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OTTO-VON-GUERICKE UNIVERSITY MAGDEBURG



FACULTY OF COMPUTER SCIENCE
DEPARTMENT OF SIMULATION AND GRAPHICS

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CHILDREN, COMPUTER AND CREATIVITY: USABILITY GUIDELINES FOR DESIGNING A GAME AUTHORING TOOL FOR CHILDREN

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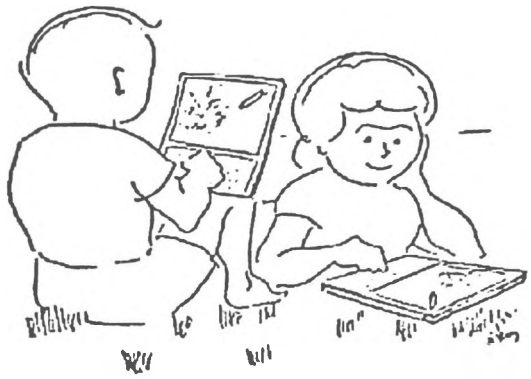
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The best way to predict the future is to invent it…Alan Kay
Illustration of children using the Dynabook originated from Kay's paper [Kay72].

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Special thanks to my parents to whom I dedicate this work.
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Abstract

The thesis is based on implementing a child-centered design approach in the creation of a game authoring tool for children to be used in the classroom as one of their learning tools. Indeed, research in designing such educational software is primarily focused on the learning outcomes, but not on the usability. However, the usability of such software for children is a prerequisite for any learning to be useful and significant. The thesis purposes with a belief that substantial improvements can be made by paying careful attention to usability during the design of the game authoring tool. Unlike the related approaches, the scope of research focuses on the game authoring tool which emphasizes on the design of the game authoring tool and concentrates on the flexibility of the interaction and construction activity in making games. This research methods started by investigating works from other researchers including comparing the usability guidelines used in other fields and exploring the existing educational programming tools for children. The findings exposed the possibility of planning and designing guidelines for usability and limitations or problems faced in these tools. The outcomes were also used to guide the first draft of usability guidelines. To demonstrate and validate these guidelines, a preliminary study was conducted. The study consists of two user studies conducted in two different locations with the goal, to get as much information as possible in childrens' preferences and needs based on the usage of two given software. Informed by these results, the prototype of a game authoring tool named Gatelock was designed. There, design features were used – game programming, game designing and game playing. In game programming, the visual programming method is being carried out. The method is being implemented in a variety of application software for children, especially in the field of interaction design for children. In game design, children use the basic elements of game design in their game making, including planning the games, designing, building, gameplay testing, and re-design. In game playing, the children can participate in the design processes with learning material and they can incorporate elements of various lessons such as physics, mathematics, science and drawing. Throughout the design and development of Gatelock, formative and summative evaluations were conducted to examine the usability and fun aspects of Gatelock. This thesis is a contribution to the scientific domains of child-centered design. It draws on ideas and techniques from the fields of children and interaction design, usability study, game design, as well as evaluating software for children. With respect to game design and children, the main contribution of the thesis can be specified as product-based and process-based. Product-based contributions include a prototype (Gatelock) which has a unique set of features due to its child-centered design, and a list of usability guidelines for designing a game authoring tool for children. Process-based contributions include a preliminary study of creating a new game authoring tool with usability as the first objective, as well as empirical evidences characterizing the preliminary study with results made by children, formative and summative studies which demonstrate the usability of the game authoring tool, empirical evidences on the usefulness of methods, tools and techniques used for the evaluating process with children, and a list of usability guidelines for designing a game authoring tool for children. This thesis also presents the results of the research with the presence of usability guidelines. At the end, both, the game authoring tool and the usability guidelines are iteratively involved in the design refinement.

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Zusammenfassung

Diese Doktorarbeit setzt einen auf Kinder ausgerichteten Design-Ansatz bei der Entwicklung eines Spiele-Autorenwerkzeuges für Kinder um, wobei das Autorenwerkzeug als ein mögliches Lerninstrument in Schulklassen genutzt werden soll. Bisher ist die Forschung bei der Entwicklung solcher Lernsoftware im Wesentlichen auf die Lernergebnisse ausgerichtet, jedoch nicht auf die Benutzerfreundlichkeit. Die Benutzerfreundlichkeit von Software für Kinder ist jedoch die Voraussetzung für sinnvolles und nachhaltiges Lernen. In der Doktorarbeit wird die Überzeugung vertreten, dass durch die sorgfältige Beachtung der Benutzerfreundlichkeit während der Entwicklung eines für Spiele vorgesehenen Autorenwerkzeuges wesentliche Verbesserungen erzielt werden können. Im Gegensatz zu ähnlichen Ansätzen konzentriert sich der Schwerpunkt dieser Forschung auf das Design des Autorenwerkzeuges und auf die Flexibilität der Interaktions- und Erstellungsabläufe bei der Entwicklung von Spielen. Die vorliegende Arbeit widmet sich zunächst der Betrachtung von existierenden Forschungsarbeiten, der Untersuchung von vergleichbaren, in anderen Bereichen verwendeten Usability Guidelines sowie der Untersuchung existierender pädagogischer Programmierwerkzeuge für Kinder. Diese Analyse erlaubte die Identifikation von Möglichkeiten, Richtlinien für benutzerfreundliche Software zu entwerfen und Einschränkungen bzw. Probleme, die bei diesen Werkzeugen festgestellt wurden, zu beheben. Die Analyseergebnisse konnten ebenfalls dazu genutzt werden, eine erste Fassung der eigenen Usability Guidelines zu erstellen. Zur Veranschaulichung und Validierung dieser Richtlinien wurde eine Vorstudie durchgeführt. Diese setzt sich aus zwei, in verschiedenen Ländern durchgeführten, Benutzerstudien zusammen, die unter Nutzung zweier existierender Software-Werkzeuge darauf abzielten, so viel Informationen wie möglich über die Vorlieben und Bedürfnisse von Kindern zu erhalten. Anhand dieser Ergebnisse wurde der Prototyp des eigenen Spiele-Autorenwerkzeuges *Gatelock* entwickelt. Dabei wurden Design-Aspekte wie Spieleprogrammierung, Spielentwurf und das Spielen bzw. Testen der Spiele berücksichtigt. Für die Spieleprogrammierung kommt eine Variante des *Visual Programming* zum Einsatz. Diese Technik wurde bereits in zahlreichen anderen Programmen für Kinder mit Erfolg verwendet, insbesondere im Bereich Interaction Design. Für den Entwurf von Spielen können Kinder typische Grundelemente des Game Designs zur Erstellung eines Spiels, inklusive der Planung, des Designs, des Aufbaus, des Testens des Spielflusses sowie der Neugestaltung nutzen. Während des Spielens bzw. Testens können sich die Kinder mit Lernmaterialien an den Entwicklungsprozessen beteiligen und Elemente verschiedener Unterrichtsfächer, wie z.B. Physik, Mathematik, Naturwissenschaften und Kunst einfließen lassen. Während des gesamten Entwurfs und der Entwicklung von Gatelock wurden formative und summative Evaluationen durchgeführt, um die Benutzerfreundlichkeit und die Spaßfaktoren von Gatelock zu untersuchen.

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1
Introduction

As a multi-disciplinary field, *human-computer interaction* (HCI) is concerned with how humans interact with computer technology. It draws its theories and models from ergonomics, psychology, social science and computer science and has traditionally been concerned with the use of systems for work. For the purpose of children as ultimate users, another field has widely become known as *child-computer interaction* (CCI) which is meant to be the subset of the HCI field but also has the need to rely on theories from child psychology, education and game research [Read05a] [Read05b]. Since it is a new discipline, many unresolved issues are still in work, particularly in respect of the methods and techniques used and implemented in HCI to be adopted in CCI, involving children in the design and evaluation of their own software, and the acceptance of opinions and judgements from children concerning the software they interact with [Hanna97][Donker01]. These unresolved issues and questions related to them were the main motivations to establish this research in the field of children and interaction design.

This research combines theories and techniques from the fields of usability study, interaction design and children, and game design. It aims to find a usable and extensible usability guideline for the development of a game authoring tool. It is also derived from a specific interest in how the tool might be deployed by children for learning and gaining computer literacy. The work is expected to deliver both a product-based (a game authoring tool and evaluation instruments) and a process-based approach (a set of usability guidelines) by developing a similar game authoring tool for children that focuses on fun in the learning environment.

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1.1 Motivation

First, other than the aspect of children being involved in software design and development, children's software applications are simply developed without looking at the direction of usability engineering which is aimed at the effectiveness and efficiency of the software and the user satisfaction. However, research on this matter is relatively scarce and studies with children in particular areas are rare [Read06]. Prominent guidelines such as Web usability guidelines [Nielsen94], interface design guidelines [Shneiderman97], interface design guidelines by Microsoft [Microsoft95] and Macintosh [Apple92], and a list of guidelines on how to conduct usability tests with children [Hanna97] have been carried out and tested, but none of them specifically aims for a game authoring tool with children as users [Yatim07b]. Nevertheless, related works in this research field are presented in several studies. One work refers to a study that propagates 70 guidelines for a Web-based user interface design for children [Gilutz02], while other studies refer to the development of programming environments such as Icicle and HANDS. In the Icicle programming environment, the designer established a list of guidelines for developing a programming environment for children [Sheehan03], while the designer of HANDS concentrated on the aspects of HCI and usability throughout the development [Pane02].

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Overall, the usability guidelines existing today are not sufficiently catered to children's software [Barendgret06][Read06][MacFarlane05b]. They should always be included among the criteria that are considered during the design of any system. Depending on the constraints of a particular project and target audience, usability may be given more or less weight. However, it is always worth considering for at least those decisions that are not already determined by other design criteria. Addressing these issues, the thesis demands to go from design concepts in building necessary technologies, to putting together the research approach and conducting studies to learn from the process. In the end, a list of usability guidelines for designing a game authoring tool for children will be presented. The usability guidelines constructed throughout this research could be helpful for the design of other game authoring tools, or could be used in other software for children. The usability guidelines can be used in two ways, either as a benchmark to evaluate the usage of children's software [Nielsen07] or as a checklist to design children's software [Resnick05]. Together with the HCI theories, principles and standards, the designed guidelines can help designers and researchers to produce good or better software products [Yatim07d], and at the end they will support and consolidate the usability guidelines designed in this research.

Second, when the thesis work began, there had been a huge popular interest in integrating children with software used for designing or constructing activities. Previous research was done by researchers in the field of children and interaction design [Harel90][Kafai96b][Robertson01]. These scholars agreed upon one thing: Learning can take place by doing and practicing with the design activities. The idea came from the constructivist theory approach which originated from Papert's ideas and works [Papert80]. The works focus on the aspects of children using educational software such as programming or simulation software, except for the work of Kafai who focused on computer game design with Logo programming for children's personal and creative expression [Kafai96b]. Nevertheless, there are still a number of unanswered questions in terms of game design software technologies for children.



Figure 1.1 Edutainment software products. (*Left*) The first title of the *Math Blaster* series was released in 1994 by Davidson and Associates. (*Middle*) *Typing of the Dead* was released in 1999. (*Right*) The first Carmen Sandiego software game, *Where in the World is Carmen Sandiego?* was released in 1985.

Developers of educational software often used games as a reward for children upon completion of the given learning objectives [Kaiser02]. The early educational software title once known as *edutainment* became synonymous with the *chocolate-covered-broccoli* or *eye-candy* approach to gaming [Bruckman97][Jegers01]. This approach defined the edutainment era where more edutainment titles such as *Math Blaster*, *Typing of the Dead* and *Where in the World is Carmen Sandiego*, as shown in Figure 1.1, dominated the games market. On top of that, in the educational field a debate came up about the use of computer games for learning.

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In other words, edutainment titles received a bad reputation and led to a great crash [Egenfeldt-Nielsen05]. It formulates the boring learning lessons and materials (mathematical worksheets, in this case) within a fun gaming environment [Edwards01]. With small development budgets, less innovation, and a lower quality of edutainment titles, the edutainment market faces a decreasing consumer interest [Dyck03][Muda05].

The edutainment approach to integrate games and learning has reported as not working and has been critizised for combining the worst aspects of both the educational and the entertainment field [Habgood07][Kerawalla05] [Trushell01]. The main reason for this is the capability of the software itself in teaching the users. Although this type of software is very common and can be easily found on the Web or on any CD-ROM format, it is usually inappropriate for long-term learning especially for children, since they have no control over its creation [Prensky06]. Most educational software provides pre-programmed scenarios and tells children what to do. The children are only being informed instead of directly and actively getting involved with the software within their own learning pace. In the end, the educational software does not provide children with creative outlets [Peppler05]. Due to this, some people are reluctant to use the word *edutainment* even though the content delivery is just the same, but yet change it to other terms such as *playful learning* [Resnick04] and *digital game-based learning* [Prensky01]. The terms refer the edutainment field to a new perspective where games are not totally designed to present the learning aspects but also primarily used to reinforce the understanding of presented material and to add a variety in learning.

> *"I prefer to focus on play and learning (things that you do) rather than entertainment and education (things that others provide for you). It might seem like a small change, but the words we use can make a big difference in how we think and what we do".*
>
> *Mitchel Resnick (2004), page 1.*

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> *"The premise behind Digital Game-Based Learning is that it is possible to combine computer and video games with a wide variety of educational content, achieving as good or better results as through traditional learning methods in the process".*
>
> *Marc Prensky (2001), page 145.*

In a new era of game development, game designers have started to examine the future course of games and started to integrate pedagogy aspects directly in the game play. This time, the term used is *serious games* [Michael05]. The serious games initiative aims at the future of game design and development in the area of education and training, government, healthcare, military simulation, business and corporate. These games are designed and developed for the purpose to educate, inform and train people who want to do things more seriously than simply having fun. Serious games are considered as the next wave of technology-mediated learning which offer a powerful and effective approach to learning and skill development in today's workforce [Bergman05][Derryberry07]. Why does the game design movement aim to be serious about games? Do serious games really promote learning? What do learners, including children, think about serious games? Several reviews of literature have been conducted regarding the educational gaming [Wolfe98][Randel92][Cavallari92], but still lack of research on the effectiveness of serious games as learning tools [Egenfeldt-Nielsen06]. Some findings of the learning outcomes from playing games are positively promising, but others are sceptical with the aspects of methodology flaws and contradictory results [Kirriemuir03]. Therefore, the thesis aims to seek the answers

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by applying games outside the realm of a 'normal' games-related initiative. In other words, instead of searching the development and social impact of children playing games, the thesis offers findings on the impact of children designing games using a game authoring tool. It is assumed that game design activities can offer a new teaching and learning tool for children, but the processes or impacts have not been investigated yet. Ideally, such software should provide a medium for children to express themselves in ways that would not be possible without a computer. As a result, an investigation with a proper research method is needed to identify the underlying factors that contribute to the problem and to find the ways and means to address it.

Third, another aspect of interest that could derive from this thesis are the promising aspects of *learning by doing* and *by thinking about what they do*, which can improve the questions of *what* and *how* children learn [Papert80]. Papert suggests that technology is an ideal way to make practical use of the theories on learning by doing as suggested by Dewey and Piaget [Ackermann09][Papert93]. For this research, the most significant question is whether the game design activity would make the computer access easier for children to facilitate learning, or if it fails to provide any of it. The *constructionism theory* is grounded in the idea that people learn by actively constructing new knowledge, rather than having information poured into their heads [Clements99]. It is believed that children can use and capitalize on the benefits of technology by using integrated computer activities to increase their achievements. The computer seems to have the potential to offer children a wealth of opportunities to express themselves and to learn. As a creative medium, computers can help children express their imagination in ways that are not possible with other materials [Peppler05]. Another issue is that sophisticated software is not learned by osmosis or even by repeated use [Kafai96b]. Children acquiring computer skills still need formal instruction to master sophisticated applications and keep their skills updated.

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Learning to program is also a valuable part of a general education for children [Papert99]. In addition to being a nice introduction to structured problem solving, programming also enables children to gain experience with complex systems and provides them with computational thinking skills that can be applied to a broad range of disciplines from sciences to mathematical contents [Harel90][Kafai96b][Guzdial01a]. Programming provides children with some hands-on experience dealing with complex systems that they create themselves [Seth96][Baldwin00]. When their programs do not behave as expected, children have to learn to isolate the problems and to solve them. They learn to narrow the scope of a problem and that a single malfunctioning program component can cause other program components to malfunction as well. In addition to the critical thinking skills that children develop through programming, an understanding of computer programming may prove to be a valuable job skill for many people nowadays. The thesis shows a promising area of the game design and development field in engaging children towards learning. This approach is referred to as *intrinsic integration* [Malone87] which combines a playful approach with a constructive activity [Dix03]. Intrinsic integration deals with delivering learning content with the flow of experience of a game [Kafai01][Habgood07].

This section reviews three motivational issues around the research. Regarding the usability guidelines, the research will propose a list of guidelines not only to be used for designing a game authoring tool, but also to be used for other children's software. In the games field, the research will investigate the integration of computer games technology within the educational field, not only for playing a game, but also for designing it. In the field of

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learning by designing, the research will incorporate the constructive designing game activity into a meaningful educational lesson that increases the learning motivation. These issues are aimed to provide a contribution to extend the capabilities of finding and practicing the usability guidelines in designing a game authoring tool for children. This research is subject to a more serious study within the disciplines of child psychology, education, computer science and sociology, all in the name of learning. However, these issues are too broad and go beyond the scope of this thesis. Therefore, the research only complies with the basic concepts and integrates them into the goal of the research, which is explained in the next section. The ability to grasp these broad and multidisciplinary areas is critical, as it represents the fundamentals in seeking usability guidelines that deal with the construction of a game authoring tool for children to be used for designing games. In addition, even though this thesis is based on education and learning, it also incorporates related perspectives of the game development community itself.

1.2 Research Goal, Objectives and Approach

The goal of this research was *to develop constructed and refined usability guidelines of a game authoring tool*. To achieve this goal, the idea was *to design a game authoring tool for children iteratively while constructing and refining the usability guidelines*. Three main objectives were specified:

- To explore the possibility of a game authoring tool and its technology for children, specifically to facilitate learning in the classroom;
- To identify the usability problems and fun aspects that might arise from the game authoring tool design and development cycle; and
- To suggests usability guidelines as a benchmark for designing and developing a game authoring tool for children.

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According to the aforementioned, the research goes into three major directions, which are (1) usability for designing a game authoring tool, (2) children and game authoring tool, and (3) interaction design and children. In this research, a design process for developing a game authoring tool for children is created, whereas usability is treated as a main objective. It is assumed that the use of a list of usability guidelines would *improve usability and fun aspects* of a game authoring tool for children. Finally, the use of a game authoring tool would convey *computer literacy skills* for children including thinking, learning and programming skills. The research is not only about testing these assumptions, but also to provide some insight into each of them. The main question guiding this research was *how the process of developing and evaluating a game authoring tool and a construction of usability guidelines can facilitate children's computer literacy and learning skills*. To answer this main question, more questions were formulated and are listed below:

- Can the usability guidelines really show the usability problems that occur in the game authoring tool?
- Do the elements in the game authoring tool need to be refined to better accommodate learning on how to design games for children?
- Do satisfaction and fun factors have a close relationship with usability in the game authoring tool?

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With such questions in mind, a game authoring tool for children was designed with a focus on children as main users. By all means, its features should match the requirements of children including the user interface, the storage system, the framework system, the way the program is integrated into the system, and even the language that the children can use to produce their own programs. The comparable existing systems are going to be explained in Chapter 2. But it is definitely too much work needed to develop a system of that extent. Most existing systems were the product of many years of development by an extensive team of designers and programmers. After investigating some alternatives, only the *programming capability* and *interaction components* are focused as the basis for this research. This is due to the fact that game programming is the main design activity which cannot be realized without a computer [Pleva04]. Other tasks, such as drawing game characters or avatars, music and audios etc. can be accomplished by integrating with any application tools.

The target audience for this research are children between seven and twelve years. The age range was chosen, because these children (also known as *middle childhood*) comply with the Theory of Cognitive Development [Piaget83]. Children of this age use *logical operations* when solving problems. The cognitive development stages are taken into consideration in this research to understand how children learn and think. Although a child's cognitive development is not a major part of the research, this point will be briefly explored in the next chapter. Secondly, children in the selected age range often have a *high interest* in learning how to program [Mano04][Robertson04]. They have creative and ambitious goals for their program making that are similar to the applications they use especially in games and simulations which are well-known for their graphically rich and highly interactive activity. It is also important to know how children use and work with software tools including the degree to which the learning matches the childrens' capabilities and their ability to involve in evaluating the tools [Hanna04]. The final reason is that they comply with the *age classification standard* set by the game industry [Bijvank09][Pan09][Unterhaltungs09]. The age rating is primarily concerned with the game rating system, game content descriptors, and as guidance for parents when buying games. All these factors act in accordance with the direction of this research.

Next, the approach of this research will be explained by referring to Figure 1.2. There are four main components of this research which are the requirements analysis, initial study, prototype development, and evaluation study. First of all, the research started with *surveys and investigating works* done by other researchers, including comparing the usability guidelines used in other fields and exploring the existing educational programming tools for children. The aim was to find a possibility of planning and designing guidelines for usability and also to find the limitations or problems faced in these tools. The outcomes were used to guide the first draft of usability guidelines. The second component was the realization of the *preliminary study*, which comprises of two user studies known as User Study 1 and User Study 2. At the end of both user studies, the children received questionnaires. These questionnaires can help to find problems in the existing tools and validate the earlier draft of the usability guidelines. The third component of the research approach is the design of *a game authoring tool* named Gatelock. The tool was designed and developed according to the guidelines established based on theoretical studies and user studies. The last component of the research approach is the *evaluation* phase. The game authoring tool was used and tested by selected children in two separate evaluation studies: the formative evaluation and the summative evaluation. As shown in the same figure, the usability guidelines have been revised constantly throughout the design and the development of the intended game

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authoring tool. It is understood that the guidelines do not specify exactly what a game authoring environment for children should look like and how it should work. But they do offer help when choices need to be made on how something should work or appear.

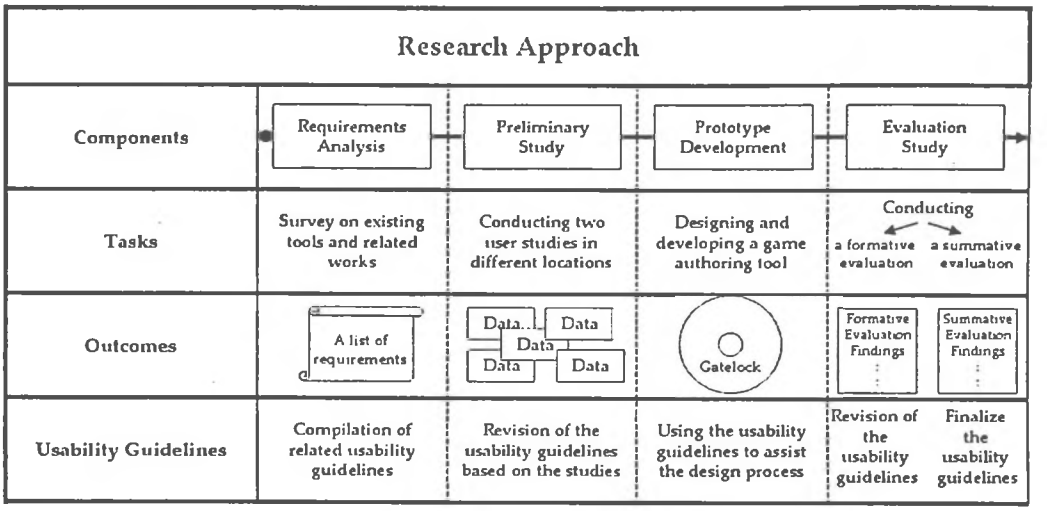


Figure 1.2 The research approach includes four main components. For each component, several tasks are identified, and their major outcomes or deliverables are defined. They indicate the completion of each task. The usability guidelines have been created and revised respectively based on the findings from each task.

The research approach is constructed in a way that is believed to provide solutions for three important issues. First, by testing several existing or related tools and having a list of usability guidelines before designing the prototype, common problems during the software development such as poor requirements, an unrealistic schedule and inadequate testing can be avoided or minimized. Second, by conducting a preliminary study before designing the prototype, the children are understood by the designers and researchers in terms of their cognitive behavior and attitude characteristics. Third, by having an iterative design of prototype, common problems found in the usability studies can be fixed. This means, there must be a cycle of designing, testing, measuring and redesigning that is repeated as often as necessary. Other than that, the research approach also follows the field of child-centered design (CCD) which was derived from the user-centered design (UCD) philosophy. There is a strong direction in children's technology design as applied research including the evaluation of the developed software product [Jensen05]. CCD provides a number of opportunities in the integration of children, designers and researchers for different perspectives on children's use of technology. This includes understanding the framework used in CCD, focusing on the development of new systems or parts of systems, redeveloping existing systems or parts of systems, and assessing or validating the systems for evaluation purposes. Due to the complexity of the field, this research will focus on the related theoretical knowledge in CCD including the evaluation process and procedures.

Several challenges have been identified throughout this research while using the approach. These challenges can be grouped into four aspects, which are engagement and learning, the design and development of the prototype, the procedure and methods of conducting evaluation studies, and the process of outlining the usability guidelines iteratively. Most of

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the challenges and problems have been solved throughout the research, while some have not been solved yet and are treated as future work. The challenges and problems will mainly be discussed in the last two chapters of this thesis; nevertheless, they are also going to be discussed in the respective chapters.

1.3 Research Contributions

This thesis presents the results of the research on designing a game authoring tool for children with the presence of usability guidelines. Therefore, the whole research contributes to the usability for designing a game authoring tool, children and game authoring tools, and interaction design and children. More importantly, through the development process of this research the game authoring tool can conform to children's needs and desires by using a set of usability guidelines. Finally, the outcomes can be summarized as technologies, applications and usability guidelines aimed at supporting children's creativity and learning. By integrating these activities, the specific research contributions are:

- a preliminary study of creating a new game authoring tool where usability is the first objective;
- empirical evidences from the preliminary study with children, which can be used to help designers generate the initial design requirements and select the appropriate authoring features;
- a game authoring tool prototype which has a unique set of features due to its child-centered design;
- formative and summative studies which demonstrate the usability of the game authoring tool;
- empirical evidences on the usefulness of methods, tools and techniques used for the evaluation process with children; and
- a list of usability guidelines for designing a game authoring tool for children.

1.4 Structure of the Thesis

The remaining chapters of this thesis are organized as follows:

Chapter 2 introduces the reader to the state of the art in the field of usability and the field of children and interaction design. The discussion starts with an overview of the existing usability guidelines, including an explanation on why current guidelines need to be more focused on children`'s software. The next part of the chapter justifies the study of usability especially focusing on the children. Then, the connection between usability and game design is explained with the premise of fun, flow theory and the field of child-centered design. The chapter continues with empirical work on a survey of educational programming environments for children including some remarks on the difference between simulation tools and game authoring tools. Three game authoring tools for children have been selected as example and have been described regarding their programming concepts, features and capabilities. The findings will be interpreted and discussed using this knowledge for creating the first version of usability guidelines.

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Chapter 3 describes the preliminary study that comprises of two user studies examining different software used by children. The chapter discusses the studies thoroughly by looking at the possibility of using a simulation tool (Squeak Etoys) and an authoring tool (Game Maker) to facilitate children's learning. The findings of these studies are helpful in refining the usability guidelines drafted earlier. The chapter ends with discussions and an outlook on the study as the basis for designing the earliest usability guidelines which will also be used for designing a game authoring tool prototype.

Chapter 4 details the design and development of the game authoring tool called Gatelock. This chapter will not only focus on the technical aspect of its design and development, but also concentrate on the implementation of Gatelock. This includes software requirements, system models, the visual representation used for the user interface and object-oriented design.

Chapter 5 describes more studies to evaluate the features and functionalities of Gatelock, as well as empirically derived evidences with respect to the children's abilities in using Gatelock (formative and summative evaluation). The findings do not only include usability and fun, but also engagement and learning as well as the field of children and interaction design.

Chapter 6 discusses the achievements and limitations of Gatelock. This includes the capabilities that Gatelock does not have, and suggestions on its improvement. It also summarizes the reflections on the usability guidelines that have been involved in several iterative processes. This chapter ends with a discussion on the lessons learned in conducting the usability studies with children.

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Chapter 7 draws and summarizes the contributions of this thesis from discussions about the major findings of the research and thoughts on the use of the game authoring tool for children. This chapter concludes by outlining additional future directions in designing the game authoring tool, and by implications on its usage in the classroom.

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