FROM SPRITES TO MODELS – GRAPHICS TECHNOLOGIES FOR INDEPENDENT GAME DEVELOPERS

CASE: Opioid Interactive

Johanna Lievemaa

Bachelor's thesis
May 2008

School of Business Administration

JYVÄSKYLÄ UNIVERSITY OF APPLIED SCIENCES

JYVÄSKYLÄ UNIVERSITY OF APPLIED SCIENCES

DESCRIPTION
Date
May 5, 2008

Author(s)
LIEVEMAA, Johanna

Type of Publication
Bachelor´s Thesis

Pages
53

Language
English

Confidential

Until_____________

Title
FROM SPRITES TO MODELS – GRAPHICS TECHNOLOGIES FOR INDEPENDENT GAME DEVELOPERS
CASE: Opioid Interactive

Degree Programme
Business Information Systems

Tutor(s)
KARHULAHTI, Mika

Assigned by
Opioid Interactive

Abstract

The purpose of this study was to find effective tools and methods for 3D modeling and animation for a small game company. The main point of view was to find cost-effective tools and to find out whether changing from pixel animation to 3D would be profitable for the company in question. The client was Opioid Interactive, a young and small company in the growing gaming field in Finland. They were interested in finding ways of producing visually pleasing graphics more quickly than before.

The study was executed by producing the same animation in both the old and new ways and comparing the resulting numbers, the durations of different tasks. The results were influenced by the researcher’s lack of experience and a tight schedule but these problems were taken into account when making assumptions from the results. Different game engines were also compared by the criteria set by Opioid, the most important aspect being open-source for minimum expenses.

The results show that even though making the 3D models can be more time consuming than drawing pixel sprites, the fast animation possibilities make it a more profitable method for game character production. The best game engines were picked out by the features wished for by Opioid, and the best one for serious game use was found. The making of this thesis provided a good base knowledge of 3D for the researcher and helped reform the company’s business plan.

Keywords
3D, computer graphics, game programming

Miscellaneous

CD

JYVÄSKYLÄN AMMATTIKORKEAKOULU

KUVAILULEHTI

Päivämäärä
5.5.2008

Tekijä(t)	Julkaisun laji
LIEVEMAA, Johanna	Opinnäytetyö
	Sivumäärä: 53 — Julkaisun kieli: englanti
	Luottamuksellisuus: Salainen _____________saakka

Työn nimi

FROM SPRITES TO MODELS – GRAPHICS TECHNOLOGIES FOR INDEPENDENT GAME DEVELOPERS
CASE: Opioid Interactive

Koulutusohjelma
Tietojenkäsittely

Työn ohjaaja(t)
KARHULAHTI, Mika

Toimeksiantaja(t)
Opioid Interactive

Tiivistelmä

Tämän opinnäytetyön tarkoituksena oli selvittää pienen pelialan yrityksen käyttöön sopivia 3D-mallinnusmenetelmiä. Tavoitteena oli selvittää, onko 3D-grafiikka taloudellisesti kannattavampaa kuin aikaisemmin käytetty pikselianimointi kyseessä olevalle yritykselle. Työn toimeksiantaja oli Opioid Interactive, pieni ja nuori peliyritys, jota kiinnosti tietää, saisiko uudella teknologialla tuotettua hienompaa peligrafiikkaa nopeammin.

Tutkimus toteutettiin tekemällä sama hahmoanimaatio sekä vanhalla että potentiaalisella uudella teknologialla ja vertaamalla testeihin kuluneita aikoja. Tuloksiin vaikutti tekijän kokemattomuus 3D-mallinnuksessa ja ohjelmistojen hallinnassa, mutta tämä pyrittiin huomioimaan tuloksien analysoinnissa. Myös ilmaisia pelimoottoreita vertailtiin, jotta löydettäisiin juuri Opioidin käyttöön sopivin valmis teknologia.

Tuloksista ilmenee, että vaikka 3D-hahmon mallintamiseen kuluisikin enemmän aikaa kuin pikselihahmon piirtämiseen, on sen animointi huomattavasti nopeampaa. Siten liikkeiden määrästä riippuen toinen menetelmä on halvempi kuin toinen. Pelimoottoreista valittiin parhaiten Opioidin vaatimuksia vastaava, jota suositeltiin kolmiulotteisten pelien tekoon. Yrityksen liiketaloussuunnitelmaa voitiin uudistaa tutkimuksen tuloksien johdosta. Työn aikana tekijä sai hyvät valmiudet oppia 3D-mallinnusta peligraafikon uraa ajatellen.

Avainsanat (asiasanat)
3D, peliohjelmointi, tietokonegrafiikka

Muut tiedot
CD

CONTENTS

FIGURES

TABLES

1 THE MODERN GAME DEVELOPER'S CHOICE

The games industry is facing major changes in the near future, only the directions of which stay unpredicted. For a decade 3D graphics have been invading the scene with increasingly impressive visual effects and escalating photorealism. Even if there is no limit to the technological advances, the audience will want some new and different development after the eye candy becomes too ordinary. New swords, bigger worlds and neater outfits will not make new games interesting anymore.

A trend for hand-held consoles has swept the world of game design to a new rise of content over appearance. The small devices today can calculate even complex 3D models but retro and neat pixel graphics look better on the smaller screens. Opioid Interactive, a small independent game company, is facing a big decision concerning the graphics technology it will use in the future. The trend towards 3D fascinates with its possibilities of faster animation and more stunning graphics and frightens with the greatness of the change and the work demanded to facilitate it. On the other hand, Opioid is an old school 2D graphics fan and has doubts about giving too much value to trends.

The topic for this thesis arose as the researcher was carrying out her practical internship in Opioid as a graphic artist in 2007. The company was contemplating the advantages and drawbacks of either changing their business plan or keeping it the same. The researcher's interest in learning 3D modeling and animation sparked the idea to start studying the subject in depth and comparing the two methods with each other to find out which would be more cost-effective in Opioid's case. At the same time she would be getting closer to her dream of becoming a professional game artist.

2 KEY CONCEPTS

Some key aspects and vocabulary of making games and game graphics are summarized here.

Games

The human being is a playful creature. From the 1970s and the 1960s computer and video games have developed, gaining popularity against the classic deck of cards, arranging the concrete chess board or playing ball outside. Multiplayer online games with stunning 3D graphics have become increasingly popular in recent years. With the constant hardware development from CPU (central processing unit) power to video cards, photorealism will become ordinary. Fascinating content and new technologies will then be the most important features for a game designer to consider. (Lehtovirta & Nuutinen 2000, 138 - 148.)

Most common forms of computer and console games provide some sort of way to steer a vehicle, race, build, fight, shoot with various guns or play different sports. There are also puzzles and the digital versions of traditional board and card games. The platforms vary, from 8 bit Nintendo to Play Station 3 to hand-held consoles, from an old PC to a high tech computer built for gaming. Everybody can find their own favorite and the games to fit their choice. (Lehtovirta & Nuutinen 2000, 138 - 148.)

The games industry is an attractive employer. Who would not want their character to run amok on everyone’s computer screens, who wouldn't want to say they programmed the clever features of the character's movement. Creating game worlds is a profession where letting the imagination go is mandatory. Conjuring up ruthless nemeses or valiant heroes is a never ending dream job for a fantasy artist. Games have always been and will be a favorite pastime of many, and working with them opens new worlds for an enthusiastic designer and artist. (Ahearn 2001.)

2D Graphics

Like any drawing on a piece of paper, fantasy characters on the computer games have traditionally lived in only 2 dimensions, the X and the Y. It makes moving straight-forward and the game play linear. 2D graphics are needed when creating 3D elements for sketches and textures. The two dimensions can even be used to imitate 3D by the use of perspective and shadowing. Even with the fast development of 3D graphics and the hardware that supports real time high-poly rendering, traditional and nostalgic two dimensional games, pixel or not, will not cease to exist completely. (Lehtovirta & Nuutinen 2000, 138 - 148; Koistinen 2008.)

Pixel art

A pixel is the smallest element in a picture. In a digital meaning, it is a dot on a screen and it has a color value of Red, Green and Blue (RGB). Together these different colored dots make a picture. Square-shaped pixels look awkward when magnified (figure 1) but pixel graphics has become popular once again due to the renaissance of retro 2D games. Pixel artists often use their special talent of putting a limited amount of dots to life to create sprites, digital 2D characters originally intended for video games. This is called spriting. Now spriting itself has become an art and sprites are considered the main focus of pixel artists. Game art also includes background tiles and environments, in retro games in as low amount of colors as possible. A pixel sprite is resource-wise an economical creature, as each pixel is individually controlled and frame-by-frame animation is relatively easy, though by the same factors, it is slow to fabricate. (SpiteArt.com 2005; Smith 1995.)

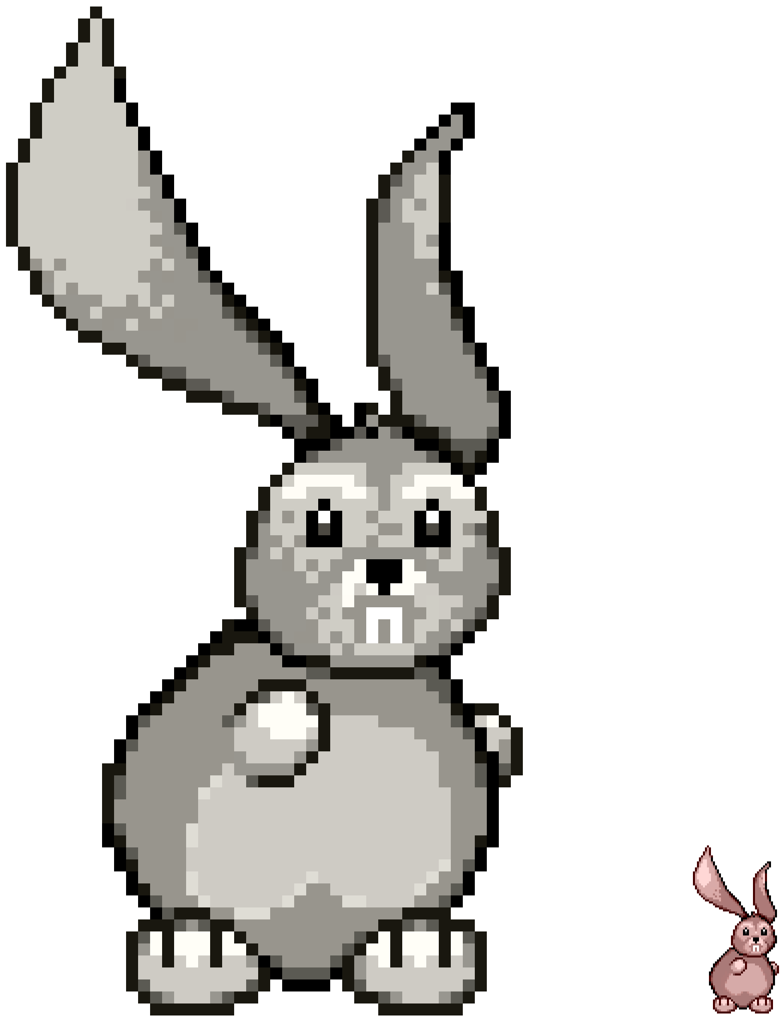

FIGURE 1. A pixel sprite zoomed in and in normal size.

3D Graphics

Sculpting a digital image in three dimensions is not unlike working with clay or wood, the interface just differs from knives and molds. Creating a 3D object on the computer has many phases from the molding to the texturing, which is like painting, and then lighting and so on. The object can be looked at from all angles like real-life sculptures but in case of a carving blunder, new material is easy to attach to the model. (Ratner 2004, 4 - 40.)

3D modeling software often uses vertices (dots) and polygons (planes) to form a wire frame mesh of the 3D object. This can be compared to a metal wire forming the shape of a sculpture. In the following figure (figure2) from top left there is the mesh and then the solid low-poly object. Low-poly means there's a low count of polygons that makes the surface uneven but faster for the computer to calculate. In the bottom left corner the model has been subdivided; each polygon face has been divided into many smaller ones. The final image demonstrates some of the effects that can be achieved by 2D textures that are applied to a 3D model. Textures can even include drawn and animated eyes that are easier to do than to model them on a low-poly object. (Ratner 2004, 4 - 40.)

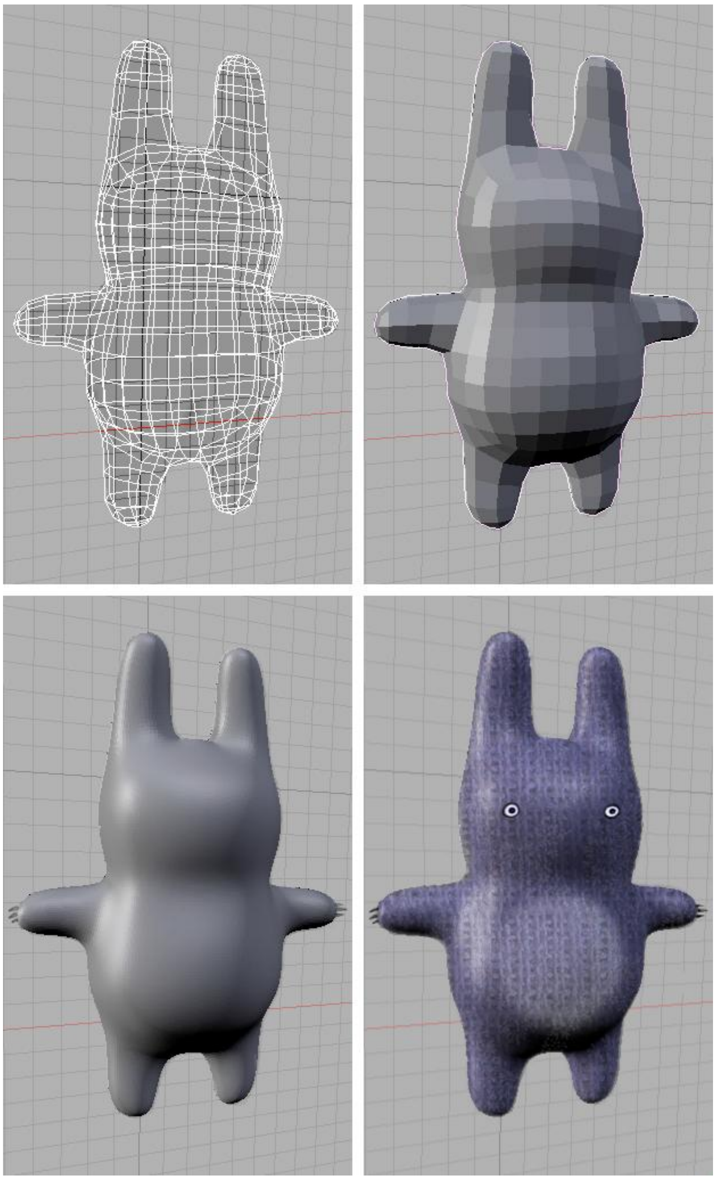

FIGURE 2. 3D: From mesh to model.

Isometric 3D Graphics

One of the ways in which 2D graphics can imitate 3D is called isometric graphics. Isometric pixel art is based upon a grid of 2:1, where one pixel up and two to the side is the rule. 2D sprites can move across the grid freely because there is no scaling to the distance but everything is strictly isometric. Originally isometric means that the x and y axes are in a 30 degrees angle to the horizontal, but in pixel art the ratio ends up at approximately 26.565 degrees due to the limitations of squared pixels. A commonly used perspective in pixel games is the 3/4 perspective, which is halfway between frontal and side perspectives (figure 3). (Zoggles 2007.)

FIGURE 3. Isometric and 3/4 perspective views (Habbo 2007; Fire Emblem 2003).

Animation

A 3D package is usually used to create animation. Multiple images played in a sequence like a film create movement. Making inanimate objects appear to move on screen that way is called animation. 3D animation can be achieved in many ways, for example by motion capture, where actual movement is recorded digitally and transferred to the 3D character. Models can also be animated frame-by-frame or with pre-calculated skeletal movements. Animating a humanoid 3D model needs precise attention to joints and how the muscles move around the bones. The most common task an animator gets is to create a simple walk-cycle. (Ahearn 2001, 15; Ratner 2004, 260 - 300.)

Engine

Without a game engine, a starting 3D game programmer would be facing an enormous problem. Getting all the graphical effects into the application would be time-consuming and difficult without available libraries and frameworks. Luckily there are free open-source game and 3D engines available with various features from world editing and rendering to lighting, shading and collision detecting. Their ease of use and adaptability vary greatly. (Junker 2006.)

Open-source

Open-source programs and software are free to use, modify and distribute. Open-source developers are often dedicated to their work and take it personally, as it is a dear hobby to many of them. The resulting programs are well designed, skillfully programmed and thoroughly tested and debated. Vast online communities are formed around the best projects and word of the new innovations carry through the forums on the net. Help can be found quickly by motivated developers and ideas are spread by multi-headed entities that are all the users combining their forces. (Junker 2006, 1-7.)

The source code must be freely available if not included in the program. Using the programs, modifying them and distributing them is free and even encouraged. The programs can be used commercially. There are, however, many complicated rules concerning open-source products, that are clarified in the various licenses used. The most often applied licenses are the GPL (General Public License) and the LGPL (Lesser GNU Public License). Most of the criteria of an open-source project emphasize the freedom of use and distribution and the absence of restrictions concerning the technologies used. (Open Source Initiative 2006.)

3 THE PREMISES

This chapter is dedicated to introducing the client and the general objective of this thesis. In this setting the work will be done. The research questions are laid out and the angle is specified and defined.

3.1 Opioid Interactive in the Finnish gaming field

Opioid Interactive (later referred to as Opioid) is a young, small company in the rapidly expanding field of digital game production in Finland. The level of interest in the field has been high from the beginning. From the 1990s business has grown and in the past few years the industry has boomed. There are many small-scale businesses and some larger, more concentrated companies. There have been great efforts made to endorse education and research of digital games in Finland by government-led organizations, and the advanced use of information technology has made recreational content production a notable line of business. Finnish game companies are looked highly upon abroad. (Finnish Game Companies 06. 2006.)

Thousands of new games are released every year in the world but only a marginal little group gets to be the best, the most wanted and played. It is estimated, that the game business in Finland will grow by 50% each year now. Investing in entertainment is very important as people have more and more free time to spend and a bigger desire for a break from the ordinary life. In order to nurture these needs, game developers need to put their heads together for wilder ideas than ever. It will be easier as the technology evolves and gives more room for imagination. (Finnish Game Companies 06. 2006; Lehtovirta & Nuutinen 2000, 138 - 148.)

Opioid is in its core a one man operation with outsourced graphics, design and sound. Basically a group of enthusiastic young people have been making computer games together for a while and now under an official company for little over a year. Opioid's fundamental activity has been producing 2D pixel games for PC and building a 2D game creation framework. The framework project has brought them recognition and distinction on the web among 2D programmers. (Opioid game dev 2008.)

With limited manpower, Opioid has had to wonder whether other (dimensions) could be more efficiently animated and handled. 2D pixel animation requires the drawing of each individual frame by hand to make a sprite move, while 3D or vector-based characters only need fixed key frames and the computer calculates the positions in between. The time it takes to draw the intervening frames could be directed to something more productive. (Ratner 2004, 70.)

Opioid is based on the love of making games, and naturally they want to make theirs as good as possible. With excellent programmers and virtuous artists everything is possible, as long as the assets are managed with care and put to their best use. If a faster, more cost-effective way of creating graphics for animation is found, Opioid would be ready to leave its origins behind and go 3D. Investing in high-priced tools or programming their own game engine from scratch would not be possible or tempting, though. (Hangaslammi 2008.)

3.2 Research questions and the purpose of the study

Hoping to find answers, this thesis will concentrate on the following questions.

1. What does 3D mean for the games industry today?
2. What are the most cost-effective tools for the trade?
3. Is it feasible for Opioid Interactive to change and start making 3D games?

The main ambition of this study is to find out if there is a cost-effective way to transform from a 2D games production group to a hip 3D gaming arena, and what that method could be. The possibilities will be explored by studying the present trends in the industry and testing the duration of a pre-planned character animation process on both techniques. The development of the entertainment content production markets and the history of 3D will be looked at briefly.

To achieve a result to the third question some choices will have to be made about the tools that will be used. The pricing and availability of the tools are their most significant attributes. There are only a few free 3D modeling tools available and the commercial ones are very unaffordable. The most convincing and most effective free 3D modeling tool available is Blender, a neat, wholesome 3D creation suite under the GNU General Public License that rivals the expensive, prevailing number one choices. Blender can do what the big commercial programs do but at no cost. Therefore, Blender will be used for the modeling of the character. (Yardley 2007; Koistinen 2008.)

As for 3D animation, there is the modeling software but also the framework for the programming. Making a 3D object is one thing, but a critical aspect of making a 3D game is the gaming platform, the graphics engine that defines how the models move. Making a new engine for Opioid is not a notable option due to the resources and dedication it would require.

There are several free open-source 3D engines available today, which makes licensing a commercial engine or making one's own less appealing considering the goals. Features available in the free engines will be studied and a list of the features that are crucial for the kind of animation intended will be compared against them. The advantages and difficulties of taking one of the free engines into use will be contemplated. The final result should be the answer to the question, whether Opioid should start producing 3D graphics for its games.

3.3 Definition

While there are many forms of 2D graphics and 3D graphics and their combinations, this thesis looks at 3D against 2D like sculpting against drawing on paper. In the middle forms, isometric pixel art mimics a 3-dimensional view with a grid that forces everything to a certain angle (25.565°), and any 2D painter can suggest the third dimension with careful shadowing and perspective. This is not useful to the cause, as 3D originally evoked interest as a faster means to produce characters and animations, which might be achieved with 3D modeling, not because of the trend of 3D itself.

All of the information handled here will in some way be about games. Games in this thesis will mean digital games in the form of playable content for mobile, console or PC platforms. The main emphasis will be on the PC, since the client company specializes in them. Finland will be the economic and physical environment in which the study is made, though estimates of the global situation will be made in the process.

The testing will concentrate on the creation and animation of a character, not on the scene upon which it moves. Advanced texturing and lighting will not be handled exhaustively. Evaluating different engines will not include testing them all in action but rely on reviews, listed attributes and preferred properties.

Cost-effective will be the most important adjective in the evaluation of any subject of interest, and in this case it is defined more specifically as free and fast. This is due to the minimal income of the company for which the research is made, and because it enables a wider usability for the results in general among small and starting companies. This will be achieved by including several open-source applications in the study.

4 CASE

This chapter specifies the process of the study and the research methods. The test case, modeling and animation, is explained thoroughly and some of the expectations that have risen so far are introduced.

4.1 Process of the study

In order to test the time it takes for an average character animation using the old and the potential new technologies, a test animation cycle will be planned. The animation cycle will consist of a simple walk and possibly some other movements a character might have. Designing the character, then modeling and spriting it, will be part of the research. The most interesting part of the study will be the animation, as the animation has always needed the most resources of Opioid's game graphics department. The presumption is that modeling and making a character presentable in 3D might take a while but once the design is ready, it can be moved around with ease compared to drawing each pixel again in their new locations.

Normally, in 2D, when a character is designed, it needs all the movements including the walk-cycle, jumping, crouching and punching drawn separately and individually. In the hopes of reducing the time it takes to make the character jump, crouch and punch, the possibilities of 3D animation in the use of a small game company will be explored. If the learning curve for 3D modeling and programming will be found too steep or if the free open-source tools will not be sufficient to work with, the investigation will have served its purpose and Opioid will know not to worry about how time-consuming pixel-pushing might be. If the new information will suggest a change is topical, new plans will be made.

More precisely

Some sketches are usually made before starting to model or draw any character. Precise sketches with the correct measurements and proportions should be made from the front and side views for modeling in 3D. A top view with the hands on the sides would also be helpful. The sketches should each be of the same size and match each others' proportions, so that they could be imported to the modeling program to serve as a base upon which to create the character. (Ratner 2004, 32.)

Tutorials are useful tools for learning a whole new program with a whole new interface, they are step-by-step instructions of how something can be achieved. There are tutorials made by expert users and the software developers themselves. (Blenderwiki 2007.)

For this test, two tutorials are going to be used. The first one at Wikibooks gives a short introduction to the software and 3D in general (Wikibooks 2008). The second one at BlenderWiki explains in detail how to model and move a character in order to produce a final rendered animation (BlenderWiki 2007).

The figure 4 below depicts the finished model from the BlenderWiki tutorial. However, the test animation for this case should be made for a low-poly model as opposed to the detailed character used in the tutorial. This will lead to a more intuitive working method with the character as every vertex and bone will not be copied from the tutorial. With more thought put to the creation of the animation, more of the information will be remembered the next time a similar project is undertaken. (Lehtovirta & Nuutinen 2000, 49 - 57 & 82 - 93; BlenderWiki 2007.)

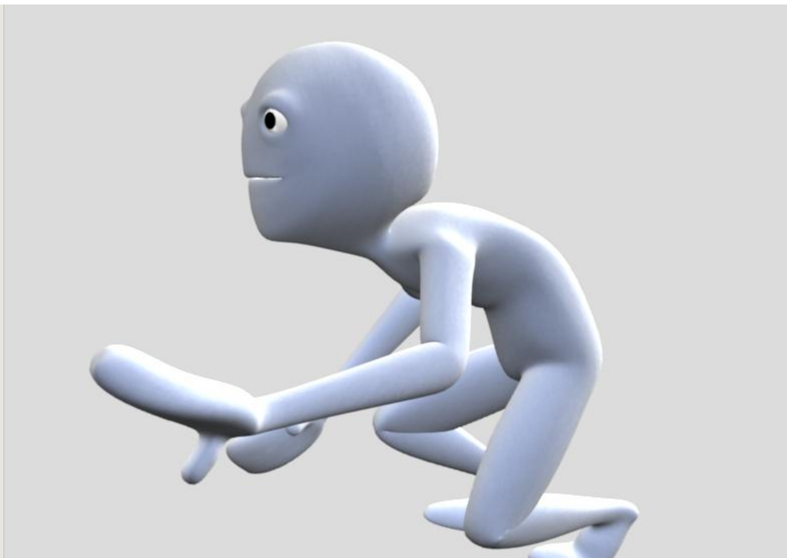

FIGURE 4. Outcome of a tutorial (BlenderWiki 2007).

After the sketches are done the character will be modeled in 3D with the chosen software Blender. The character will be modeled with its hands stretched to its sides in a basic modeling pose (figure 5). It will then be rigged with a skeleton made of different bones that are assigned to move different parts of the model. Unlike a regular human skeleton the animation skeleton has extra bones set to control some elements of movement. This way the joints will not bend awkwardly and parts of the body can be moved separately from the rest. (Lehtovirta & Nuutinen 2000, 179 - 184; BlenderWiki 2007.)

FIGURE 5. The standard modeling pose (Wikibooks 2008).

The same character will be brought to life with the usual 2D methods to compare them to the new 3D techniques and the resources they demand. Tutorials will not be needed as this is the regular procedure used in the company. The character will be drawn from one side and then copied to a new frame, where the posture will be slightly changed and copied and changed again until the cycle is finished. This will not completely match the walk cycle created for the 3D model, as the sprite will only be viewable from one angle and even reversing the direction of the stroll would require adjustments to the parts that are not symmetrical.

An animation of the character walking along will be produced and the time it takes to create it will be measured with both methods. Different tasks of both operations will be specified to see which are the most time-consuming. Video clips of the walk cycles will be included in a CD in the appendices. During the creation process each task will be marked in a spreadsheet to track their duration. When both characters are finished these arrays will be made to charts and compared with each other.

The game engines will not be tested in the same way as the modeling and animating. Instead the right engine will be looked for by carefully comparing certain aspects and features of the most notable open-source engines. The senior programmer and founder of Opioid will be interviewed to gather the most sought after features which such an engine should possess and the results will be evaluated in chapter 7. Studying the engines is every bit as important as the modeling process is for Opioid, and therefore these two aspects are examined hand in hand.

4.2 Research methods

This study will be performed using mainly the qualitative method of study. All conclusions made from this study aim subjectively for the profit of the company in question and may not be generalizable as such.

Choosing qualitative research as the basis of a thesis is not only choosing a method of ideas against numbers but a whole strategy of approach. It is also wise to use different strategies in a study to get a more complete picture of the subject. A research may include experimental studies and surveys. Used research methods are consequential in finding the right answers to the research questions and problem. (Hirsjärvi, Remes & Sajavaara 1997, 126 - 128, 182 - 185.)

In a qualitative method of study the subject matter is studied in its own environment, observed from many angles and not just to prove existing truths but to find some new ones. The intent is to do a comprehensive examination of the topic yet tightly bound to relevant aspects. The subjects of study are chosen purposefully and not by random, on account of the resources and certain criteria. (Hirsjärvi, Remes & Sajavaara 1997, 160 - 168; Vilkka 2005, 126.)

Things can not always be measured in a simple way, which is stressed in the qualitative approach of study. In a test-case like this the researcher's subjective knowledge and viewpoint will unquestionably have an impact on the results that are received. Therefore she must understand how to distinguish subtle nuances in the interpretations of things that make one subject better than the other. This is achieved by promoting an extensive theoretical setting. (Vilkka 2005, 98.)

Also, some numeric values will be obtained when measuring the effective working time it takes to perform given tasks on different test subjects, which will then be valued and organized quantitatively. This requires systematic observation and information will be collected systematically and premeditatedly. Those are premises of a quantitative research. (Vilkka 2005, 76.)

4.3 Expectations

4.3.1 3D characters

Despite the current trend towards visually overwhelming special effects and graphics and photorealism, many game developers cherish the 2D graphics and the mood it conveys. Even Opioid squirms rather reluctantly before the prospect of changing to a completely new way of gaming. Still it is willing to see if some improvement can be achieved and if the graphics department finds 3D significantly more pleasing than pixeling, they are ready take steps to benefit from it. (Hangaslammi 2008; Koistinen 2008.)

4.3.2 Engines

An engine that would be sufficient and effective for Opioid's use should have at least certain features and it should obviously be free. The engine should have good support for loading model, texture, material and animation data from the chosen 3D software (Blender). It should feature skeletal animations that support blending several bone animations together and mesh morphing between key frames to support facial animation. There should be 3D collision detection with several levels of detail, for example range-check, bounding box and vertex collision. (Hangaslammi 2008.)

The engine needs to be usable with free tools on all platforms, Windows, Linux and Mac OS X. This limits the use of any C++ engines dependent on commercial C++ compilers out of the question. The engine should also support rendering outdoor terrain based on height maps. Extra points would be earned by built-in support for blending terrain textures. Other recommended features include good 3D particle effects support and built-in support for billboarding. (Hangaslammi 2008.)

There are also several websites around where engines are compared. Some engines are better than others and many of them are designed to serve different purposes. That is why documenting these features is important, though harnessing a new engine to proper game use will be difficult and demand a great deal of work. It is possible, however, and even incorporating a 3D engine to Opioid 2D framework has been considered. (Hangaslammi 2008.)

5 A CLOSER LOOK AT THE KEY CONCEPTS

3D is a wide concept with many usages. Here the terms involved in making 3D games are explained briefly and some of the history and future trends of the field are examined. Other concepts concerning this thesis are introduced as well. Because 2D graphics is the old and already familiar way of Opioid's animation tactics, it will not be discussed in detail.

5.1 3D basics

Usually a 3D object is built from vertices (points), edges and faces (the surface between 3 or more vertices). These form the wire frame mesh, the clay of the digital sculptor. The mesh constructs the shape of the object, and it is modified by moving the vertices around in various ways. There are also other ways of forming 3D objects, for example NURBS (Non-Uniform Rational B-Splines). (Lehtovirta & Nuutinen 2000, 21.)

The density of the mesh, more precisely the amount and size of the faces is called polygon count. A game character may only consist of a restricted number of polygons depending on the video cards calculating efficiency as the computer can only handle so many polygons at once (Ratner 2004, 38). Subdividing the faces to form more and more polygons will make the surface of the model appear smoother and more curved. The term used for low polygon objects like game characters is low-poly; a model of few polygons. (Lehtovirta & Nuutinen 2000, 21 - 22, 145.)

What was considered technically high achievements a few years ago are now low-poly models in light of the constant hardware development. As the machinery gets stronger, the polygon count gets higher, and more complex characters and environments are seen in games. There is no end to the progress of 3D graphics as long as consumers keep wanting more stunning visual effects (Lehtovirta & Nuutinen 2000, 148). People want photorealism and magic, they want the wow-factor and they will be bored with it the next year, as the hardware development has taken another leap forwards. (Ratner 2004, 326 - 327.)

Using 3D modeling, anything imaginable and more can be created. 3D models can be surprisingly real and at the same time imaginative. Modeling makes it easier to get even stranger movements, proportions and angles right, as the computer does most of the calculating and the model can be looked at from every angle. It is still often found more expensive and complex than simple 2D drawing. Creating outstanding 3D graphics can be time-consuming as well. In one example, the artist and modeler used a day to photograph textures for a machine gun and to apply them to their model. (Ahearn 2001, 11 - 15.)

Modeling different parts of a whole may sometimes be easier using different applications. Other software are better at handling some aspects of modeling and others provide evolutionary methods of adding details or are concentrated on environments instead of characters. Even rendering can sometimes be performed separately from the modeling software. Rendering is the part of 3D modeling where the modeled objects are rendered to a 2D picture with the carefully designed lighting and from a specific camera angle. (Lehtovirta & Nuutinen 2000, 22 - 23, 45.)

Opioid's investments in 2D tools (mainly the input devices and graphics software) wouldn't become redundant with the adaptation of 3D graphics, as every 3D character and level needs a concept design, painted textures and other 2D assets. Painting, drawing and photographing elements to use as textures is a large part of 3D modeling. Uniting patterns to form textures is an art of its own, making seams disappear while keeping the images small enough. Even with the progress of machines to calculate them, 3D designers tend to keep their models as low-poly and as small in file size as possible. (Ahearn 2001, 13 - 15.)

Other uses for 3D than games include architecture and all kinds of design, medicine, advertisements and movies. Modeling gives designers a good idea of whatever they are planning to build, craft or sew before wasting any materials. Different options of for example color or size are easily tested. The effect of different options can even be studied before anything is manufactured. 3D imagery can also provide useful information as cross sections of the objects in question can be printed on manuals and simulations of dangerous actions can be practiced in the safety and comfort of computers and screens. (Lehtovirta & Nuutinen 2000, 116 - 159.)

5.2 History of 3D and future trends in games

Digital games have come a long way from text-based adventures (like still-popular Nethack, figure 6) and simple 2D fights (like tank wars, figure 7). In mid 1990s 3D made a huge entrance to the field with Tomb Raider and Quake (figure 8.) The popularity of 3D was evident immediately and all major game production houses started developing their own masterpieces. (Lehtovirta & Nuutinen 2000, 138 - 148; Lauppert 2007.)

FIGURE 6. Nethack (Nethack 2008).

FIGURE 7. Tank Wars (Lauppert 2007).

FIGURE 8. Quake 1996 (Lauppert 2007).

One of the recent most prestiged 3D games is Crysis from EA Games (Hangaslammi 2008). Its graphics are considered advanced and gorgeous, setting the standard for modern games (figure 9). But like with any beautiful piece of 3D, Crysis needs high-end video cards and computer power to run properly. There are, as often is the case with the power eating 3D games, options set for lowering certain graphics elements accuracy. Players with older machines under their saddles can tweak the options in hope of achieving a faster frame rate with less visual candy. (Crysis 2008.)

FIGURE 9. The beautiful 3D graphics of Crysis (Crysis 2008).

3D requires a lot more CPU power than 2D games. Designing games for PC is a game of dice because of the haphazardness of the hardware in people's homes. Producing a game for Play Station or Nintendo Wii is simpler because the hardware specs and limitations are known precisely. Yet with the current trends of smashing 3D effects the video card manufacturers and consumers opt for the best 3D support available. The result is, 3D games can make the most of the hardware even if 2D would not require as much. (Hangaslammi 2008.)

Learning 3D modeling or some part of it now would be a good career move, in light of the number of new game companies looking to employ and the growing amount of 3D in games. Only taking an interest in mobile games would suggest pixel arts skills could be of use, as they are the only medium in which 2D graphics are still prevalent. Koistinen states in his interview (2008) that 2D will not die entirely and that devoted game makers like Opioid will keep making pretty pixels (Koistinen 2008). Opioid's team is indeed skeptical about being swept by the trends but realizes this is the path every major game company is taking. (Hangaslammi 2008.)

The cost-effectiveness of 3D animation interests Opioid more than the trend factor, but it is clear from picking up any game magazine that graphics catches the reviewers' eyes and the more spectacular the better (Hangaslammi 2008.) But what to do when the most real photorealism has been achieved? The plastic surreal look previously attached to 3D game models is slowly evaporating and they are becoming life-like with imperfections and dirt. The industry has replied the challenge by inventing new ways of taking advantage of the technologies. The latest Paper Mario game for example (figure 10) is 2D from one angle but allows the player to flip to a 3D view where some things are flat and others 3D. (Ubisoft 2008; Super Paper Mario 2008.)

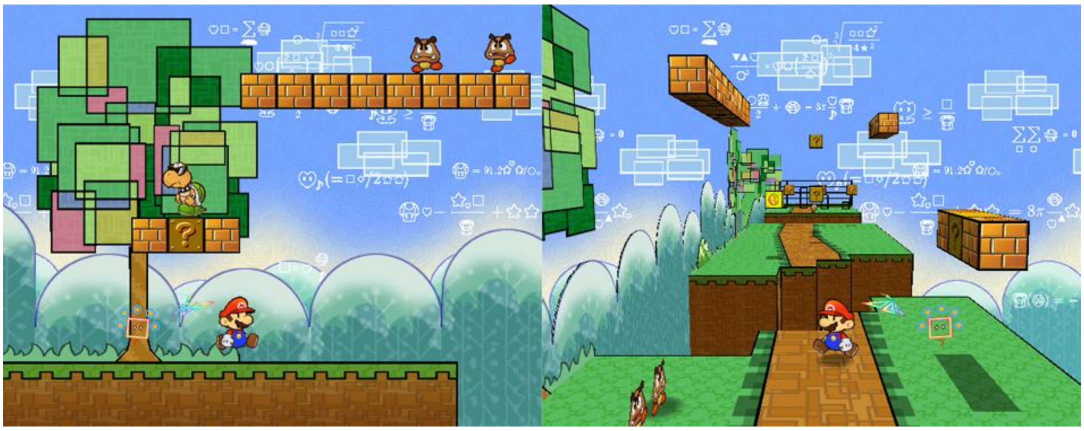

FIGURE 10. Super Paper Mario, two views (Super Paper Mario 2007).

3D games can also be made to look like traditional 2D with stunning consequences. One example of such is the new Naruto game (figure 11) which looks very much like a hand drawn anime series but in reality runs on a 3D game engine, which makes the characters move extraordinarily well and the surroundings animate beautifully (Ubisoft 2008.) Nintendo has also tackled the problem by discarding visual supremacy on the Wii console and developing new ways of input and gameplay. Using the wii-mote makes the player move physically around in front of their TV and develop some sweat, while Mario defies gravity in Super Mario Galaxy (figure 12). (Nintendo 2008.)

FIGURE 11. 3D as mock 2D in Naruto: Rise of a Ninja (Ubisoft 2007).

FIGURE 12. The inverted worlds of Super Mario Galaxy (Nintendo 2007).

5.3 Animation

Animation is often considered equivalent to drawn and otherwise modeled movies, like doll or wax animations, Disney's feature films (the most recent of which are all 3D) and small figures drawn on the sides of a notebook that move when the pages are flipped rapidly. Yet animation is an important aspect of games as well, and not only on the pre-rendered parts where the story is told with no input from the player. The game characters all move with the commands the player gives, but someone has had to draw or model the movements and save them to the game so that the resulting movements look accurate.

Animation is a moving image composed of several still images in a row, put together to simulate movement. Animating means giving life to a drawing or a model, clay or 3D. Single pictures in a film are called frames. Frame rate indicates how fast the frames change. (Ratner 2004, 260 - 288.)

Timing is the key to animation. The Disney animators followed famous actors and performers and their acts in the 1930s to compose a list of the most important principles of animation. These principles make the movement of a character fluent and natural and perhaps more descriptive. The list includes actions such as anticipation, staging, secondary actions, exaggeration etc. that give their animated characters that extra sense of authenticity and spirit. (Ratner 2004, 263 - 272.)

The first animation sequence usually made is the walk cycle. These principles provide a good basis for the walk. A 3D model is easily animated, but making the motion look good and proper requires expertise (Lehtovirta & Nuutinen 2000, 58). Human bones and muscles make hundreds of tiny movements even in a simple motion of walking, and the more of these the animator recognizes the more natural the outcome. (Ratner 2004, 260 - 288.)

Different types of 3D animation

Keyframe animation means that there are important frames marked in the timeline where the movements are in some kinds of turning points. A familiar technique from vector based flash applications, where the objects are posed at certain points and the computer calculates the transition in between. Original background for this method is in hand-drawn animation, where the senior artist draws the keyframes and the assistant fills in the gaps. (Ratner 2004, 32 - 49.)

Skeletal animation literally involves bones. Most animating software support adding skeletons to their models, which is usually done in the basic T-pose and then the skin is assigned to move with the skeleton or armature. Skeletons use kinematics and inverse kinematics to determine which child bones react to parenting bones and vice versa. This type of animation often needs tweaking at the joints to avoid undesirable deformation of the mesh, and handles to determine which way some parts of the body are facing. (Ratner 2004, 52 - 67.)

Motion capture is a way of transforming real life movements to computer 3D models. This technique demands several cameras for recording the movements of reflective dots that are pinned to the actor's suite in consequential spots like the joints. The dots can also have sensors in themselves. The idea is to capture the position of the body parts in motion and to bring that information to the 3D program. Facial expressions can be recorded as well. A memorable use of motion capture was seen in the film The Lord of the Rings by Peter Jackson, where the gestures of Gollum's voice actor were repeated in animation. Motion capture is an expensive method usually used by large film or game productions. (Lehtovirta & Nuutinen 2000, 106 - 108.)

6 ANIMATIONS & ENGINES

This chapter presents the test case and the animations as they were made. Modeling and spriting the character is expressed with screenshots of the actual work process. Information about the different engines is gathered and summarized here before a more exact analysis.

The work for this thesis was started in November 2007 with the commission from the writer's practical training period in Opioid Interactive. A research plan was made to find out whether Opioid should start producing 3D games and what would be the best tools to make the transformation easy and affordable. The writing started in March and the tests took place in April 2008. The choice of topic was influenced by the researcher's interest in the gaming business and her ambitions of becoming a professional game artist in the future.

6.1 The test case

6.1.1 Sketches

Here is the concept sketch for the character that is going to be used as a test case for this thesis with the front and side views. The concept sketch took about an hour to make after the decisions of the character's race, gender, and profession were made. Different views with the proportions calculated are good for both the 3D and 2D characters before the actual drawing and modeling. These views in figure 13 are not good for importing as a base to Blender, as the pose is not the standard modeling pose, hands outstretched.

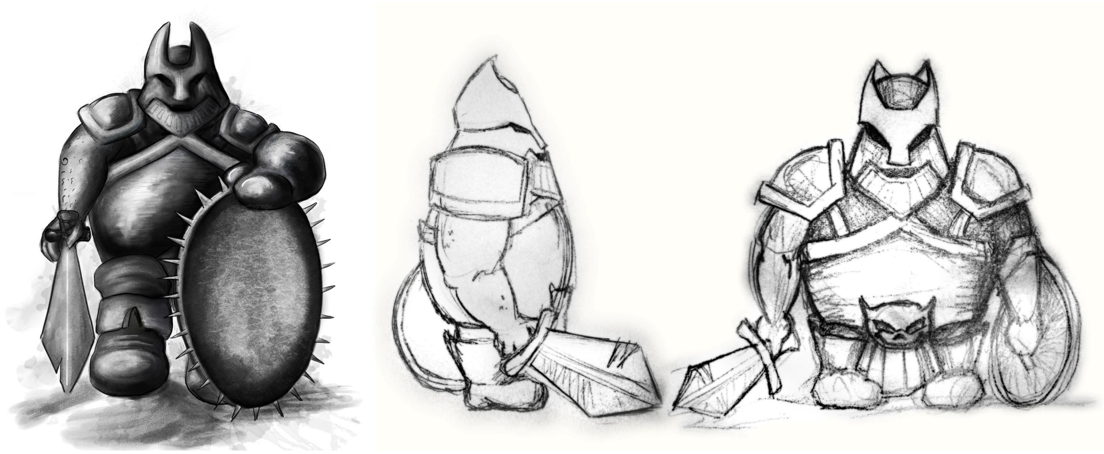

FIGURE 13. Sketches and proportional studies.

6.1.2 3D Modeling & animation

Due to the researcher's lack of previous experience in 3D modeling, a great amount of time was spent reading the earlier mentioned tutorials. The reason they say that the learning curve for 3D software is high, was found out immediately, as the modeler had to wrestle with the first simple cube (figure 14) for more than thirty minutes. A test character was modeled in December to get familiar with Blender. When the bunny from figure 2 was started a few months later, it was noted that all key shortcuts and buttons had been forgotten.

After the early blunders the sculpting became easier and forcing the vertices to form shapes was satisfyingly easy. The character was built from head downwards to the boots with very basic 3D modeling practices of extruding faces and vertices. Tweaking and re-shaping was easy throughout the procedure. Figure 15 shows a work in progress of the head and the torso, where there are holes ready for the limbs.

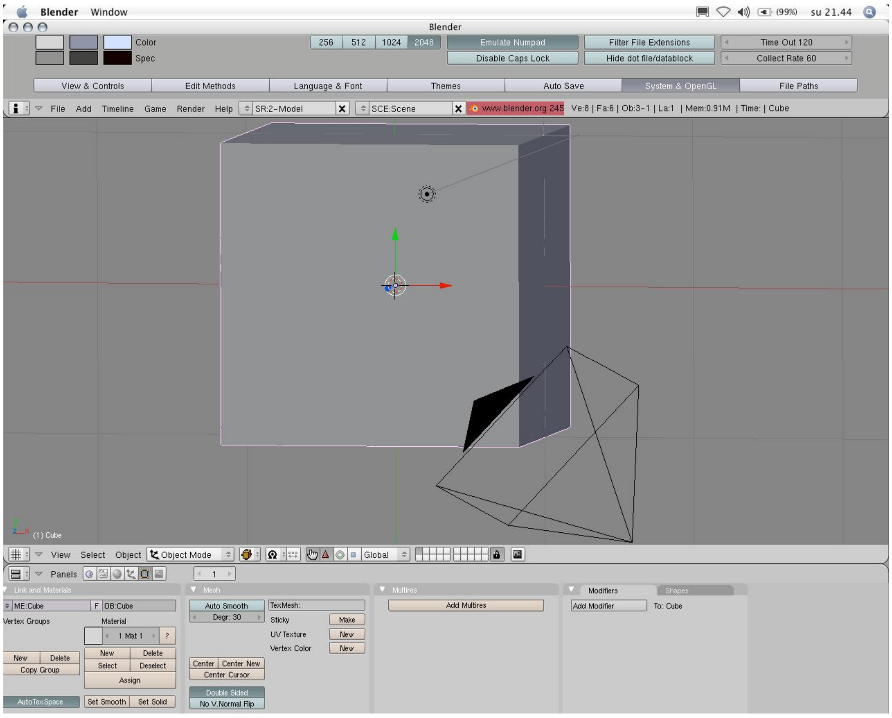

FIGURE 14. Blender's initial view.

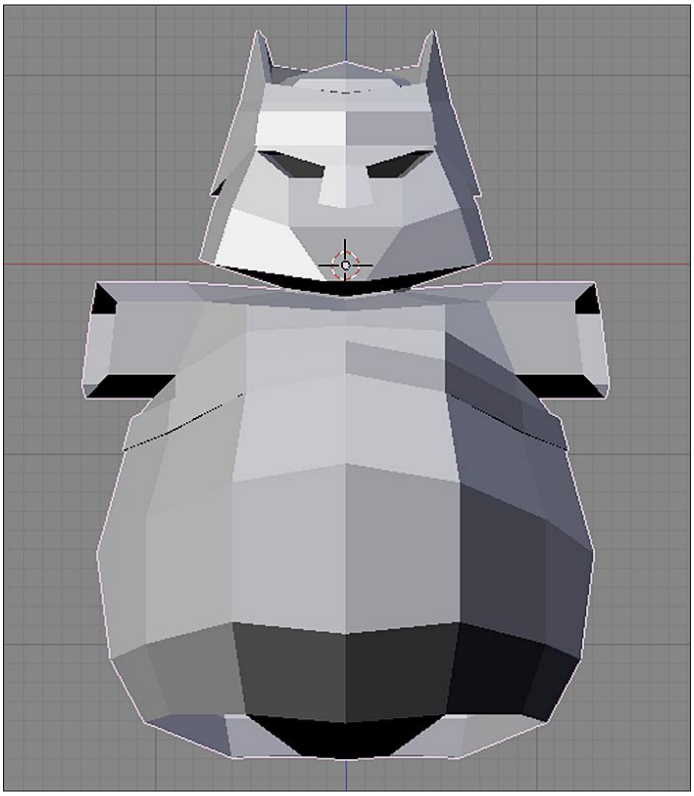

FIGURE 15. An early version of the 3D character.

The test character was designed to consist of as few polygons as possible. It is acceptable for the average game character to have 1500 - 2000 polygons and the dwarf character ended up with less than 1000. In the first view (figure 16), the character is in its basic posture with solid faces. The second view (figure 17) shows the armature that was built into the character. The octahedron-shaped objects are bones and they were named accordingly. This is a simple skeleton but the dwarf does not need to be very agile and its eye movements are concealed behind its helmet.

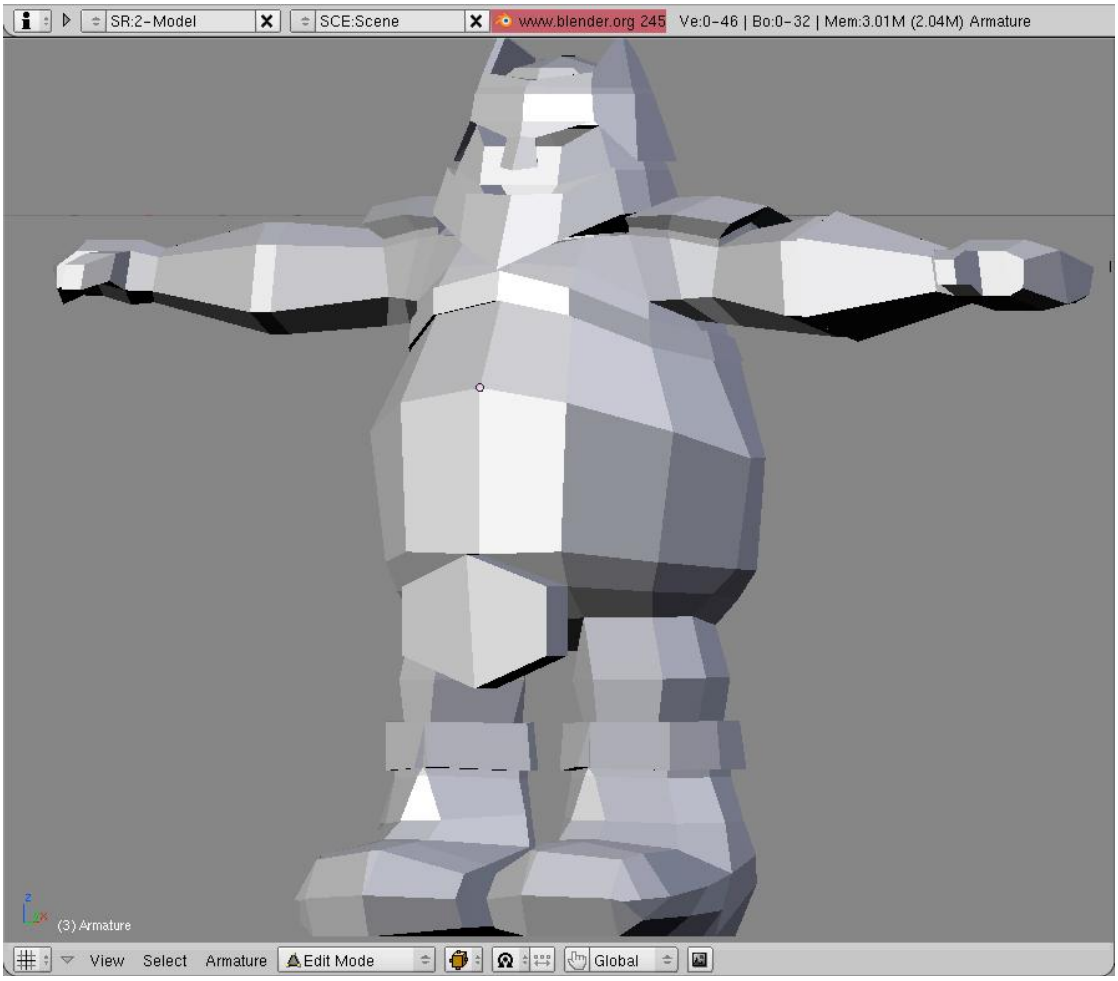

FIGURE 16. The model in the standard modeling pose.

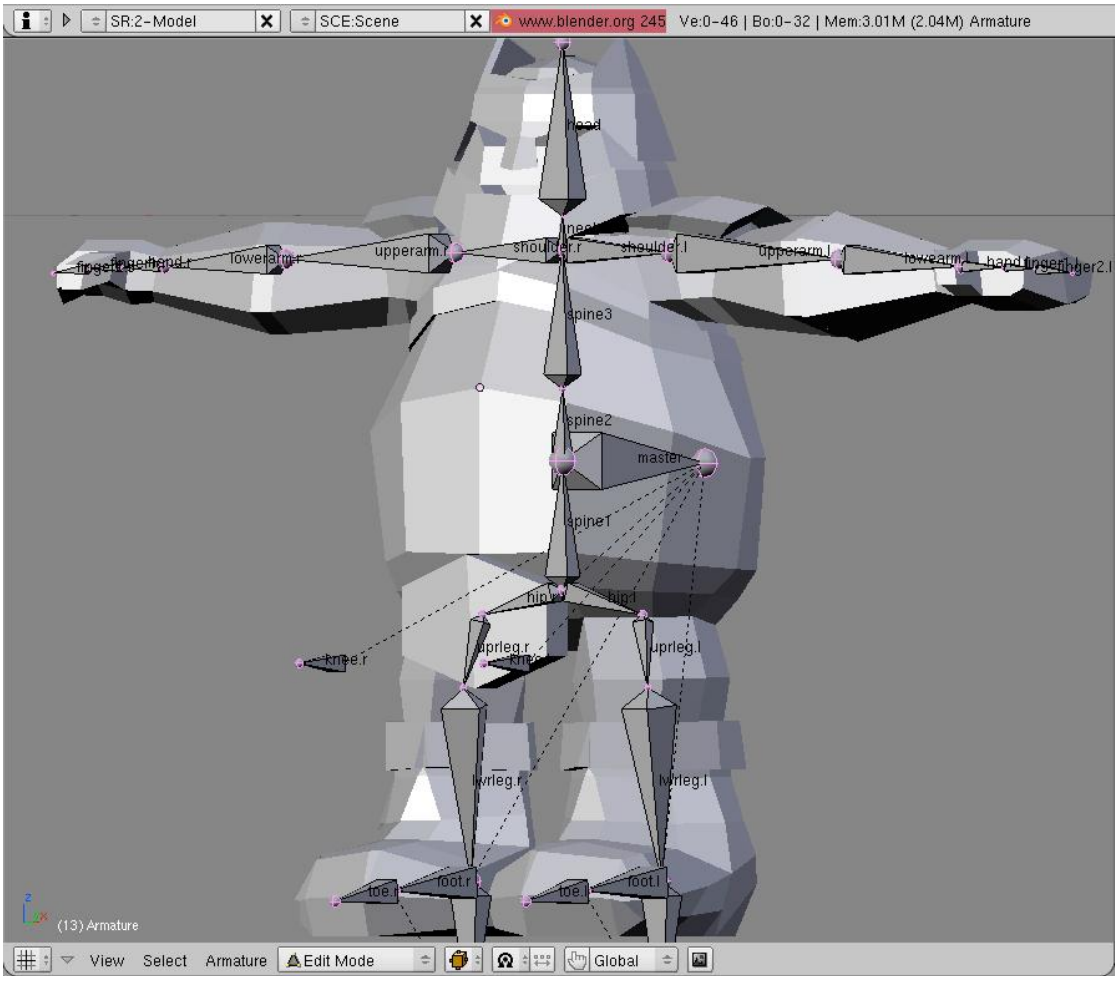

FIGURE 17. The model and its armature (skeleton).

Building the armature, deciding which bones were essential and which should go where, was the hardest part of the modeling so far. Making the bones act in the way they are supposed to act, was also difficult. Luckily the tutorial was precise and by going back some steps the problems were fixed. In the final view (figure 18) the character mesh has been told to follow the bone movements in order to pose the character.

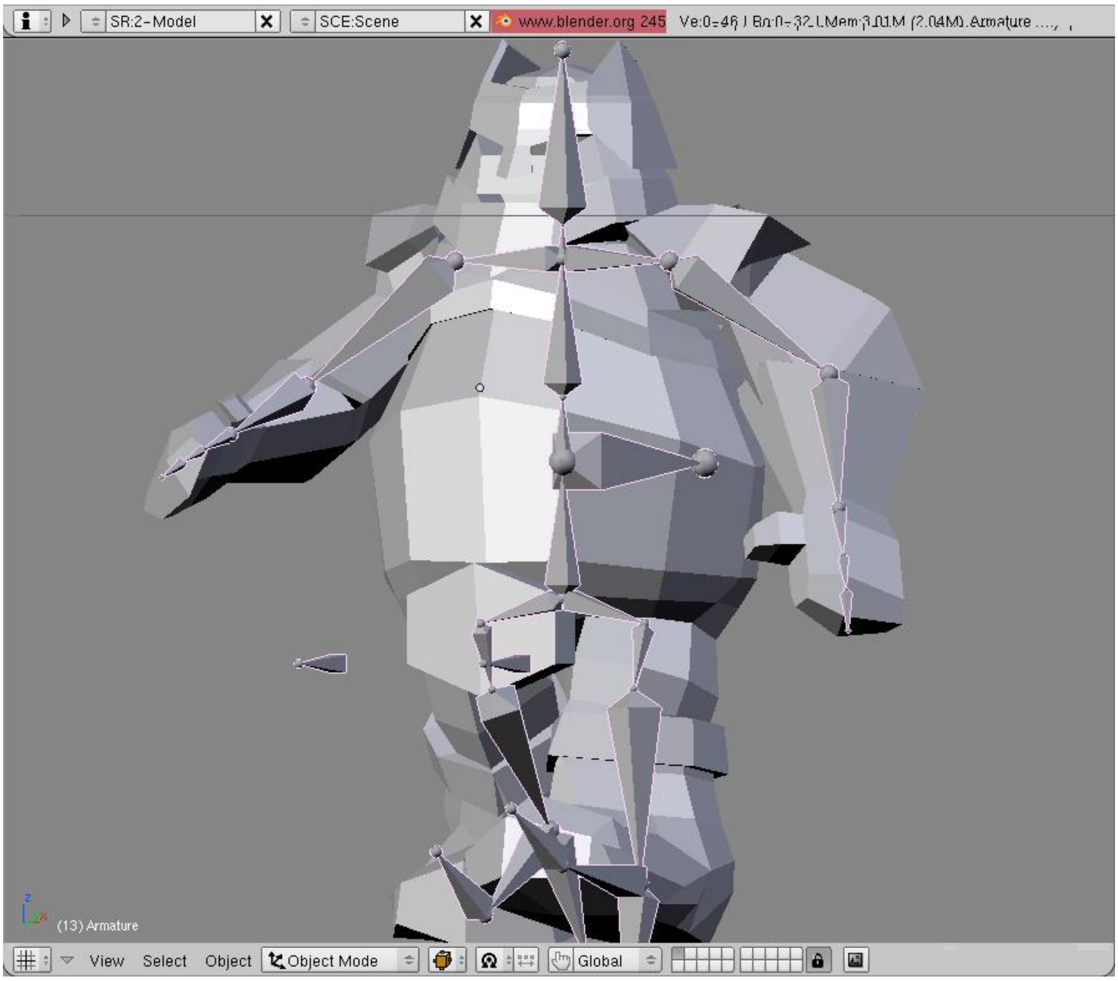

FIGURE 18. The model posed to walk.

The animation interface seen in figure 19 makes it possible to handle different frames in the timeline. The first position of the walk cycle was created and it was flipped to frame 11 and copied to frame 21 and the computer calculated what could be in between. With the posing of one frame, a 21-frame animation was almost complete. Some of the intervening frames were tweaked and thus the walk cycle was finished.

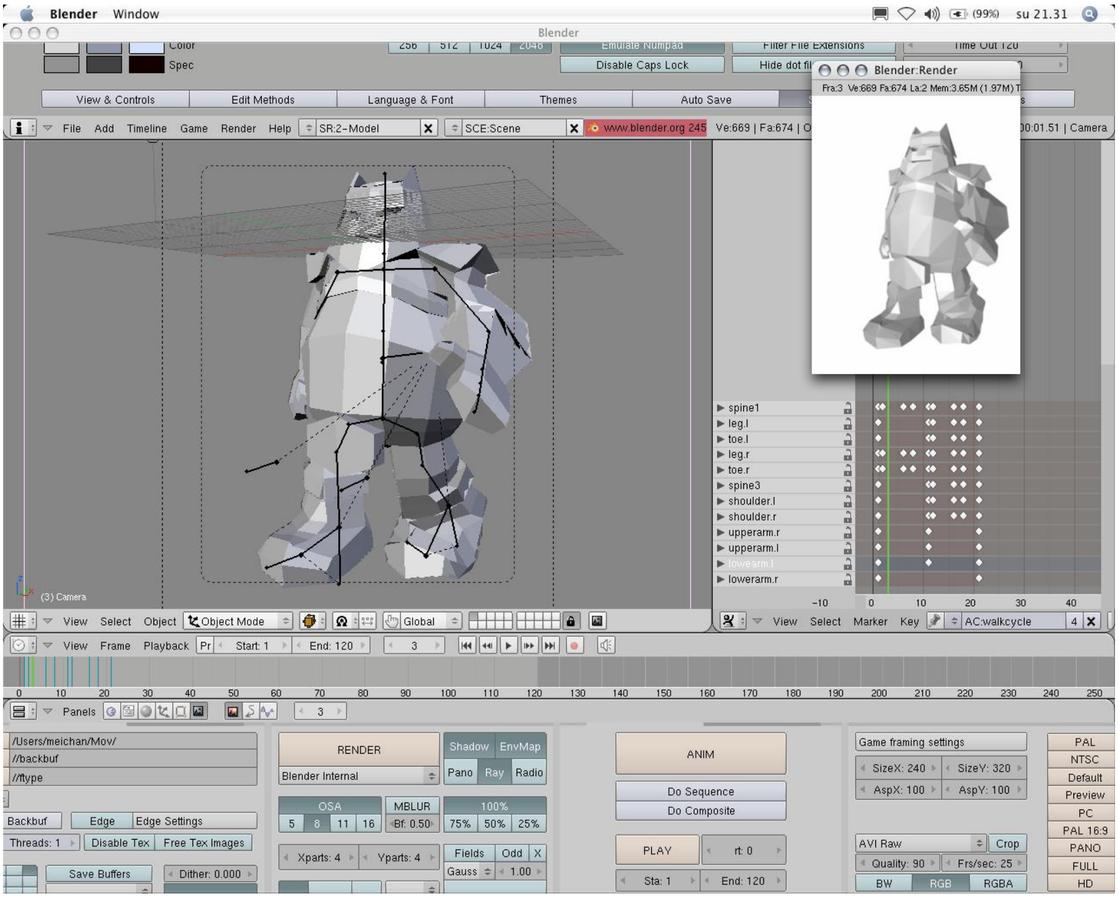

FIGURE 19. The animation interface in Blender.

6.1.3 2D Pixeling & animation

Spriting was done with a free pixel-program called Pixen. The dwarf was drawn, shadowed and colored, as seen in figure 20, rather quickly. It was done in the size of 48 pixels but there is a blown up version to show the difference (figure 21). The sword and the shield were drawn as well to make the tiny character look more menacing. Adding details to a pixel image is relatively easy and can be done more quickly than modeling new artifacts in 3D, as the drawing process takes little time compared to modeling.

FIGURE 20. The development of the pixel sprite.

FIGURE 21. The zoomed in pixel sprite.

After the sprite was finished it was supposed to walk, too. Even with the stout little legs it was a struggle before they moved believably. Drawing the boots again from scratch in every frame was almost mandatory. The animating of the hand movements proved to be even more difficult, because of the square nature of pixels. Moving the arm diagonally meant more trouble calculating the new positions of the pixels. Depending on the character's size subtle movements with pixels can be hard to manufacture, as there can be no half-pixel shifts.

The final walk cycle benefited from the 3D animation which was at that point already finished. The pixel animation did not look right until stop frames from Blender were studied in order to get the postures right. The same effect could have been achieved by filming a test person walking or perhaps studying the mirror. Watching the pre-animated 3D version of the same character was easier and more educational, though. The final pixel animation is also included on the accompanying CD and pictured in separate frames in figure 22.

FIGURE 22. The complete pixel walk cycle.

6.2 Engines

To evaluate the engines, first some were chosen for a deeper look. These game engines seemed most suitable for the task of filling Opioid's needs.

Source engine

An example of a commercial engine. The Source engine is developed by the Valve Corporation and the most famous games it has played upon are Counter-Strike: Source and Half-Life 2. Its API (Application Programming Interface) is for C++ only. There is no public pricing information available, prices are negotiated separately for every licensee and all pricing information is under NDA (non-disclosure agreement). (Source 2007.)

Soya3D

Soya is an entirely free engine that uses Cal3D (a stand-alone character animation library) to handle all its animation features. It has support for skeletal animations but not for mesh morphing, which makes for nice facial animations. Soya3D supports data from Maya, 3DSMax and especially Blender. The programming API for Soya is Python. (Soya3D 2008.)

Crystal Space

A rather stiff C++ game engine framework, difficult to adapt. Crystal Space is one of the oldest 3D game engines and it has grown in size almost too much; at least learning all the libraries would be hard. It has good technological support groups available, though, to ease the learning curve. (Nuclex 2007.)

Ogre3D

Ogre is not exactly a game engine but a rendering engine for game use (note, opposite to Crystal Space). Of the free engines, Ogre3D has the greatest amount of features. Its rendering quality is outstanding. It has many exporters for different 3D modeling software. Ogre's programming interface is originally C++ but some wrappers (language ports) exist for higher level scripting languages, like Python. Ogre should be usable even with no knowledge of C++ but how efficiently the wrappers work remains to be seen. (Ogre3D 2008.)

Ogre is a versatile engine with great design. Its popularity is based on its power and neat design solutions. It has a large library of plug-ins for specialized tasks. A lot of ground work would be required to start an actual game development project with Ogre. (Nuclex 2007.)

Panda3D

Panda 3D engine supports Python as the primary API, C++ is a secondary choice. Panda does not have as many features as Ogre yet, but it is steadily gaining. It has a very high level API so that prototyping 3D games could start very quickly. Panda's support for advanced animation features is limited, there is no mesh morphing for example. Its support for the modeling tool of choice, Blender, is also limited. (Panda3D 2008.)

7 RESULTS

The following chapter concentrates on the results of the study. The test process is considered again from a more analytical point of view. Charts are made of the durations of completing different tasks and they are then examined. Conclusions about the charts and the engines are made.

7.1 Charts

The combined time of producing the character and animating it was very different in the two test methods. The pixel sprite took 220 minutes, that is 3 hours 10 minutes, to complete with the walk cycle and colors. Achieving an animated walk for a non-textured 3D model took 607 minutes, more than 10 hours of work for a novice modeler. The tables 1 and 2 below show detailed information, which is amplified in the following charts (figure 23 and 24).

TABLE 1. Combined 2D durations.

2D	Time (minutes)
Pixel sprite	95
Coloring	15
Animation	110
combined	220

TABLE 2. Combined 3D durations.

3D	Time (minutes)
3D model	270
Rigging	210
Lighting	25
Animation	102
combined	607

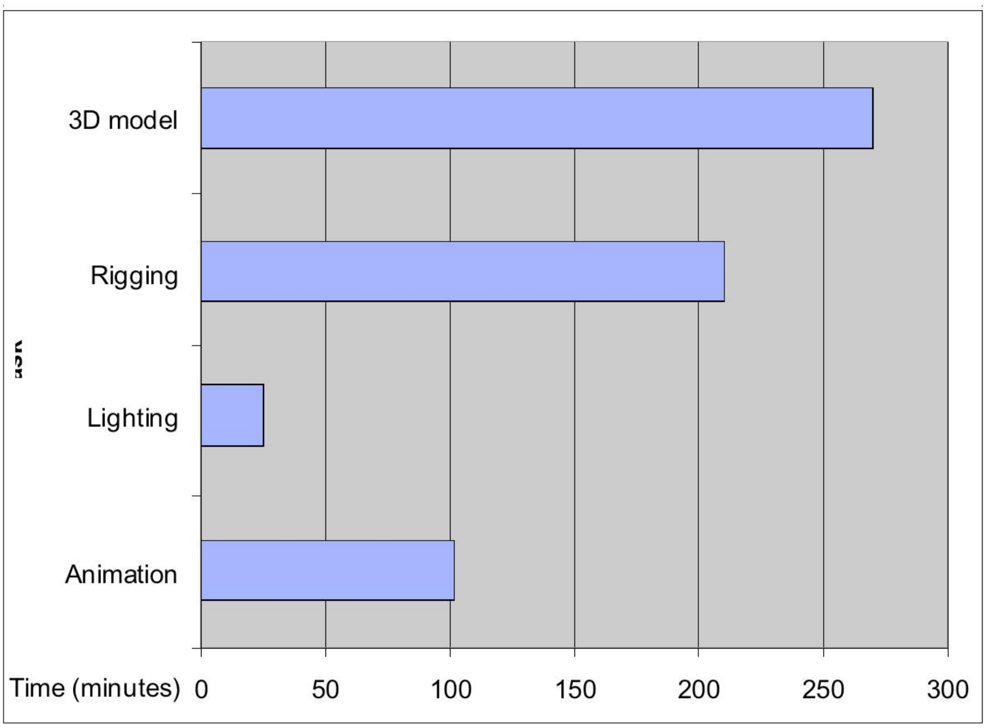

FIGURE 23. 3D complete durations.

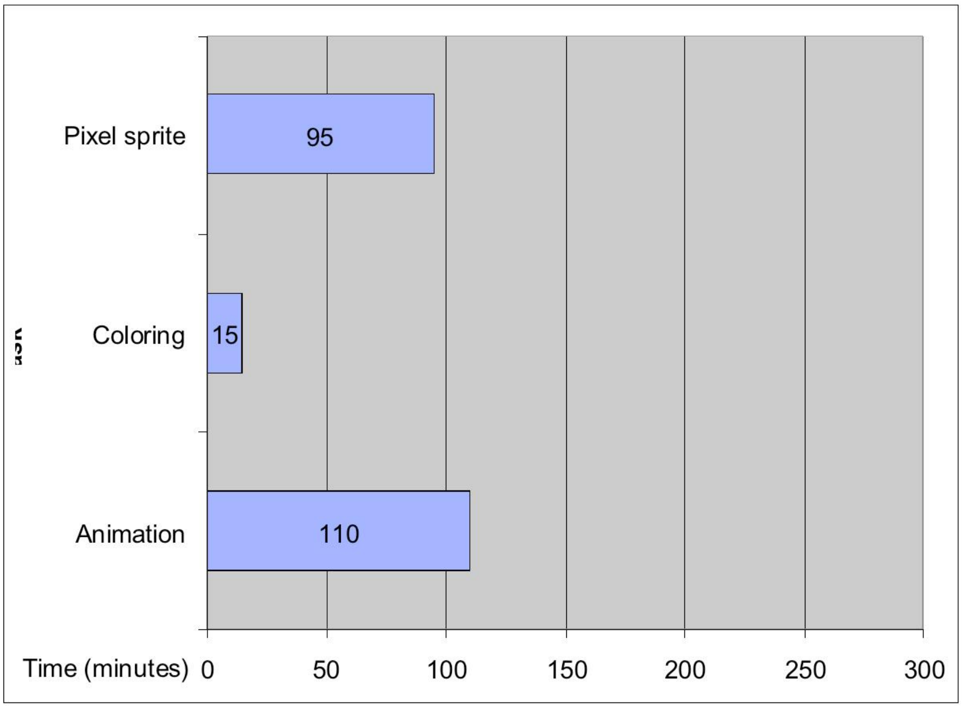

FIGURE 24. 2D complete durations.

With these charts (figure 23 and 24) the result would clearly be in favor of the old method of pixels and frame-by-frame animation. Rigging (putting on the armature or bones) and animating the character took considerably longer than drawing the walk cycle in 2D. However, the forthcoming animations for the pixel sprite would all probably take about as much time. The 3D character on the other hand is already rigged and ready to bounce off in any direction wished and more. Additional animation would not require as much resources as the first.

Furthermore, these sheets and charts include the whole process including studying, correcting mistakes and fixing the characters and animations. The researcher's experience in the other and inexperience in the other method influence these numbers. When stripped of the excess numbers the results even out a bit more. The pixel animation only required 10 minutes of corrective work while the 3D modeling process consisted mostly of reading the tutorials and starting over because of rookie mistakes. The following table 3 bears the complete durations of all 3D related tasks individually.

TABLE 3. Detailed task durations.

3D	Actual work	Tutorial	Test	Corrections	Fixes
3D model	170	100			
Rigging	70	90		50	
Lighting	5	5	15		
Animation	19	48	10		25
combined	264	243	25	50	25

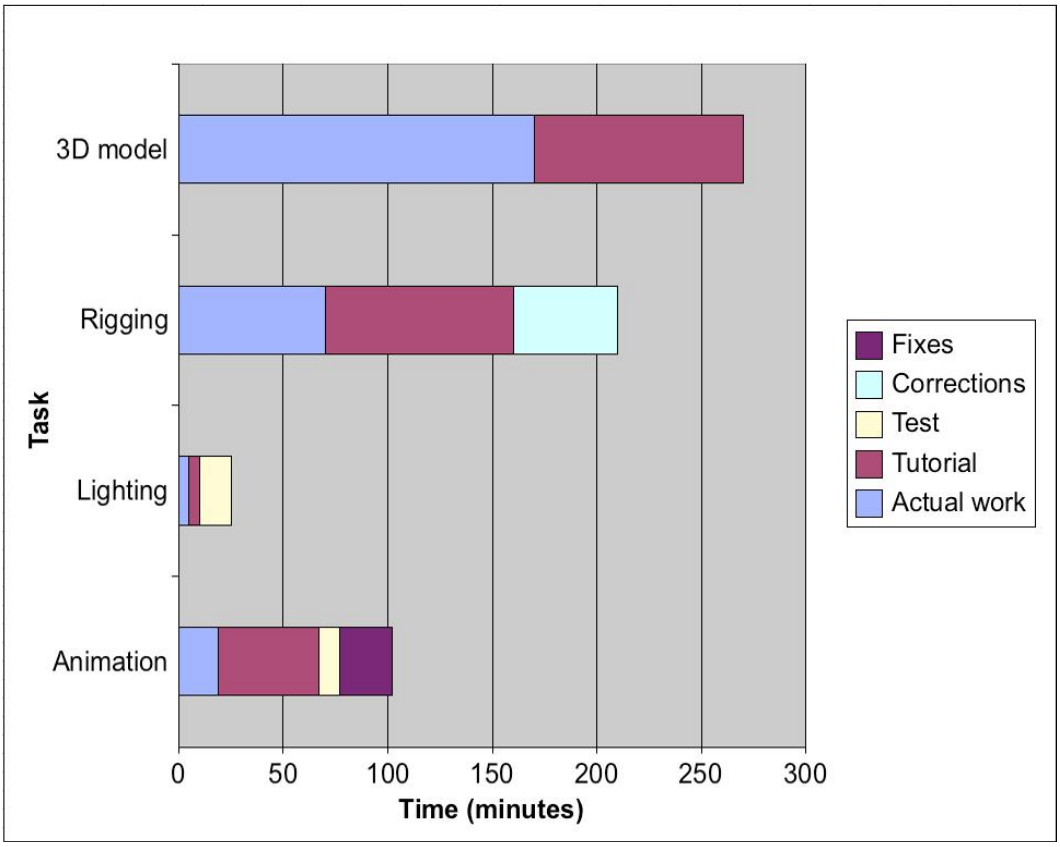

FIGURE 25. Detailed task durations in color codes.

In light of the initial impression from tables 1 - 2 and figures 23 - 24, the new 3D method would seem only to slow down the graphics production. But as figure 25 indicates, the time that the creation of the 3D character required would not be as long if the modeler was previously acquainted with the procedure and software. It can be presumed that the effective time of 264 minutes the modeling and animation actually took could be reduced even further as the skills accumulate.

7.2 Assumptions

The active working minutes from figure 25 have been drawn together with the original 2D durations in figure 26. It indicates that the 2D process would be approximately steady with 1 - 2 hours of work required for each character and each action. In contradiction, the 3D model's duration chart is descending, meaning that after the initial efforts of modeling, the additional movements are cheaper and can even be tested just for the fun of it. Assuming that each new 3D movement would not take more than 20 minutes and that drawing them in pixels would take at least an hour each, the whole composition would turn around very quickly to support the change.

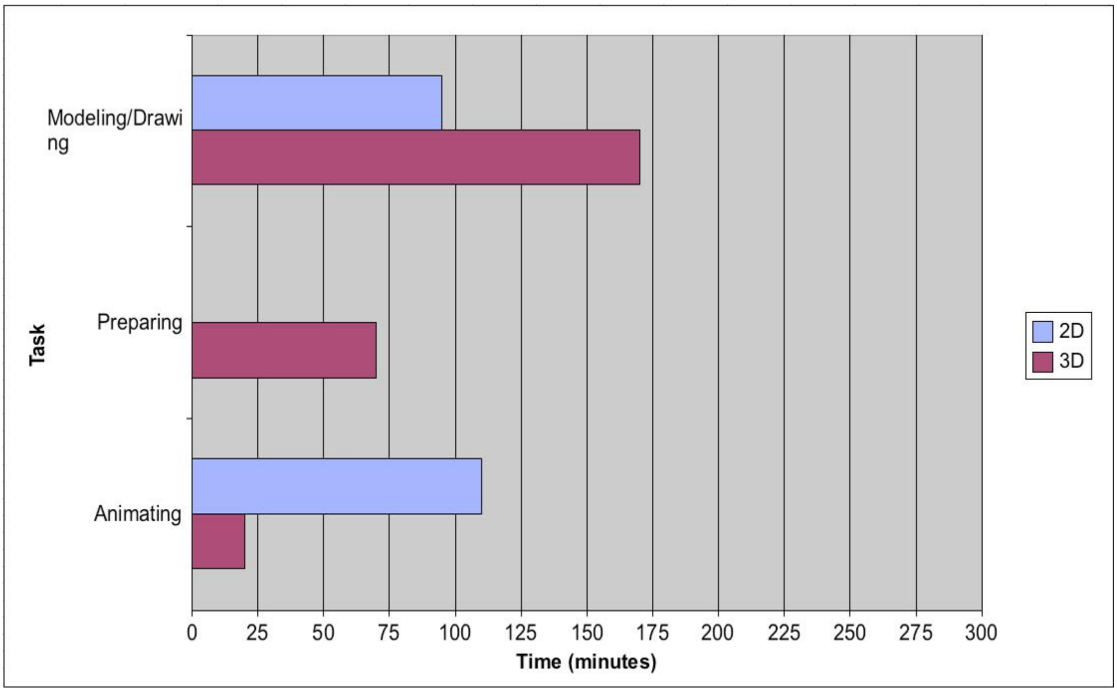

FIGURE 26. Time-consumptions compared.

Even with the assumption that the modeler's experience in 3D would reduce the active modeling time, it is unlikely that the whole process of a similar character modeling and animation in 3D could be reduced below the time of the pixel spriting. This test does not include the time that would be needed for texturing the character for example. However, if more actions were to be animated, as usually is the case for a game character, the most cost-effective method could easily be found in 3D.

This makes measuring the texturing process unnecessary as the pros and cons of these methods are clear from the figures. Additionally, the researcher found that animating the 2D legs of the pixel character to walk was easier only after studying the 3D character's movements. With this epiphany, conjuring up 3D models to help animate pixel characters did not seem such a bad idea. Modeling and rigging can be a little more time consuming than drawing the initial sprite but animating the finished model and adjusting it or parts of it later is particularly easy in 3D. For instance, the model can be made fatter or shorter or colored differently even when the animation is finished without having to animate it again. Frame-by-frame animation can not rival 3D skeleton animations in flexibility, quickness or accuracy.

7.3 Engines

Blender's own game engine provoked interest in Opioid's team after using the software for modeling. The engine was not found particularly useful for full-length game projects, though. The best engine for quick tryouts and checking out ideas would be Panda3D. It has been designed from the ground up to be an easy framework for learning 3D. It is in fact often used in educational projects. To add to its charm Panda3D has a very high level API and good Python support. Ogre3D on the other hand has the best features and extendability.

Ogre would be the best choice for Opioid as an engine for serious commercial game use. It seems intriguing and after the preliminary 3D tests Opioid would be interested in giving it a go. But learning the library and integrating the engine to Opioid's framework would take months of work. To embark on such a journey would mean that the company was serious about this change and sure about its benefits.

7.4 Deductions

The tests presented here are naturally very subjective and singled. Given more time the researcher would have performed multiple character animations to rule out singular exceptions. Even making more movements for the test characters would have made the results more reliable. Yet this case would give reason to assume that the modeling process is not critically longer than the drawing, and that the animation is a lot faster with 3D, in accordance with the educated guesses made in the early stages of this study.

By the writer's previous experience in 2D animation and the intelligence from Opioid Interactive's graphics department it can be assumed that the pixel-animation indeed takes the time measured in this case also. Taking into consideration the researcher's complete lack of experience in 3D models, the animation was really fast and painless.

It is highly unlikely that with experience, this would become any slower. It is safe to say that 3D models really do animate easily.

Then again this test is not conclusive. A game needs far more than just a character that walks at a steady pace. The character should have weapons, tools and such; the character should be textured and move delicately to imitate real life. It needs interesting surroundings to plunder in. 2D games are allowed to look rough but there is no "retro 3D" graphics style that would give way for a cheap looking 3D game. Going to the 3D world would mean dedication to details and the results would have to be stunning at least.

In addition to the programmers' mountain of work to learn the new techniques there are piles of graphic elements needed for the environments, literally 360 degrees more work for the level design and artists. Then there is adjusting everything so that the average PC game player has the proper equipment to run the heavy files on their computer. Turning to 3D is a big decision and these findings about the graphics side and proper engines are only the beginning.

8 CONCLUSIONS

8.1 2D vs. 3D

The purpose of this study was to help determine weather Opioid Interactive should or should not take up 3D graphics and animation in its business plan as opposed to keeping in the old 2D ways with their restrictions and benefits. The pros and cons of both were studied by trying both methods on a similar project and comparing the resulting charts about the durations of different tasks.

Interviews and the study of current trends in the industry revealed that the gaming field is indeed in turmoil and reorganizing with new innovations, finding new ways of doing things that have been done the same way for a long time. Photorealistic visual appearance is not only a must, it has become so common that game developers will have to go one step further, where ever that step might lead. Graphics is an important part of a game experience and pleasure, and now the games need to be out of this world to provoke interest in potential consumers.

The research concluded as was assumed that 3D models are so much easier to animate that the pain of modeling is an acceptable cost. It became especially clear that Opioid's graphics team could manage the hardship of learning 3D and the suitable application was found. The modeling and animation process proved to be less complicated than was feared in advance. The final information about the demands and problems of producing real 3D games in an independent small company will remain to be seen.

8.2 Business implementation

Only testing the chosen tools in a real game-making event will tell how easy or difficult or impossible it finally is. It would depend on the size of the games that will be made and Opioid's eagerness to try the new methods whether they will be employed in in real action. The researcher had an inkling that the programmers would get excited about the prospect of a whole new game making experience and was rather right; it is very likely that after this study Opioid's next projects will involve experiments in 3D and hopefully a whole game using the methods examined here.

The study showed that there is a nice number of open-source engines available and that some of them seem suitable for real game work. Opioid is not the only independent game company with 3D desires and the engines are quite professionally reviewed and debated over the Internet. Growing interest in 3D is a natural boost for the free engines to grow and develop, and many of the engines had promising features due in the near future. If there is not a perfect game engine in existence yet, some of them are bound to serve the purpose as they mature.

Even if the engines or the amount of work involved in 3D become overwhelming, some aspects of this study will be taken advantage of in the future practice of graphics production in Opioid. Creating simple 3D models of 2D characters and animating them to be used as reference for 2D animations will be a useful tool now that the procedures have become familiar. Creating 2D animations from 3D models is also considered, as this would produce graphics and animations more quickly compared to the old methods and the existing 2D framework could still be utilized. Not only would these methods be a perfect golden mean but trendy too, as new ways of gaming and game making are constantly arising.

8.3 The Research

The first problem of this study was that the researcher had practically no previous experience on the subject. Repeating the tests again after knowledge of the operations and the software has grown would give different numbers. The qualitative method of study was suitable as it gives space for such anomalies and room for analyzing them. The impact that the researcher's lack of experience had or did not have could be included in the study. The second problem of the study was lack of time.

The thesis was written in a rather short period of time and the tests were made on the side. This was due to the researcher's graduation timetable. The process was very well contained and kept in place mostly because of the tight schedule, which was found as a positive aspect even though the researcher wished at some points that there were more time to make more comprehensive tests and really dwell on the subject instead of a quick plunge.

This thesis provided an excellent reason for the writer to get acquainted with the software and learn how 3D models are built. Her ambitions of becoming a professional game artist have been given a good opportunity to start becoming more solid with the knowledge of 3D acquired, although learning other, commercial, software would also be helpful concerning the possible future modeling career. All in all, the study was an interesting one to make and profited not only the client but the researcher as well.

SOURCES

Ahearn, L. 2001. 3D game art - f/x & design. Scottsdale (Ariz.): Coriolis.

Blenderwiki. 2007. Referred to on April 23, 2008.
http://wiki.blender.org/index.php/BSoD/Introduction_to_Character_Animation

Crysis. 2008. EA games: Crysis. Referred to on May 4, 2008.
http://www.ea.com/crysis/.

Finnish Game Companies 06. 2006. Kauppa- ja teollisuusministeriö. Referred to on March 29, 2008.
http://ktm.elinar.fi/ktm_jur/ktmjur.nsf/all/02AC89016E43E558C22571870040B6B2/$file/pelijulkaisu_verkkoon.pdf

Fire Emblem. 2003. Fire Emblem Game Boy Advance. Referred to on May 3, 2008.
http://www.fire-emblem.com/.

Habbo. 2007. Habbo Hotel, hangout for teens. Referred to on May 3, 2008.
http://www.habbo.fi/.

Hangaslammi, S. 2008. Senior programmer and founder of Opioid. Interview April 14, 2008.

Hirsjärsi, S., Remes, P. & Sajavaara, P. 1997. Tutki ja kirjoita. Helsinki: Tammer-paino.

Junker, G. 2006. Pro Ogre 3D Programming. New York (NY): Apress.

Koistinen, A. 2008. Game Developer, Universomo, Finland. Interview April 17, 2008.

Lauppert, T. 2007. Timelines and history of video games. Referred to on April 19, 2008. http://members.chello.at/theodor.lauppert/games/.

Lehtovirta, P. & Nuutinen, K. 2000. 3D-sisältötuotannon peruskirja. Jyväskylä: Gummerus kirjapaino.

Nethack. 2008. Referred to on April 19, 2008. http://www.nethack.org.

Nintendo. 2007. Super Mario Galaxy Wii. Referred to on May 4, 2008.
http://www.nintendo.com/sites/supermariogalaxy/.

Nuclex. 2007. 7 Engines You Should Know. Referred to on May 3, 2008.
http://www.nuclex.org/news/2007/12/05/seven-engines-you-should-know.

Ogre3D. 2008. Ogre engine. Referred to on April 14, 2008. http://www.ogre3d.org/.

Open Source Initiative. 2006. The Open Source Definition. Referred to on April 14, 2008. http://opensource.org/docs/osd.

Opioid2D Framework. 2008. Opioid Game Creation Framework. Referred to on April 17, 2008. http://opioid-interactive.com/opioid2d/.

Opioid Game Dev. 2008. Referred to on April 17, 2008. http://opioid-games.blogspot.com/.

Panda3D. 2008. Panda engine. Referred to on April 14, 2008. http://panda3d.org/.

Ratner, P. 2004. Mastering 3D animation. New York (NY): Allworth Press.

Super Paper Mario. 2007. Referred to on May 4, 2008. http://ms.nintendo-europe.com/superpapermario/?l=enGB.

Smith, A. 1995. A Pixel is not a little Square! Technical memo 6. Referred to on April 14, 2008. ftp://ftp.alvyray.com/Acrobat/6_Pixel.pdf.

Source. 2007. Source engine. Referred to on April 14, 2008. http://source.valvesoftware.com/.

Soya3D. 2008. Soya engine. Referred to on April 14, 2008. http://home.gna.org/oomadness/en/soya3d/index.html.

SpriteArt.com. 2005. Pixel tutorials, links and examples. Referred to on May 4, 2006. http://spriteart.com.

Ubisoft. 2007. Naruto: Rise of a Ninja | Ubisoft. Referred to on May 4, 2008. http://narutoxbox360game.uk.ubi.com/.

Wikibooks. 2008. Wikibooks, collection of open-content textbooks. Referred to on April 21, 2008. http://en.wikibooks.org/wiki/Blender_3D:_Noob_to_Pro/Modeling_a_Simple_Person.

Vilkka, H. 2005. Tutki ja kehitä. Helsinki: Tammi.

Yardley, M. 2007. Ed Tech Review: Blender 3D Free Raw 3D Creation Power. Referred to on April 15, 2008. http://www.edtechreview.net/2007/02/blender-3d-free-raw-3d-creation-power.html.

APPENDICES

Appendix 1. CD

Contains pixel sprite images & animation and 3D model data & video.