to find ways to transform learning domains into games. Maybe this could even result in some kind of guide on what kind of elements to look for when trying to transform a learning domain.

It could also be challenging to compare the learning outcomes of Sneak Teaching Games to those of regular teaching methods. According to

Egenfeldt-Nielsen (2006) this is the ultimate task for researchers of Educational Games, to compare the learning outcomes to those of regular teaching methods.

Whether or not the concept of Sneak Teaching Games turns out to be vital, the ideas proposed in this thesis about how to realise a tight bond between the game mechanics and the educational content are worthy of further research. It is likely that ways to including (parts of) the learning domain into the game mechanics will be seen as a welcome tool that can help contribute to the design of engaging Learning Games.

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Appendix A - Bridge apps on Google Play

The descriptions below give information on seven of the available Bridge applications available on Google Play.

Bridge Baron

Rating: 4.7 / 5.0
Price: 118.49 NOK
Category: Playing bridge
Downloads: 100 - 500
User remarks: Graphics could be cleaner. UI is chunky.
Description: *"Play some serious Bridge with your Android phone or tablet. BridgeBaron is based on the best-selling computer Bridge game Bridge Baron, and is using its bidding and bridge play engine, which has won Five World Computer Bridge Championships."*

Omar Sharif Bridge 3

Rating: 4.4 / 5.0
Price: 35.87 NOK
Category: Playing bridge
Downloads: 500 - 1000
User remarks: Lack of documentation, no description, no help button. Confusing.
Description: *"Featuring ACOL and Standard American bidding systems, Omar Sharif Bridge will challenge the most proficient player yet still allow the beginner to develop their game. Fantastic graphics and a strong and respected bridge engine allow players to become involved, stimulated and challenged with every deal."*

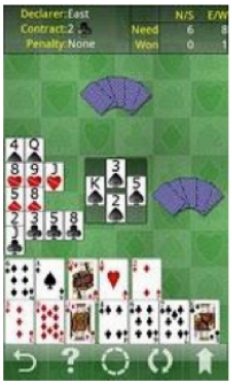


Figure 28: Review of Bridge Baron & Omar Sharif Bridge 3

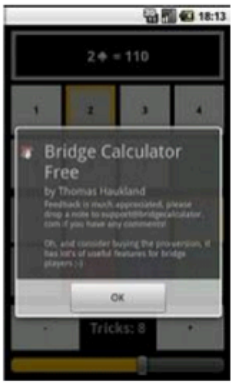
WeWeWeb Bridge (Free)

Rating: 3.9 / 5.0
Price: Free
Category: Playing bridge
Downloads: 10.000 - 50.000
User remarks: Application doesn't remember or save the game.
Description: *"A Bridge Game application that can be played by self-offline against robot or connect via Internet to play with your friends. The robot uses SAYC (partially implemented). It is a beta-release and is subjected to continue development efforts."*

Bridge Bidding

Rating: 4.3 / 5.0
Price: Free
Category: Conventions
Downloads: 5.000 - 10.000
User remarks: Troublesome to browse
Description: *"Over 200 Bridge Bidding Conventions. Bridge Bidding is a searchable cross-referenced compendium of bridge bidding conventions."*

Bridge Calculator Free

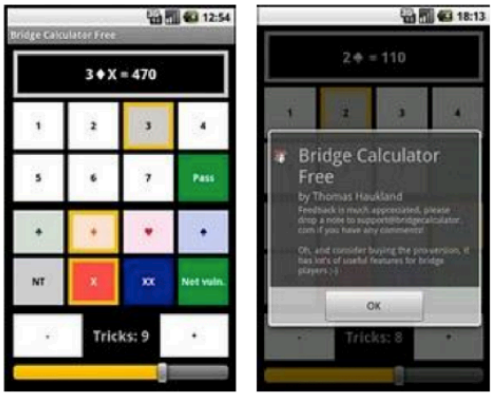


Rating: 4.5 / 5.0
Price: Free
Category: Calculator
Downloads: 1.000 - 5.000
User remarks: -
Description: *"Score bridge contracts. This app calculates the score of a bridge game contract given the number of tricks taken."*

Figure 29: Review of WeWeWeb Bridge, Bridge Bidding, & Bridge

Bridge Calculator Free

Rating: 4.5 / 5.0
Price: Free
Category: Calculator
Downloads: 1.000 - 5.000
User remarks: -
Description: *"Score bridge contracts. This app calculates the score of a bridge game contract given the number of tricks taken."*



Bridge Score Calculator

Rating: N/A
Price: Free
Category: Calculator
Downloads: 100 - 500
User remarks: -
Description: "Be ready for a game of Bridge anywhere anytime with the Bridge Score Calculator! The Bridge Score Calculator displays any duplicate score possible. Simply Swipe and Tap your way to the contract and result desired!"

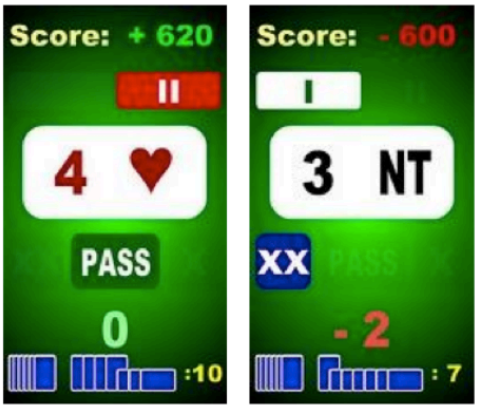


Figure 30: Review of Bridge Calculator & Bridge Score Calculator

Appendix B - Card play techniques

Below are short descriptions of card play techniques. These descriptions are simplified and show only the relevant information for *Britz!* chapter 1, and should be extended when more cards or more opponents are involved.

promotion
Driving out the high cards of the opponent. This means that you gain trick(s) by offering one (or more) tricks to the opponent.

finessing
Making a trick with a card that is at that moment not the highest one. For an example see figure 15.

endplay
Giving the opponent a trick, after which he cannot avoid giving you a trick with cards that are not the highest one.

ducking
By not taking a trick, even though you can, creating a situation in which the opponent is endplayed.

developing long suits
Making tricks with a suit that is no longer in the possession of the opponent.

cashing winners
Playing the highest card left in a suit.

trumping
By playing a card of the trump suit (super suit), when you can't follow the suit that is asked.

a combination of these
For example: first cashing a winner and after that endplaying the opponent.

Appendix C - Interview guide: heuristic test

Introduction of participant

- Could you introduce yourself, and your relation to Bridge teaching?

Introduction to game

- Explanation of the game (meant for beginners to do with course, or as stand alone game)
- Showing the levels of first chapter
- Explaining how the next chapters would evolve: playing with a dummy and two opponents; having the cards shortly open for opponents, then closed; Possibly multiplayer, giving a set of cards playing against each other.

Questions

1. Do you think your beginners (or non beginners) could benefit from solving these kind of puzzles next to the course material?
2. Do you think people who played only this game would have an advantage over others after they played this game?
3. Would you say over these 30 levels, the level of the puzzles goes up evenly?
4. Would you say the learning curve is too low, good, or too high?
5. Is there enough variation in these puzzles?
6. Do you have any other additions or tips?

Appendix D - Storyboard level 1

Figure 31: All steps of the storyboard of level 1.

Appendix E - Interview guide: user test 1

Interview part 1: establish if participant fits in target group

- What is your age?
- Do you enjoy playing games or puzzles?
- Do you play card games? (which ones?)
- Do you own or have access to a smartphone or tablet?
- Do you play mobile games?

Interview part 2: reflection

1. Did you enjoy playing this game?
2. Did you feel this game was challenging you?
3. Did you feel getting the stars was a reward?
4. Did not getting all the stars on a level make you want to retry?
5. Do you feel as if you were playing a game, doing a training, or learning?
6. Do you think the replay button should be available all time?
7. What is your association with Bridge?
8. *Added as a result of interview 4*: Would you like to know the maximum amount of tricks every game?
9. *Added as a result of interview 5*: How did you feel about getting the stars in real time?
10. Is there anything else you would like to add?

Appendix F - Wireframes

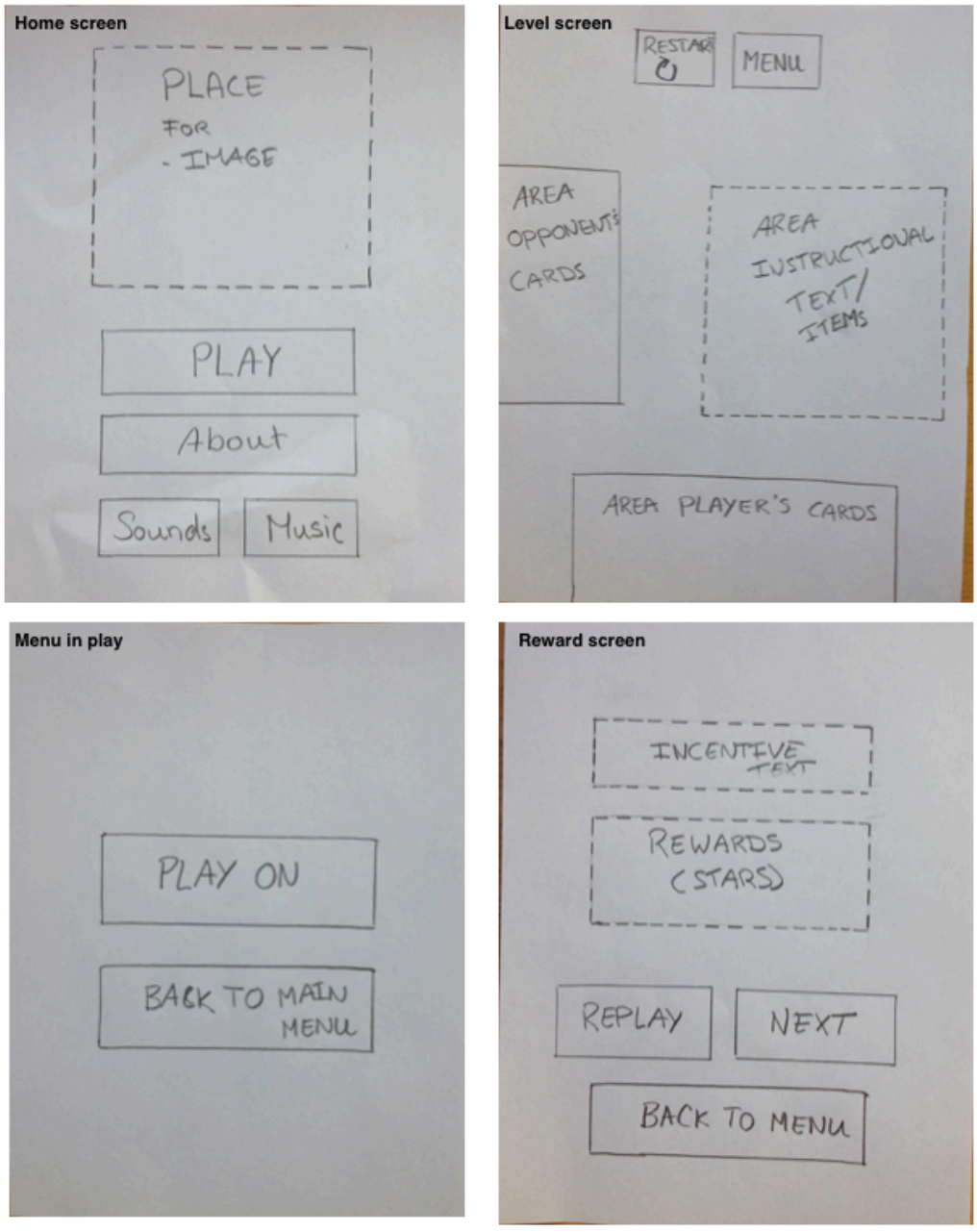


Figure 32: Wireframes of the Home screen, Level screen, Menu in play, and Reward screen

Appendix G - Screenshots *Britz!*

Figure 33: Screenshots of Home screen 2x, About screen, and In play menu

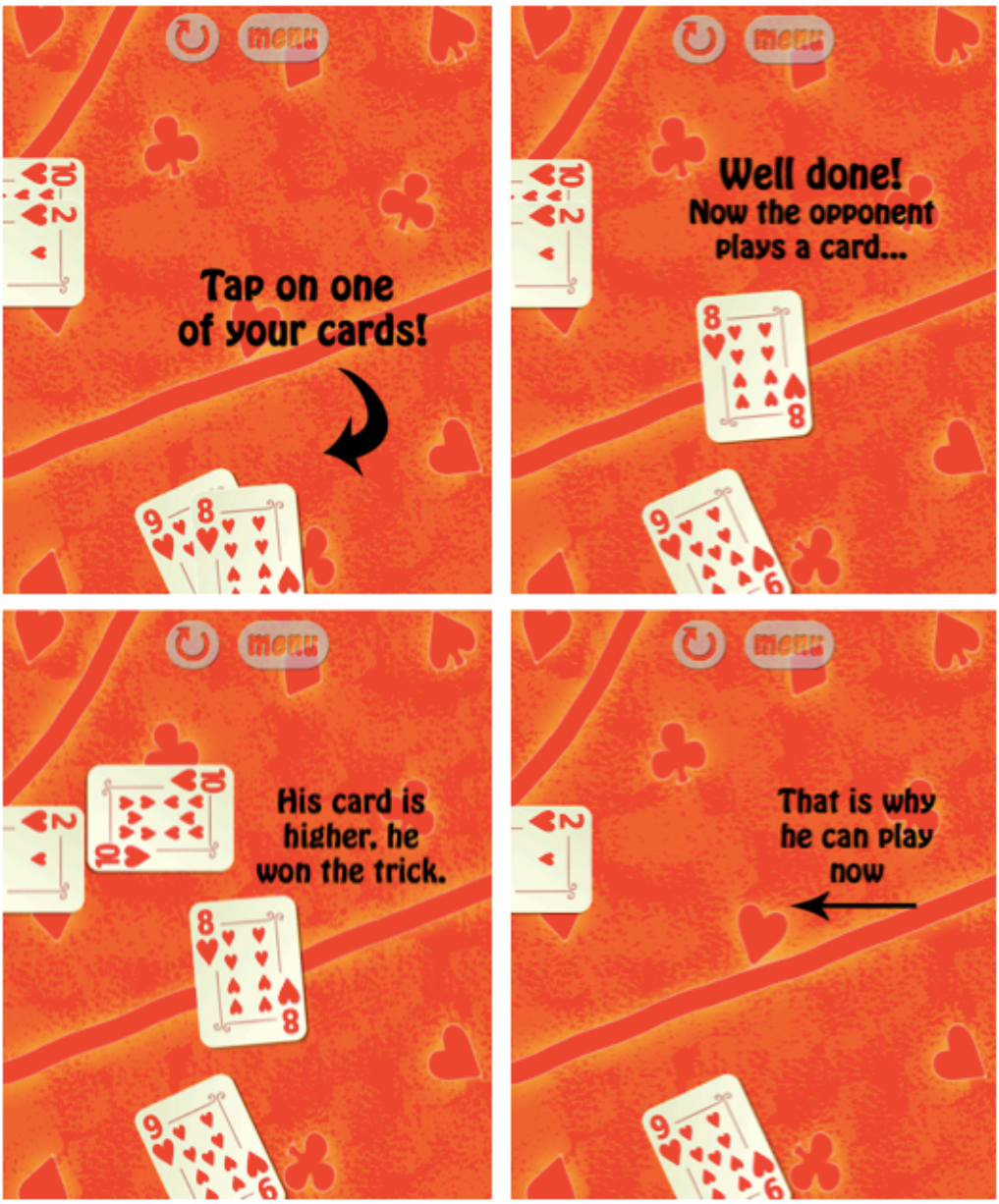


Figure 34: Screenshots of Level 1

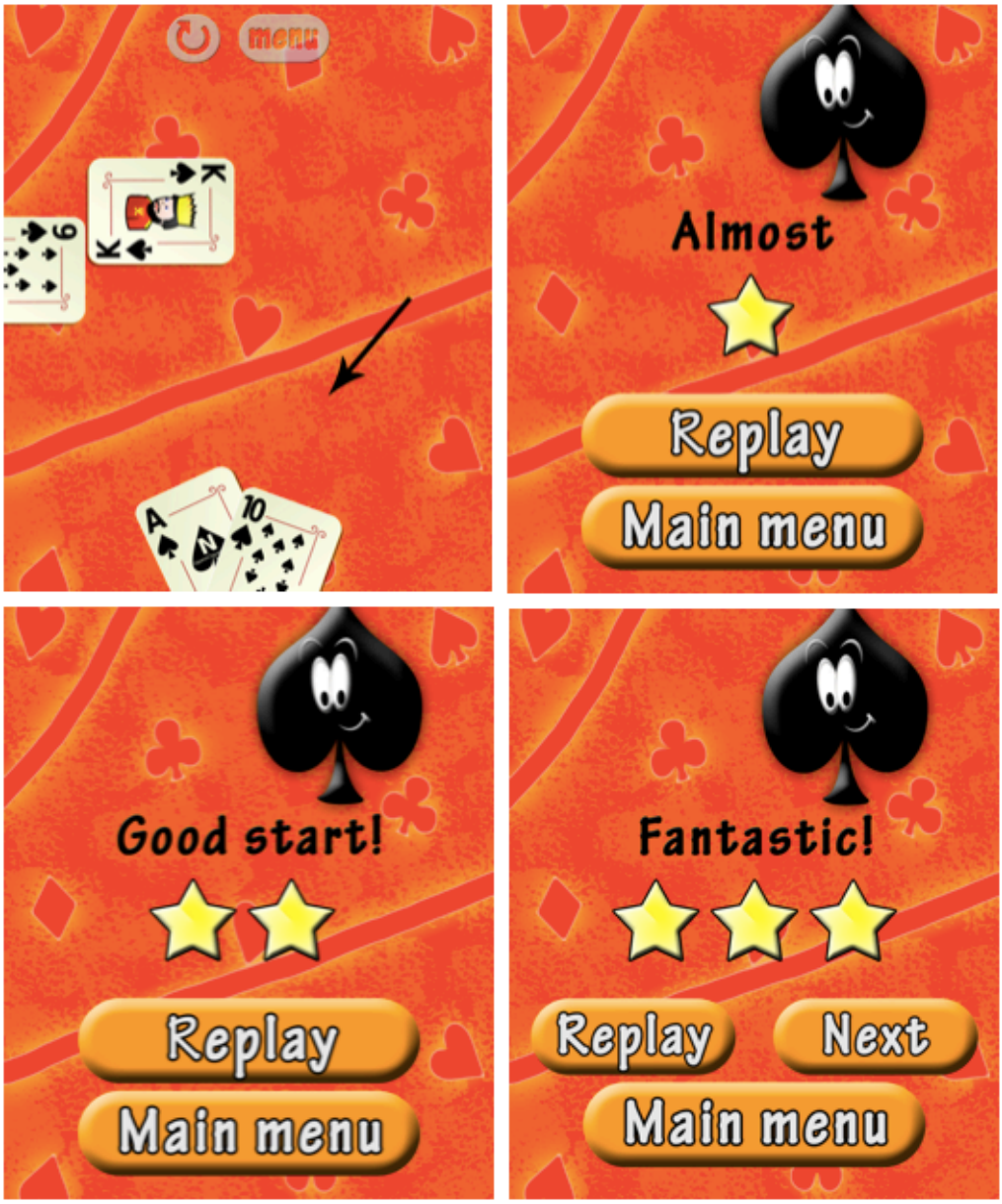


Figure 35: Screenshots of Level 3 and Results screen 3x

Appendix H - Interview guide: user test 2

Interview part 1: establish if participant fits in target group

- What is your age?
- Do you enjoy playing games or puzzles?
- Do you play card games? (which ones?)
- Do you own or have access to a smartphone or tablet?
- Do you play mobile games?

Interview part 2: reflection

1. Does this game look like it could be an iPad game?
2. What do you think of the visuals?
3. What do you think of the game?
4. Do you have any more ideas or tips that can make the game more fun?