TAMPERE UNIVERSITY
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Animated Infographics in Digital Educational Publishing

Case Study of Educational Animated Infographics

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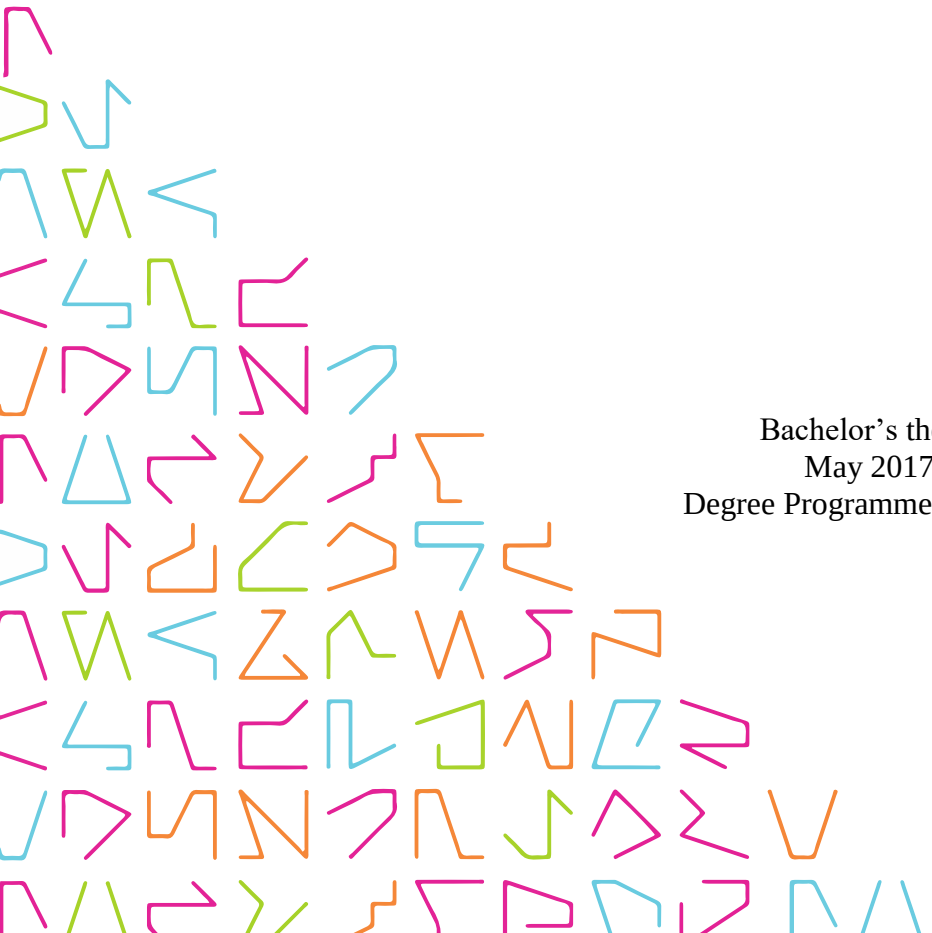

Bachelor's thesis
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ABSTRACT

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The purpose of this thesis was to study the possibilities of animated infographics in the technologically developing field of educational publishing. Digital books can be enhanced in many ways, including animations. This thesis explored the advantages and disadvantages of animated infographics in digital schoolbooks in Finland.

First the current state of Finnish educational materials was charted examining the potential for digital learning. The history of infographics and animation were then studied in the context of educational use. The theory was applied to case animations in order to create effective animated infographics.

The commissioner of this thesis was e-Oppi Oy, a publisher of educational books that are primarily made for digital platforms. Three technically diverse infographics from different subjects were chosen to be animated.

It was concluded that animations as infographics have unique benefits in learning materials. They should be used with consideration. Whether a specific infographic should be animated or not depends on the subject matter and if there are enough resources to be used. More animations will be used in the books of e-Oppi Oy as a result of this study. More research needs to be done on the effectiveness of animation as an educational tool as technology opens up possibilities for even more immersive applications.

Key words: e-learning, infographics, animation

CONTENTS

ABBREVIATIONS AND TERMS

E-learning	Learning based on electronic educational technology and materials
E-book	An electronic book published in digital form
E-reader	A device specifically designed for reading electronic books
Infographics	Visual representations of information
Information Literacy	The ability to collect, understand and apply information
Motion Graphics	Animated graphics
PISA	Programme for International Student Assessment
Matriculation Examination	The final exams in the Finnish upper secondary school
Gamification	The application of game design, game mechanical elements and game principles in non-game contexts, usually situations where entertainment is not the primary goal
Virtual Reality, VR	Computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real and physical way by a person using special electronic equipment, such as goggles with gloves or other controllers fitted with sensors

1 INTRODUCTION

This thesis investigates infographics used in educational materials in Finland and the possibility and advantages of animating some of the graphics in them as the traditional schoolbooks are turned into e-books. With the latest changes to the national curriculum, learning in Finnish schools is supposed to take a dramatic leap toward the digital age. Publishers are endeavouring to make learning materials available in a digital format. Converting the old printed materials to digital form is an excellent opportunity to re-think the whole concept.

Infographics are visualized information. We are used to seeing infographics in our schoolbooks. There are maps, mind maps, graphs, illustrations et cetera to bring the information to the reader in an easy to digest visual form to encourage learning. Because they are so powerful, visual methods of conveying information play an important role in learning materials. The new digital platforms open up new possibilities for the graphic design of the books. Adding animated graphics or motion graphics can be considered. They grab the viewer's attention even more intensely than still images do.

This thesis includes a case study that consists of three animations made for a client, e-Oppi Oy, a Finnish publisher and producer of digital educational materials. The purpose of this thesis is to study the history of animation and infographics and their classical use in educational materials. That information is applied to examine animated infographics. The practical exercises created based on that theory will be published in actual educational e-books.

The client for this thesis is e-Oppi Oy. The customers who buy the products e-Oppi publishes are Finnish schools, chief educational officers for cities, active individual teachers or even individual students. The end users are the teachers and students who use the books in their daily school lives. The Finnish education system has been respected around the world and thought of as very effective, as PISA-studies indicate. In order to produce the best possible books that enhance learning, help keep the PISA scores high and bring success to the company, the possibilities, disadvantages and merits of animation will be studied.

This thesis will concentrate on the aspect of animation in digital learning materials. In this context animation means motion in drawings or graphics, like diagrams, graphs or maps that have moving elements in them. Live videos, which are already widely included in the e-Oppi books, are not considered. There are also many other ways in which the new platforms can and should be taken advantage of. Some of the most interesting ones would be, for example, interactive infographics and gamification. Those, however, should be subjects for other theses and their study given the time and effort they deserve.

The content of this thesis is restricted by the case. The visual design department of the company has only a limited amount of resources to use at this time. Therefore, animation was chosen as the quickest and easiest and, at the same time, the most powerful way to harness the powers of digital learning materials and show that it is worthwhile to invest in them. Possible sounds and voiceovers for the animations belong to a different department. The study is of a qualitative nature because it is difficult to estimate exactly how much time and effort each animation would take compared to traditional still images and how much each animation boosts sales and supports the learning process. If this study proves that motion is good for educational infographics, more of them will be incorporated into the books in the future.

Although the case and client define the limits of this study, these findings are universal and can also be used in the future. The technical circumstances, platforms and their restrictions or software particulars are not given much weight in this thesis, as they keep changing so fast that the text could be obsolete even before its results are applied.

Pictures in this work that do not have references specified are made or taken by the author.

2 VISUAL & DIGITAL LEARNING

A digital book is nothing like its predecessor, the printed volume, with its tactile page turning experience. The foundation is still the same, it is a book, there is content that tells a story of some kind. The advantages of the more agile digital version are investigated in the next paragraph. Slowly but surely publishers have also started using the potential of the digital realm, enhancing the reading experience with animated book covers or video trailers. As this trend continues, educational materials follow suit. The Finnish matriculation examination has recently taken a new, digital form (Digabi, siirtymäaikataulu). To prepare for the final exams, students could greatly benefit from early introduction to modern digital learning by using digital schoolbooks throughout their school years. These developments and the potential within the change are discussed in the following chapter. The possible pitfalls the client of this thesis might stumble into are also examined.

2.1 The Future of Print

The many benefits of reading digitally on a tablet or a dedicated reading device start with the compact format of the books, meaning that the user has a whole library in their pocket. The devices weigh no more than a paperback and hold thousands of books. The user has instant access to millions of books, with no need to travel to distant libraries or wait for an order when they need a specific publication for their thesis or the previous part of a series ends in a cliffhanger. E-readers have extra usability comforts; even the text size can be customized. There are often translators and dictionaries built into the device and specific words can easily be searched for in the book. (Newton 2014.)

Some of those advantages might not be true with e-books read online, but there are common benefits as well. E-books are easier and cheaper to mass produce and distribute (Weinberg 2015). They can be updated on the go if necessary. An example of this would be a map of the EU on an e-Oppi book that was recently updated because of the BREXIT-vote and will be updated again as the situation unfolds. There is no need to use more paper and distribute new versions when the material is online. Also, the built-in ability to share what one reads on social media is a must in this day and age.

According to sociologist Dana Beth Weinberg however, the printed book is not becoming extinct. E-reading is gaining popularity but so is the reading of printed books. She cites a survey done in America by Pew Research Center showing that the number of people who had read printed volumes within a year was around 70 % compared to the mere 20 % for e-books. Digital books are becoming more common but print has a substantial lead. It is still easier to sell a physical book that can be put on the shelf in a physical book store than to get an e-book noticed online. Authors often dream of seeing and holding their creations in print, and readers still like the tactile feel of printed titles. (Weinberg 2015.)

The same study from 2016 shows little change in reading habits (Pew Research Center, Book Reading 2016). Technology still has a long way to go before e-readers look and feel as comfortable as real books. Reading electronic materials on the web can be even harder if the tech will not cooperate. Even if the printed book will never be completely substituted by e-books, both formats will have their place on the market. As this happens, we have a chance to rethink how the content would best serve its purpose in its digital form. In order to assure the best quality in educational materials and the education of the next generation, it is important to utilize the potential of the new platforms. This is also a chance to check the content and make sure it is up to the latest standards.

2.2 Educational Infographics

Sizeable infographics are used on the Internet and in editorial publications for their attention value. Many online infographics use some interactivity or motion graphics. Schoolbooks could also use those styles of graphics that are found effective and that reflect the design of the present time. A Finnish study found that the books in the Finnish educational system use more images than before and the images are of better quality but still leave a lot to wish for (Kautto & Peltoniemi 2006, 126–131). The use of infographics should still be carefully considered and the production professionally handled. The ones that are put into the books should always be pedagogically valuable. Quantity does not substitute quality in educational materials (Kautto & Peltoniemi 2006, 34–36).

The area covered with graphics in Finnish school books compared to the overall amount of space is small, which suggests they are only used as support for the text and not to give new insight into the material (Kautto & Peltoniemi 2006, 109–113). E-Books can afford as many full colour images as can be produced, as printing them will not be an issue. Full page spreads and animated infographics could be used not only to support the text but to present new ideas or offer different perspectives to the content as well. Especially animated stories or simulations could convey the information more effectively than plain text does, which is discussed in chapters 3 and 4.

2.3 Digital Learning

Neuroscientist and author Sam Harris discusses the paradigms of education in his Waking Up podcast with physicist Lawrence Krauss. In the pre-digital culture schools, along with libraries, were repositories of information where students could fill up on knowledge. Now there is more information in one's pocket than one could learn in a lifetime, but that information is hidden amongst misinformation and distortions, and it is difficult to discern truthful information from the false. That is why information literacy and source criticism are some of the most important subjects schools should teach children in these times so that they can navigate through this jungle of facts and false information. (Harris 2017.)

Bringing learning materials into the digital world helps the students learn how to search for information online, realize they have to check its validity and filter the information overflow. It also forces them to learn how to use the devices. Using infographics early on in schoolbooks helps students learn how to read them, which in turn helps them read and understand comparable information sources online.

Education and creativity expert Sir Ken Robinson talks about completely changing the way education is viewed and organized. The current situation all around the world is old-fashioned and does not prepare students for the working life of the 21st century. He thinks the education system with its eagerness for standardization and conformity is responsible for smothering creative thinking in children before they join the workforce, where it could be a valuable asset. He also states that all students are different and learn things in different ways. (Robinson 2010.) The trend of standardization is not the most

prevalent component the Finnish school system. The teachers have more freedom than in other western countries, but on the other hand, the equal treatment of all students rarely allows for tailored study methods for each student's personal needs (Paalasmaa 2011).

Using schoolbooks online has its own benefits and specific potential. With the agility of the digital book format, it is easier to give students tailor made exercise programs suiting their personal strengths and learning habits. Teachers also have different teaching methods. For example, compared to printed books, e-Oppi allows teachers to edit their version of the book to suite their own teaching styles, and the company can improve and update the material according to the feedback. The books with outdated information can be updated. Exercises are also digital, so the students can do them at home (even if they would forget the printed book at school) and try again if they learned something new. Completely new ways of teaching and learning could be discovered.

One of the potentials of the digital platform is using more powerful visual aids. It might even be necessary to use more infographics. Web usability expert Jakob Nielsen describes a study done on the average behaviour of a user on a webpage, and the results in a nutshell are they read only 20 - 28% of the text (Nielsen, 2008). We use digital information differently than printed data. When the majority of the information we consume comes from online sources, we have so many sources competing for our attention that we need to scan the content and skip most of it while multitasking many information sources at the same time. Infographics look good and attract the attention of the viewer, which is a crucial feature in the vivid competition. (Smiciklas 2012, 12.)

The end users come from different backgrounds concerning their digital prowess. The material needs to be easy to use even for those who are not particularly interested in technology. A lot of the success of the books depends on the teachers' willingness to use them, so the materials have to persuade even the most traditional individuals, who might find new approaches scary and difficult. The adaptation to change is stressful even if the change is for the better, so the company needs to be ready to help and instruct the users until they have fully mastered the use of the new platform. One of e-Oppi's ways of using the potential of the digitalization is providing sample chapters of the books to be examined for free.

3 INFOGRAPHICS

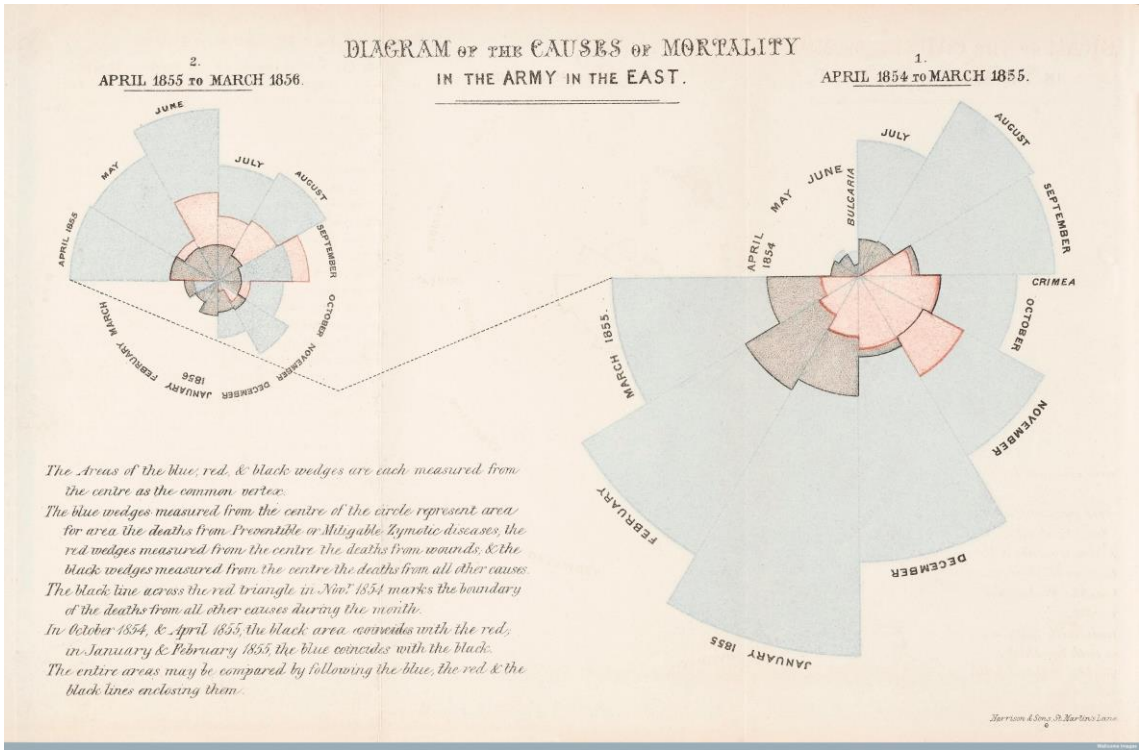
This chapter will concentrate on the nature of infographics and how visual support for text makes a difference in learning results. There have been multiple uses for visual information throughout history. There are many forms of infographics, but the combining factor is giving information of some kind; infographics does not mean data decoration. Visually oriented support in educational materials has been studied and found useful for learning (Kautto & Peltoniemi 2006). Processing visual information drastically differs from sequential processing of words and sentences (picture 3). Studying these laws of perception will give the graphic designer powerful tools for creating more effective infographics. More effective infographics in educational books could lead to larger sales for the publisher and better results for the students.

3.1 Visual Information

Infographics have been around at least since the late paleolithic era. The first remaining figurative drawings were made by our ancestors on cave walls in Indonesia, France and Spain some 40,000 years ago (Smiciklas 2012, 8). At least some theories suggest the painted images of animals and hunting scenes were not merely decorative or religious but a way of communication. That is the core of infographics: communicating information. Maps are a good example of infographics that have a long tradition of use and have evolved from representing skies and geography to depicting concepts of any context and scale. As science discovers more complex theories, it is important to be able to depict them visually. How to explain what different energy states of an elementary particle look like? The scientific formulas do not aid in visualizing it, but there are excellent infographics representing what is known of them.

Mark Smiciklas draws a timeline of the growth of infographics from the cave walls to modern newspapers. Graphs and infographics have become more prominent in the past centuries as several notable artists, philosophers and engineers have created them. One of them was Leonardo da Vinci (1452–1519). He studied human anatomy in order to learn how to draw believable characters, and he created stunningly accurate depictions of the innards of the body with annotations and guidelines. Another notable case is

Florence Nightingale (1820–1910), known for pioneering the field of nursing and creating infographics effective enough to result in changes to hospital conditions in the Crimean war and reduced numbers of soldiers dying of preventable diseases, see picture 1. In the last couple of decades, infographics have turned into mainstream content in magazines, news and other media. (Smiciklas 2012, 126–131.) Explaining things visually has always been seen as an effective way of conveying information. Infographics, such as maps, graphs and mind maps are a natural and important part of schoolbooks and learning.



PICTURE 1. Effective infographics (Florence Nightingale, The Smithsonian)

The quality of the data is important when making good infographics. The facts must be right or the graphic will not be of any use. The designer must simplify and adapt the complexity of the message to the target audience, without sacrificing the content. (Cairo 2016.) In the case of e-Oppi, the content of the infographics is determined by the author, and in the school setting, the content is ultimately regulated by the curriculum. The graphic designer must understand the concept before they can depict it correctly and understandably. The target audience and context must be kept in mind while building the image. Schoolbooks range from elementary to upper secondary and vocational or even university level. The ages and levels of understanding of the students vary greatly. The amount of details and the way concepts are introduced must be modified to suit the

end users. Also the subject influences these decisions. For example, maps in history books have different information included than maps in geography books would.

Data-journalist Alberto Cairo draws a distinction between candid and strategic communication and defines what infographics are not. Infographics are not made to delight or charm the audience. They are not intended just to liven up text content. The aim of infographics is not to sell anything. They can be and are used in advertisement, but when data is presented in a biased from in order to boost sales, the term is not infographics. (Cairo 2016.) For example, the poster in picture 2 is constructed as if to resemble an infographic, but when you take a closer look at it the data is in reality not so informational after all and the poster is actually just an advertisement for a xylitol product line.

Infographics are also often used in magazines and newspapers. However, if relevant information has been omitted from the graphic in order to overemphasize some details, manufacturing a shocking graphic to drive more traffic to the article, it cannot be called infographics. The foundational purpose of infographics is to inform (Cairo 2016).

PICTURE 2. A prime example of not an infographic

Design is important in many ways, however, not only in ensuring the accuracy of the data and the legibility of the infographic. When pursuing clarity, by following the principles of perception (discussed further in chapter 3.2), the graphic artist inadvertently creates visually pleasing graphics. Also, the designer would purposefully try to create a balanced viewing experience, choose colours that go harmoniously together and gently guide the viewer's eye around the image. A beautiful infographic could be more effective as it stands out more, and the audience is drawn to it and keeps studying it for a longer period of time (Cairo 2016). The digital era stretches our attention with a profusion of information, and we tend to look for easily digestible chunks of it, which visual representations offer (Smiciklas 2012, 14–16).

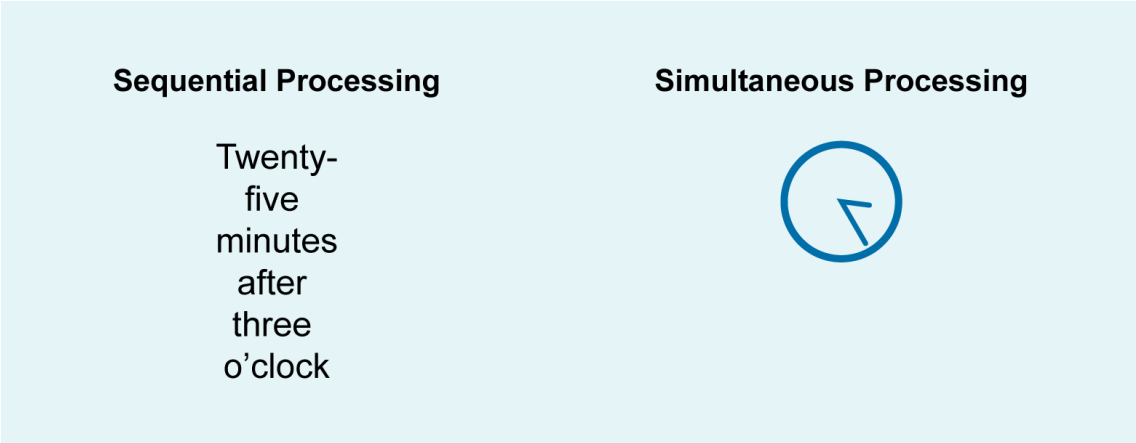
Design is important also for technical reasons. Infographics used in digital educational materials can be projected on a screen in the classroom with all kinds of projectors with different settings, so they might end up too light, too dark or just overall muddy. With the budgets and cuts, there might not be a projector to begin with. The books and images could also be looked at from a variety of sizes of tablets or monitors. The internet connection might be slow or have problems. Some users might prefer traditional materials and print them out on paper. The data visualizer must take these conditions into account when choosing colours and values, font sizes and generally the amount of details crammed into the images. (Cairo 2016.)

Other circumstances to consider include individual users, not only their age and level of understanding, but their possible impairments in vision. The art department at e-Oppi has taken great care to ensure that for example colour blind students will be able to read the images without too much trouble. Informational passages on top of maps that are usually green do not use the colour red if possible, and if unavoidable, the value will be significantly different from the base so that the message still reads clearly. The same conditions, and all the ones mentioned so far in this chapter, are also relevant when designing animated infographics.

3.2 Perception

Cognitive sciences have studied perception and how we interpret what we see and use the information and learn from it for over a century. It has become obvious that the brain takes the data from the senses and processes it (meaning, chucks out unimportant parts) quite far before letting it seep into the consciousness, otherwise we would be overwhelmed by the data we get just by opening our eyes in the morning. (Vilkko-Riihelä 1999.) The brain automatically picks out things that are different from the noise; therefore strong visuals have the power of getting the reader's attention (Smiciklas 2012, 11–14). How the brain interprets what it sees depends on a multitude of variables, but there are certain principles where it automatically jumps to conclusions and fills in missing data on its own. That is why visual illusions work, why we see animation as continuous movement and why graphic designers can delicately direct the eyes and perception of the viewer.

According to Albert Cairo (2016), an infographic is "a graphical display intended to convey information". It is said that a picture is worth a thousand words and that is what infographics and data visualisation design are all about. Visual communication can be efficient and valuable when explaining new topics. Mark Smiciklas explains in his book The Power of Infographics that acquiring information by reading requires hard sequential processing from the student's brain. All the work is left for the reader, who must produce the visuals in their head and balance all the facts from around the page in their mind before full comprehension is formed. Visual information, on the other hand, enables simultaneous processing of different aspects of data. A "picture" is formed instantaneously, as can be seen in picture 3. (Smiciklas 2012, 3–11.) Visuals make it easy to understand the message. Whether it is good for learning and processing information, is another matter.



PICTURE 3. The difference between Simultaneous and Sequential Processing (Infographic inspired by Mark Smiciklas)

In his book The Truthful Art, Cairo states that an adept data visualizer can convey a large amount of information in a concise and easy to digest packet, including built-in insight into the data. For instance, comparing elements or indicating connections between them or the change, flow or direction of trends can be easily included in the visual design of infographics. (Cairo 2016) Cairo might not completely agree that motion would enhance the communication value of an infographic (Cairo 2013), but those insights just mentioned (comparing elements, indicating direction, connection, or trends) would be even more clearly communicated in motion. A study on motion in the principles of grouping is discussed in chapter 4.2.

To make the most of the physiological aspects of vision, the designer should refer to the principles of grouping. Also called *Gestalt laws of grouping*, this set of rules comes from Gestalt psychology that states that the human brain has a set way of perceiving patterns in sensory data. The theory studies how the human brain interprets visual cues. Objects or shapes appear to group together by the principles, and the designer can use the knowledge to their advantage when suggesting relationships between concepts. (Soegaard 2002.)

There are other principles in addition to these but the main principles of the *Gestalt laws of grouping* are:

- Proximity
- Similarity
- Closure
- Good Continuation
- Common Fate
- Good Form

Design should be split into easily digestible chunks. Text walls or solid masses of information may seem intimidating or time-consuming. *The Gestalt principles* come to play when designing clear visual hierarchies, as it is easier for the viewer to tackle the data if it is clearly divided into chunks. When the page has visually clear and aligned sections, enough white space to separate them, and related things grouped together, the viewer will not abandon hope even before beginning to read. In animation, it means short chapters or short movies demonstrating the idea at hand. Everything cannot move at once and in every direction. (Meyer 2016.)

4 ANIMATION

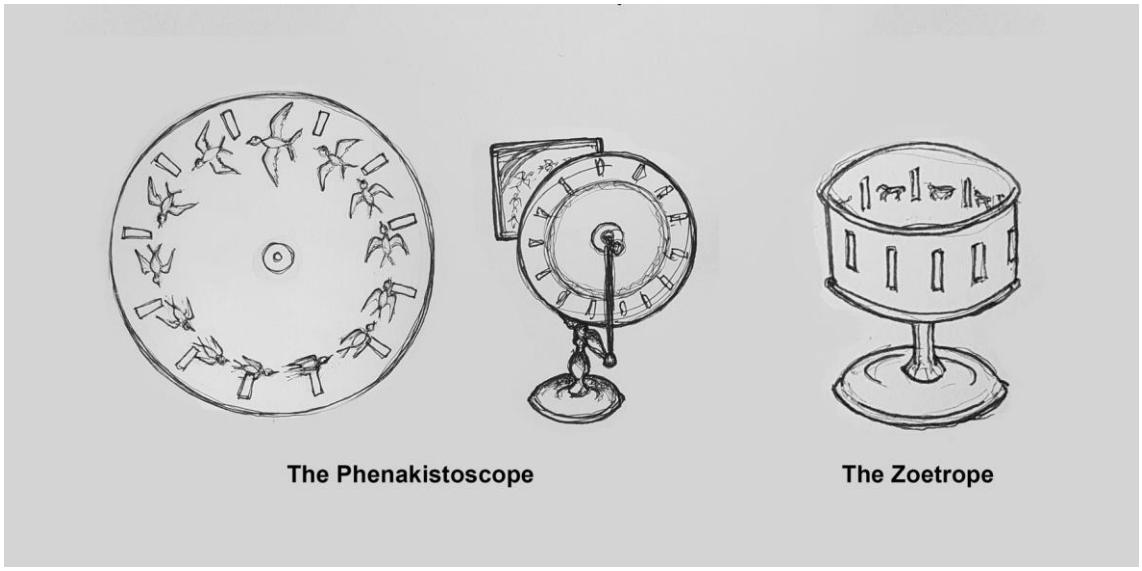
This chapter will explore the fundamental theme of this thesis: animation and its use in educational infographics. The rapid evolution of animation from flipbooks and rotating disks to 3D - the fervent interest it sparks in people - predicts that it will keep its position as an important part of our visual lives. Technology advances in great leaps but motion infographics have not been utilized in educational books before, for the simple reason that the books used to be printed not digital. Animations are not established features of schoolbooks, so traditional publishers might overlook their potential when moving to the digital age. The purpose of this study is that e-Oppi wants to at least investigate the advantages and disadvantages of using animations in their books. How will this affect the company? Will the customers be swayed by them? And how will the end user, the student, be affected.

4.1 What is Animation

Animation, like infographics, is an old concept. Some of the cave paintings mentioned in the previous chapter bear signs of the artist wanting to depict movement in the wild boars they drew on the walls. Animated stories have been told long before the conception of film. (Beckerman 2003.) Shadow puppetry is an ancient form of entertainment from Southeast Asia, see picture 4. It is an artform where the viewer sits on the other side of the screen and watches how the story unfolds as colourful shadows on the strongly lit screen. A skilled artist can animate walking, dancing, natural phenomena and basically anything imaginable with just paper cutouts on sticks.

In the early nineteenth century the concept of moving pictures took a couple of strides forward when the phenakistoscope and the stroboscope (1832) were invented (see picture 5). They were simple discs with small slits that gave the appearance of moving images when spun around facing mirrors. The zoetrope (1834), a more advanced gadget with changeable drawings on paper strips came about soon after those and the praxinoscope (1877), re-introducing mirrors to make viewing the action yet more comfortable, followed. (Beckerman 2003, 4–8.) Animation is such an inspiring field that these are just a few examples of how artists and inventors have tried to capture the imagination.

PICTURE 4. Shadow play or shadow puppetry in Beijing



PICTURE 5. Early animation devices

What is it that gives the illusion of movement to those rotating disks and apparatuses from 200 years ago? When sequential still images are shown at an appropriate (one sixteenth of a second) rate our brains seem to blend them into smooth movement. The images need to be close to each other in shape and location for the effect to appear. Motion perception is a complicated process in the brain. The brain is known to play all kinds of tricks on us concerning the interpretation of sensory data among other subjects. Visual illusions show that the brain is very adept at coming up with explanations for missing parts of data, inferring the causalities. It interprets chronologically progressing images as movement, and that is the base for endless entertainment in the form of animation. (Beckerman 2003, 4–5.)

The beginning of the 20th century brought along increasing technological advancement in film and animation. The first stop-motion films were made, gradually moving an object in front of a camera, capturing single frames to form a continuous action. The first drawn animations also arrived. Drawing each frame by hand is an enormous amount of work, meticulously following the action frame-by-frame, but individual artists as well as larger studios (Disney) around the globe kept refining the craft. Characters started becoming live on film. Rotoscoping, drawing from live footage, was invented. Animation was combined with life footage. Slowly during the first half of the century, colours, synchronized sound and personality were added to animations and animated characters. The way of storytelling developed. (Selby 2013.)

By the 1980s, animation had become a remarkable industry. Computer animations started taking over and animated special effects became standard in live action films. Creating animation has always required advanced knowledge on the technical side alone but making inanimate items seem to move also demands deep understanding of motion itself. The lessons and teachings from old masters who had practiced the art for decades, like *the 12 Principles of Animation* from Disney veterans, formed the basis for studying the discipline. On top of these, the animator also needs to master the more artistic and emotive parts of the trade like storytelling, timing and drama. (Selby 2013.)

The 12 Principles of Animation have been adapted to everyday animation work and are explained in all major publications of the field. More information on these can be best found in the book Illusion of Life (Johnston, O & Thomas, F. 1981) where they were first introduced.

1. Squash and Stretch
2. Anticipation
3. Staging
4. Straight Ahead Action and Pose to Pose
5. Follow Through and Overlapping Action
6. Slow In and Slow Out
7. Arc
8. Secondary Action
9. Timing
10. Exaggeration

11. Solid drawing
12. Appeal

The production of even one minute of animation is, even with the digital advancements in technology, time consuming and requires special skill at least from the key animators. Still there are countless movies, series and shorts and more produced every day. Some of the animated entertainment is directed at children, some for adults. For example the awarded films by the Japanese Studio Ghibli have brought animation to the consciousness and enjoyment of many adults. Animation is present in our daily lives so much that we do not even notice it. It has evolved into digital motion graphics that are everywhere and what is more remarkable, the software have become so smart that nearly anyone can create simple animations themselves.

There are animated movies and shorts and then there are animated graphics that are closer to still images but have some motion in them. There are animated emojis and stickers in our everyday chat conversations on our phones. The operating systems and apps are animated. Casual gaming has become a major pastime activity and games are of course packed with animation. There are even animated informational traffic signs for construction sites. The abundance of visual stimulation we get constantly from the internet, the television and our smartphones even changes how our brains interpret what we see. We are used to talking cereal boxes, singing clown fish and dancing broomsticks. We have come to expect them. Therefore it is only natural to include animation in schoolbooks, the media that children and young adults should focus most of their attention on.

4.2 The Advantages of Animation

In his book Animation, the Whole Story, Howard Beckerman says about animation that "There is no other graphic art that so stretches the imagination to get a laugh, display an abstraction, explain a method, or sell a product." It is a way of telling stories, as abstract or imaginative as can be. (Beckerman 2003.) One of the advantages of animation is the possibility to give abstract concepts a visual presentation. That is a key component of educational graphics. The visuals are there to support learning, and if the concept is best represented in motion, the potential of the digital platform should be used to its advantage. Animation can also explain complex things in the simplest ways, and open up

new perspectives for the viewer. The viewer might not have been able to visually imagine what is explained in the material in text form, but a still infographic could help form the idea, and an animation could push the realization even further.

Even a very complex infographic can become intelligible if the contents are spread over a timeline. (See picture 6 in the next chapter.) There is an immediate sense of direction, timeline and movement, and clear implications of cause and effect. For the theme of this thesis, this effect could most easily be exemplified in an infographic for the subject of history of war. Such animations have been presented in educational videos before, but now it could be embedded straight into the book. Let us imagine a map that has attacking forces depicted as arrows advancing on the ground. The size, speed and course of the army are indicated with the size, speed and path of the arrows. A lot of explanatory text could be eliminated from the infographic. The core lesson for making legible infographics is simple is beautiful. To ensure readability, data in infographics should be depicted in the clearest possible form. Animating the simple elements on the infographic allows for more simplicity by reducing explanatory items.

Animation can give more meaning to a simple sphere than still graphics can, which makes it possible to show complex concepts in very simple visuals. Animation can give that simple sphere some limbs and maybe a mouth and it can already run and shout. As a way of communication, animation has an exceptional ability to cram a lot of information into a small package (Beckerman 2003). The sphere can also be given more meaning with only movement. Jinsook Kim, Ph. D. has an interesting study about motion in *the Gestalt principles*. It is suggested, that the laws of grouping are overruled when the same principles appear in animation. To illustrate a simplified example, three squares and three spheres would be grouped into squares and spheres in a still image. However if one of the squares and 2 spheres move in the same direction while the others have another path in a different velocity, the groups would be formed by the motion-similarity by direction. (Kim 2007.)

Another advantage animation has over still images (or text without images) is the power of grabbing and keeping the viewer’s attention. Motion can grab the attention of a passer-by and engage them for some time, even if the content is not that interesting to them. This is built into our system, as it has been crucial to our survival to notice even the tiniest movement in the tall grass (and run) before the creature lurking behind the

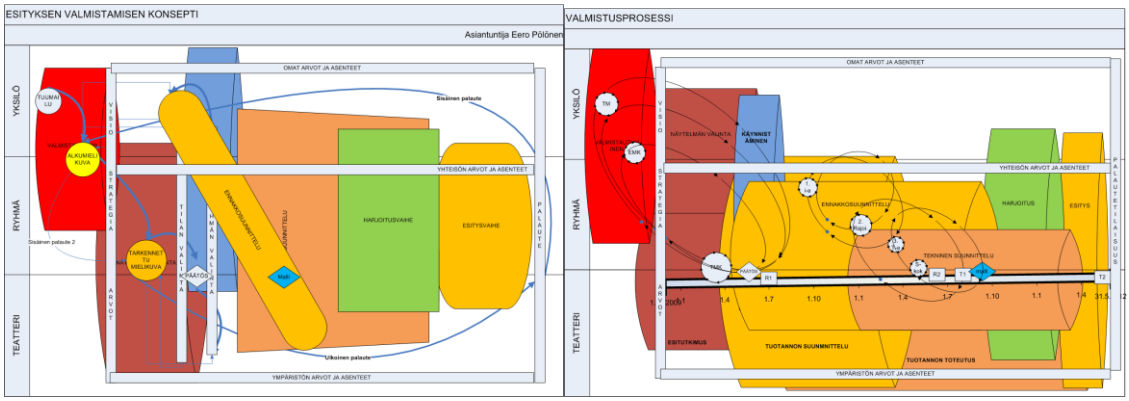
grass jumps out and eats us. (Vilkko-Riihelä 1999.) Movement is consequently a strong visual element. It surpasses all the Gestalt laws of grouping in attention value. If one of the components in an image is moving, the viewer cannot ignore it. A teacher, a potential customer, would have to give the book more attention if there were animated infographics in the sample chapters. The usage of the latest technology for enriching the content would also help form an impression of a company whose material is deeper and more demonstrative than is typical of schoolbooks in general.

Some of the teachers who ultimately decide if the books are worth purchasing and using with their class might be technologically challenged or at least not schooled in the use of the very latest gadgets. Complicated systems and non-user-friendly applications discourage the customers from trying out the new technologies. Gamification and fun interactive elements in the books and especially in the activity sections are probably a great benefit both for the learning process and the selling of the books, but they might be scary at first glance, because we are not used to seeing them, at least in any serious publications. It could be too much of a change, as the customers might have used the same materials they prepared their first year of teaching over and over for years and decades. However, a simple animation could be smoothly integrated into the book amongst other graphics, and it could run with just one click, or even be set to automatically loop whenever the page is opened. The familiarity of a page with text and images with added depth from animation could help the teacher to courageously choose the new platform.

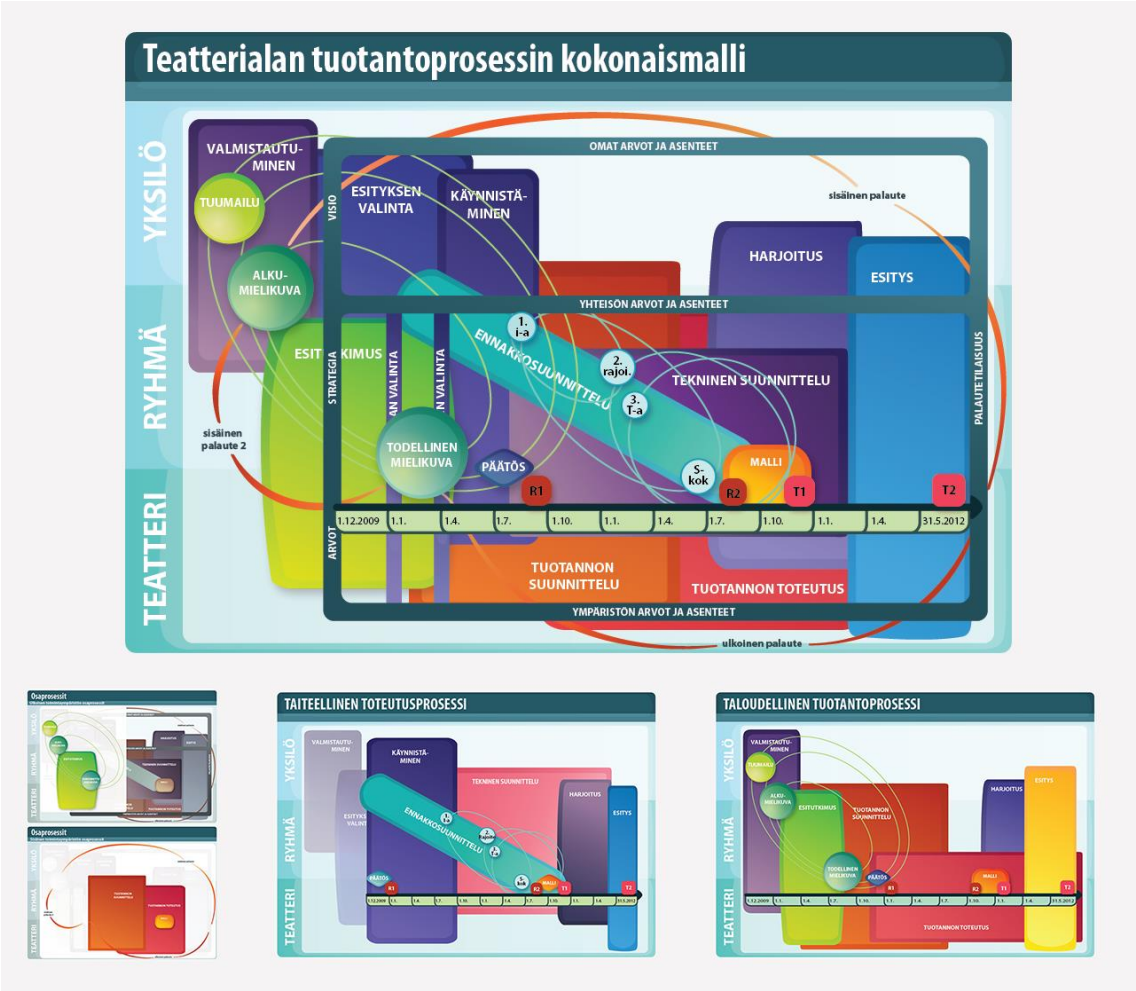
4.3 Examples

Chapter three charted how visual presentations aid the learning process. Infographics with an added dimension of a timeline have even more power to help clarify difficult concepts. An animated graph made for a project in TAMK R&D in 2013 is a good example, see pictures 6 and 7. The project describes an overall model for the theatre production process. The diagram has so much information and is so complex that it is almost impossible to understand any part of it or even where to start reading it. The visuals were made easy on the eye with the idea in mind that attractive graphics can keep the interest of the viewer for a longer time period, maybe long enough to decipher the image. They were also animated and narrated, and suddenly the complex graph became

understandable. The information was divided into sensible chunks. The narrator described the first parts while they appeared onto the screen one by one, forming the background. When they were set, the next chunks were added one after another, explained and highlighted as they appeared. Each chunk also used specific colour families to accentuate grouping. When the whole graph is formed, the viewer has been provided with a step by step guide to reading it and can hereafter understand it.



PICTURE 6. The raw information for the animated graph (Eero Pölönen, TAMK)



PICTURE 7. Project Kierre, an example of complex infographics made legible with animation (animation available at http://kierre.tamk.fi/)

Another example of effectiveness through quite a small input concerning animation is the logo for the same project, Kierre (picture 8). The original, clean, still logo was traced on TVPaint, a frame-by-frame animation software that mimics traditional animation on paper. The Finnish word Kierre means twist, vortex, curl or spire. To play on the meaning of the name, the letters dance onto the stage, winding and spiralling into place in different velocities and arcs. There is an emoji in the logo formed by the final 3 letters. Together with the underline they form a smiling face. An added level of playfulness was achieved by animating a twinkle in the eyes on the serifs. Even small tidbits of animations have a lot of power. Just by adding a blink to the eyes of a character in an infographic the animator would add greatly to the attention value and approachability of the image.

PICTURE 8. Logo for the project Kierre, animated

4.4 Possible Drawbacks

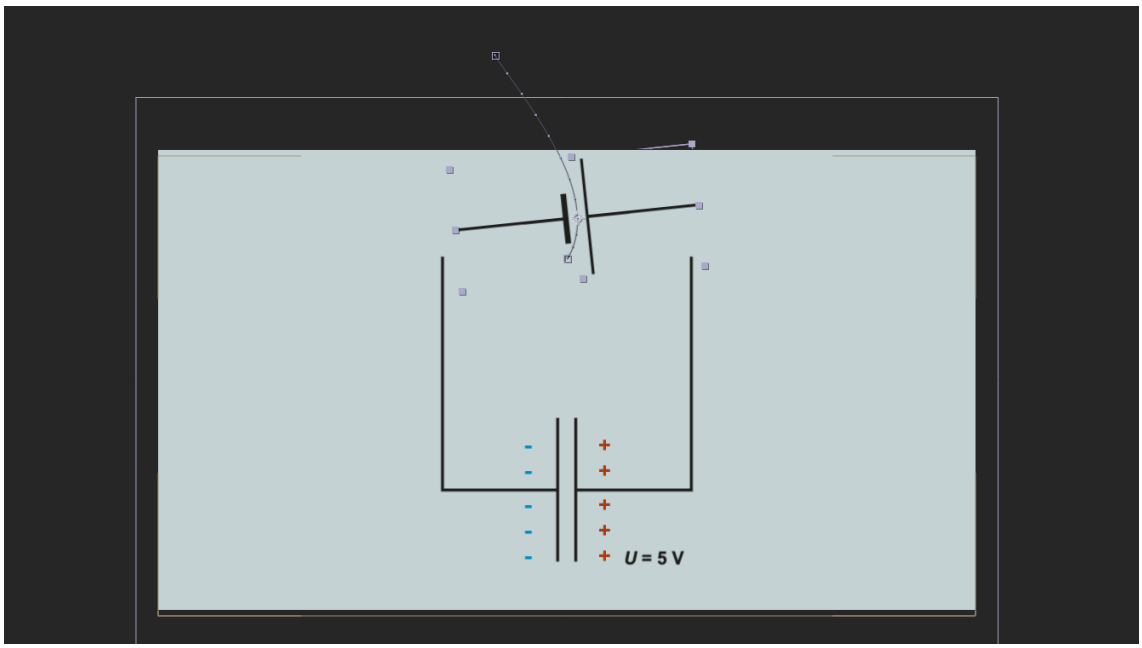
Does motion enhance understanding? As the usage of animation in infographics increases, the question becomes consequential. While animation is incredibly entertaining and engaging, there are studies in cognitive science suggesting it might be detrimental to communicating the message. The research found that still images of the topics studied were more effective in communicating the concept than animated ones. (Simmon 2013.) It is also possible that readers would spend more time on a graphic if it were printed rather than digital, and animation could distract from learning more than it helps convey the message (Cairo, 2012).

Despite the power of grabbing attention, animated banner ads are not as effective as advertisers believe (O'Toole 2013). Overused effects lose their impact and merely irritate. Of course there needs to be more research, and all the variables must be taken into account before the decision on the benefits of animation for education can be considered decisive. While some topics might benefit from motion in their visualization, others might not, and vice versa. Cairo suspects that watching something move on the screen takes the control away from the viewer, who might not have been ready or be able to absorb the information at the pace dictated by the motion. Short time memory is short, and if a student is shown a lengthy animation of any new subject, it might be difficult to

follow the core of the story to the very end. In that case, a suitably designed infographic that stays put and lets you study it unhurriedly would be more effective. Then again an animation would specifically suit to illustrate a linear development, where each step builds on the previous one. (Cairo 2013.) It should be carefully considered which data visualizations to animate, and which to leave as they are.

Modern pieces of animation software have partly eradicated the most tedious frame-by-frame work that used to make animation so slow and expensive. Graphics are made to move through various arcs whose speed and trajectories are defined by code. Arcs are also mentioned in *the 12 principles* meaning the natural curves in most natural actions. See picture 9 for the vector arc the battery (at the top of the box / circuit) follows. The animator defines the start and end points for position and rotation and the velocity and curve between them. There are also tools to adjust the velocity curve to enhance *the 12 principles Slow in and Slow out* effect. 3D programs come with systems to include bones or other types of moving mechanisms for rigging the models.

Animation, even with modern software however, is slow work. Creating a still image takes a certain amount of time, but if the same image needs to be animated, there is extra working time on top of that. The image would need to be prepared for animating, put in the right software, and animated. It may not be a significant amount of extra work, but it is still more than it takes to make the still image. The person making the motion graphic also needs to have specific skills. Even though these days almost anyone can use ready-made software online to create small gifs, the serious animation for educational use needs to be properly produced to ensure the best learning results.



PICTURE 9. The vector arc in video editing software

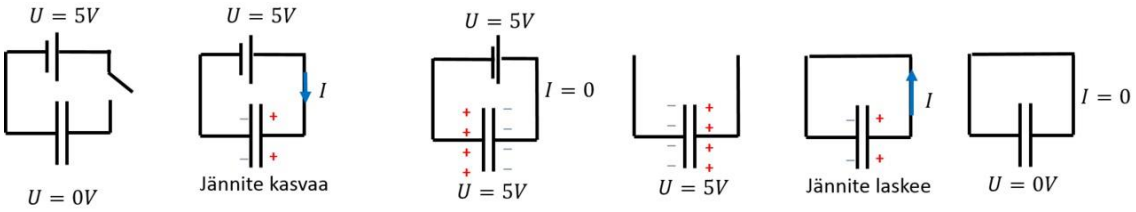
Animated films have been used in classrooms just like educational videos have for decades, but animations in infographics and schoolbooks are a new, specifically digital phenomenon. This raises the question if animations are considered first and foremost distraction or entertainment and their educational value inconceivable. The animation could attract the viewer to the content, but if the animation was thought of as entertainment, it might be viewed as such. If the animation does all the work explaining the subject, the viewer might enjoy the show and forget to do the learning.

5 CASES

Next in turn are the case studies for this thesis. There are multiple animation projects planned for the time being, three of which are presented here. All the cases are different from each other both in subject matter and execution style. Starting from the simplest one in looks and subject for physics and through a more complicated depiction of the progress of the plague on the map of Europe to a more contemplative scene for language studies, these cases showcase different sides of motion graphics.

5.1 Simple Simulation

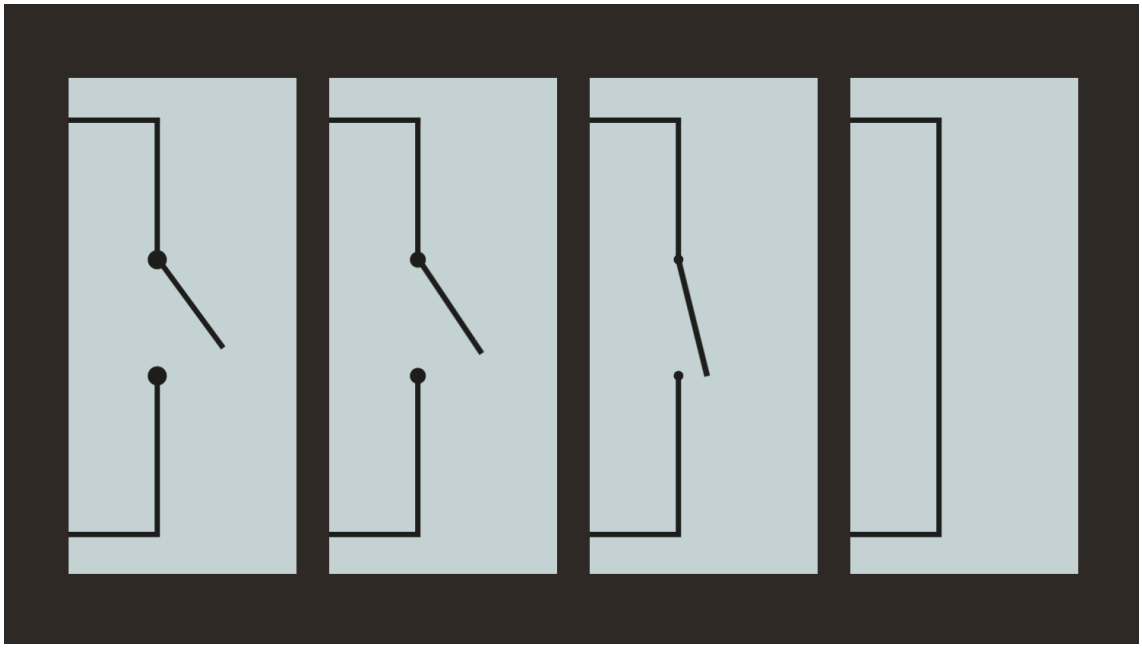
Some really simple illustrations for upper secondary level physics were decided to be animated. The authors can also export simple animations themselves from *GeoGebra*, the software they use for simulations. These small but effective animations dispersed throughout the book brighten up the content and bring out the positive sides of digital study materials. The simulations are accurate, but nevertheless automatic creations. An animation, hand animated by a professional animator, can tell a story. In this first case it is the story of a capacitor where the circuit is closed attaching a direct current source into it, after which electric current goes through the circuit increasing the capacity of the capacitor. When the potential reaches equity inside the circuit the battery is removed and replaced with a conductor. After this the potential slowly decreases and finally drops back to zero.



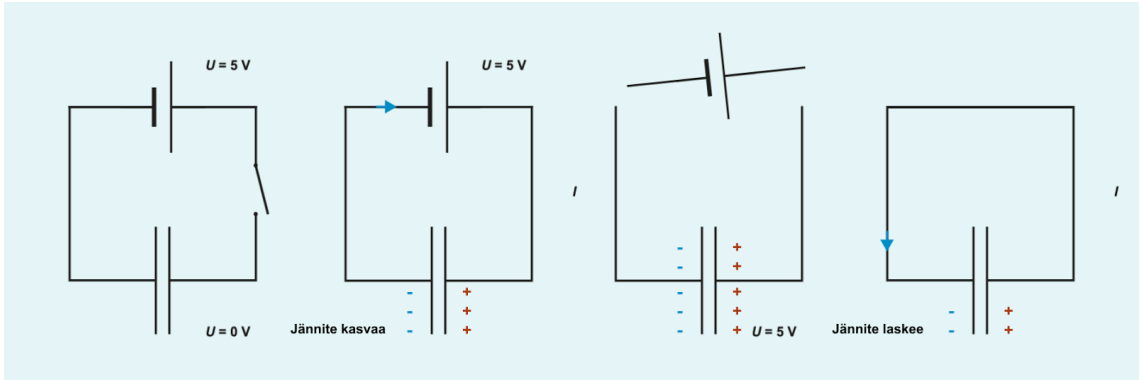
PICTURE 10. Storyboard for the Capacitor by the authors of the book

First the switch is animated when it closes (picture 11), which is not possible with *GeoGebr*a or other simulation tools. Those tools do not implement *the 12 Principles of Animation*, which are used in these simple animations just as well as in complex ones. The same goes for the removal of the battery and the attachment of the wire. The whole

circuit could squash and stretch along the animation, if it were taken to the full extreme. That is not necessary for this type of a simulation though. It is enough to animate the moving parts in and out, and pay attention to timing so that the viewer has time to read everything. These elements make the simple animation a story that explains the phenomenon in the most easily digestible way.



PICTURE 11. Number six *Slow In and Slow Out* of *the 12 principles* creates the smooth closure of the switch



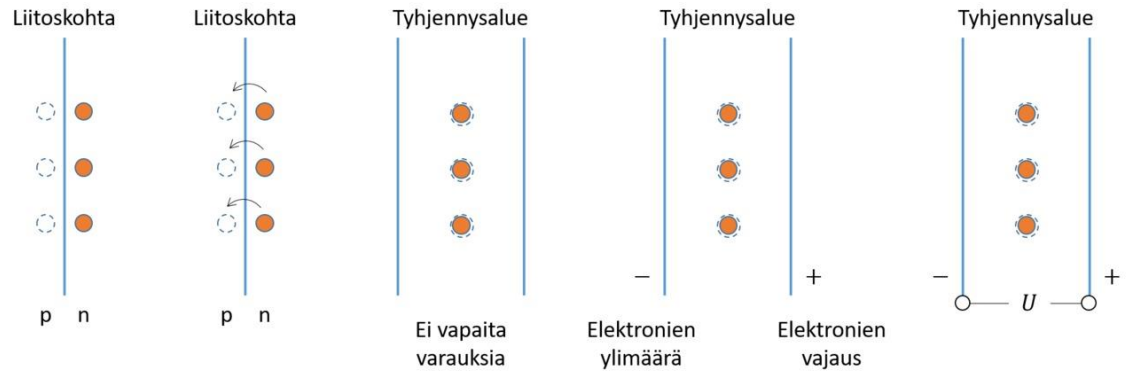
PICTURE 12. The continuation of the animation for the Capacitor

There are always problems, even in a simple case like this. A regularly occurring problem with animations has to do with storyboarding. The storyboard stage is the stage where everything is thought through and placed roughly in the final positions. More often than not this does not happen, and clear errors end up in production. For some reason the plus and minus signs in the capacitor storyboard (see picture 10) switch plac-

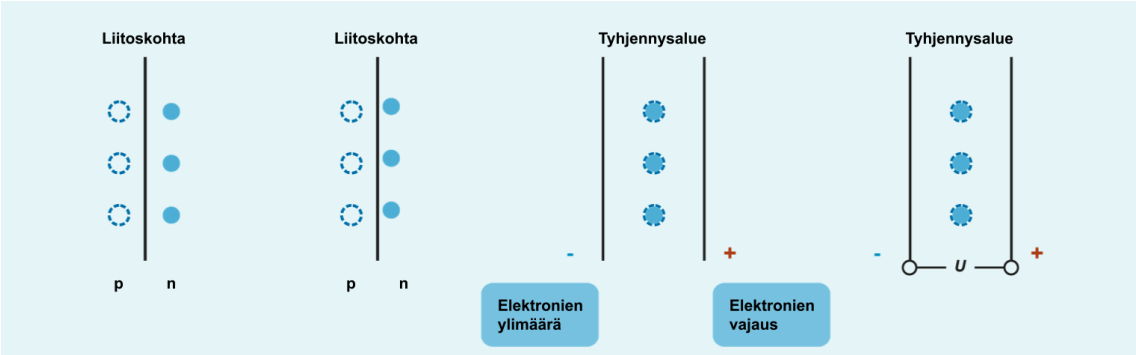
es between steps, so they were animated accordingly. These errors are unfortunately easier to spot from the final animation.

After the animations were initially accepted, it turned out that the authors did not want the arrow depicting electric current to actually move. The graphic designer rarely has a deep understanding of all the subjects they are tasked to illustrate. This includes knowing the conventions of physics diagrams. The rotating arrow has such a demonstrative effect when animated, for instance you immediately understand the direction of the movement, that replacing the rotating element with electrons, which are the elements moving in the current, would be beneficial to understanding the concept as a whole. Luckily modern animation software, in this case video editing software *Adobe After Effects*, makes it easy to add and replace elements on the go. Correcting a hand drawn frame-by-frame animation would have been a larger operation.

Another animation made for the same book was even simpler, as seen in pictures 13 and 14. The storyboard explains the need for animating this phenomenon. The electrons (in the storyboard marked orange, in the animation blue as has been the convention for all e-Oppi books for electrons) move from the n-side to the p-side and next the area is shown in a different way. The events move forward linearly which is perfect for animation, which has a timeline that moves forwards. The text fields in this animation are quite long, which might make it harder to follow. It would be optimal if the animation was self-explanatory and did not need any text in it.



PICTURE 13. Storyboard for Diode



PICTURE 14. The continuation of the animation for the Diode

5.2 Timeline on a Map

The task was to show how the plague moved across Europe in the 14th century. Essentially this meant moving borders on a map. To draw the affected regions year by year in one still image marked by different colours would of course be a possibility, but animating the spread of the disease gives an immediate sense of progression of time and dramatically also gives emphasis to the intensity of the Black Death as it had profound effects on the history of the continent.

Maps are a good example of infographics as representations of reality. They have a distinct visual language one has to learn to read in order to survive in this world outside one's own home. Nowadays maps are widely available for everyone. They can even be found in our pockets, digital, interactive and talking, but the same rules apply. The blue bits are water and the green or brown is usually safe to walk on. They give us lots of information in a condensed space.

On a grand scale, maps are also distorted representations of reality. The projection used in any 2D map will exaggerate one part of the geography or another. The choice of projection should be considered according to the context. Other distortions in maps arise from the details that are included and omitted. The context determines what details should be shown in a map and the amount of them should be adjusted for the target group.

e-Oppi already had a 40 second version of the map, picture 15. The maps in the current books of e-Oppi look quite different from this one. The projection commonly used for

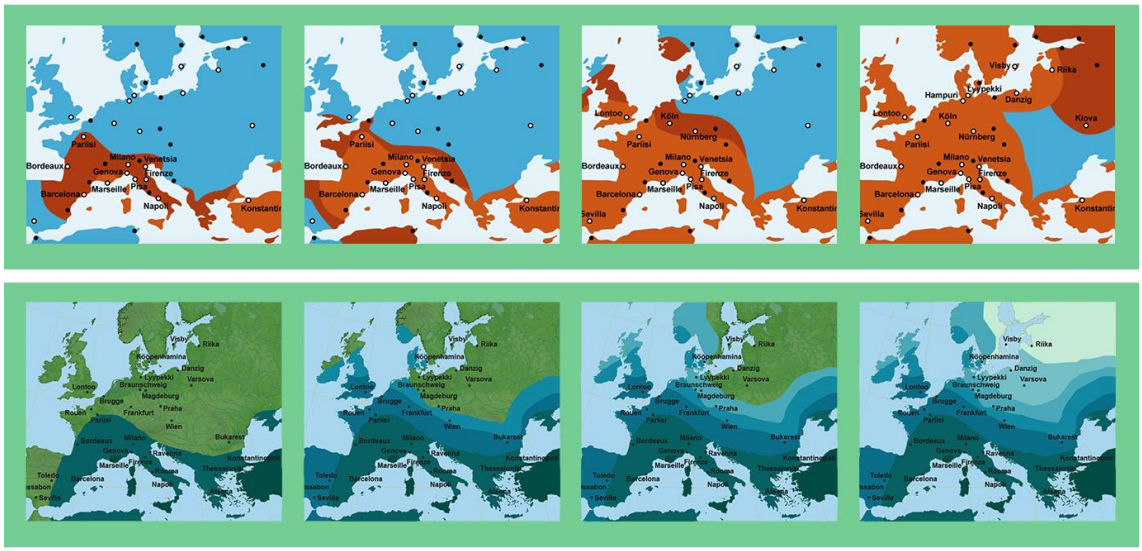
Europe is different and had to be updated. There are more details in the new maps. There was also a usability test where it was decided that ground cannot be coloured blue because blue colour is always perceived as water. Blue was used because it is the official colour of e-Oppi and colour unity within books makes them visually pleasing and calming. Blue and red would also suit colour blind students better than green and red.

The first thing implemented differently than on the original infographic was the placement and animation of the year. In the original map (picture 15) the year in question in each segment is hidden in the title of the page. It is difficult to notice that it changes along with the growing plague border. To avoid the confusion, the year was placed in a noticeable spot directly on the map and the changing of the year was emphasized with animation (picture 17).

PICTURE 15. Screenshot of the original animation of the plague

Another question about distraction is the cities and city names on the map. That is one of those content related design questions where the author's input is necessary. The graphic designer cannot decide which cities or place names are important in the context. The legend is also a bit distracting because of the length of the text. It was eliminated from the final animation.

In the original map, the plague advanced in a darker red orange colour and the previously affected areas were marked with an orange colour, as shown in picture 16. In the new map a simpler approach was used to promote clarity. Each year is of a different colour and stays that way throughout the animation.



PICTURE 16. The use of colours in the original map compared to the new map

The final question was whether to animate the border or add new layers one by one. This was answered by the production value attribute. The latter would be faster to produce compared to the first one, and evidence of added educational value was not found.

PICTURE 17. Screenshot of the final animation

5.3 Creating a Scene

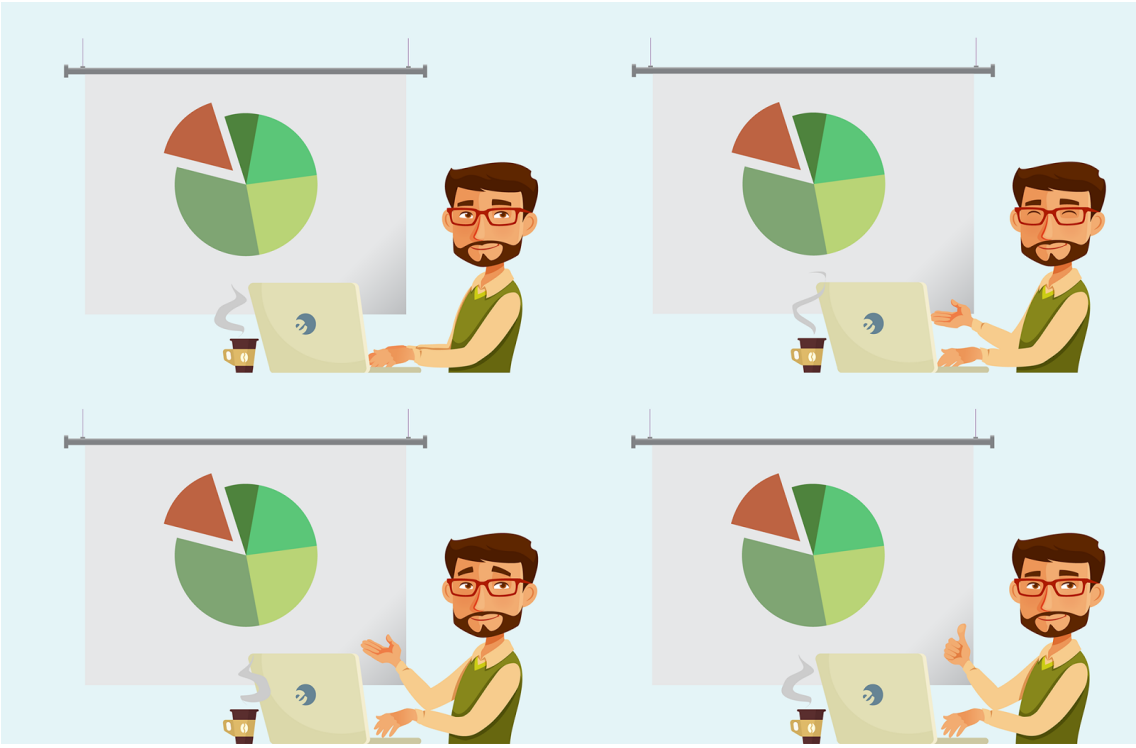
The case of an animated short where a teacher is giving a lecture in front of a blackboard was for language studies. The situation cannot be presented similarly in pictures or only in text format. Even a video might not convey the atmosphere in the same way as animation, where the designer can direct the viewer's attention and mood in imaginative ways. These two clips exemplify a type of speech on a lecture. The animation creates a sense of the situation and the speech.

A little bit of animation is enough to liven up an infographic where a narration drives the story along. This is optimal use of animation for educational infographics. A lot of production value is gained for minimal work. In the first clip the teacher was standing in front of a blackboard, and the character moved his hands and head a bit in the rhythm of the speech. Lip sync or other detailed animation was not necessary. The text was also written on the blackboard and animated with an effect to emphasize the point about the incomprehensible language used.

PICTURE 18. The teacher is standing in proximity of the blackboard with the unintelligible text, the two elements form a group (The bases for the character illustrations in chapter 5.3 come from Subarashii21/Shutterstock)

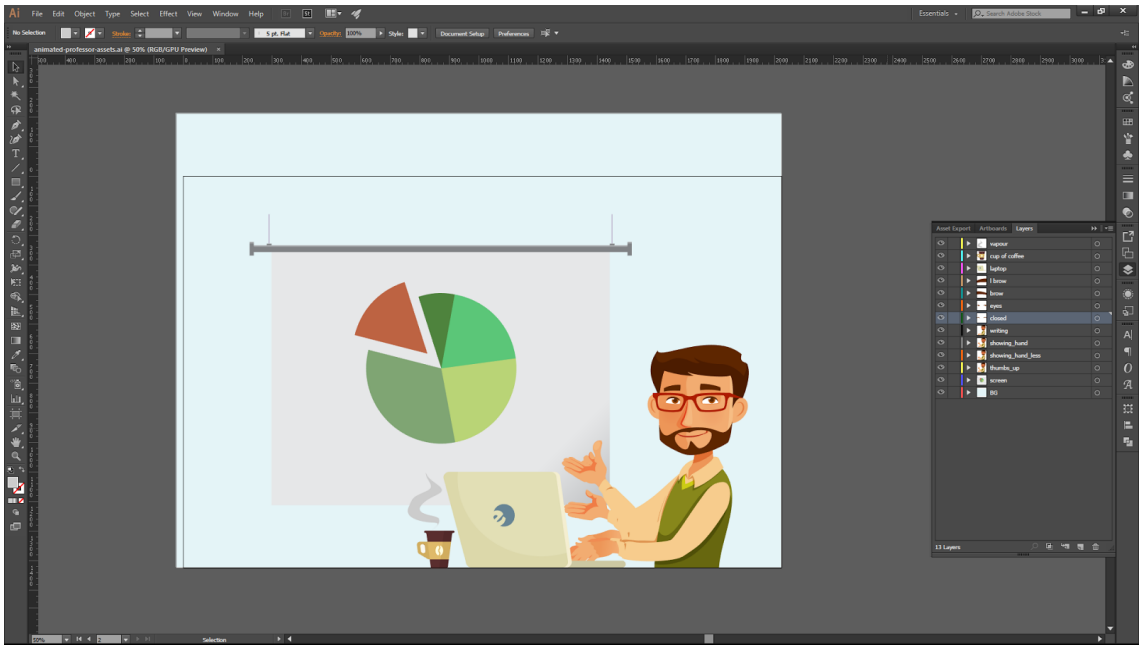
PICTURE 19. Even very slight movement with the character gives the infographic a lot of life

In the second clip there was a professor whose digital learning materials were projected onto the screen behind him, picture 20. The narrator read the speech and the professor's hands moved, eyes blinked and he raised his eyebrows. The vapour from his coffee mug slowly twirled up. The animation did not overpower the scene but created interest and helped convey the message.



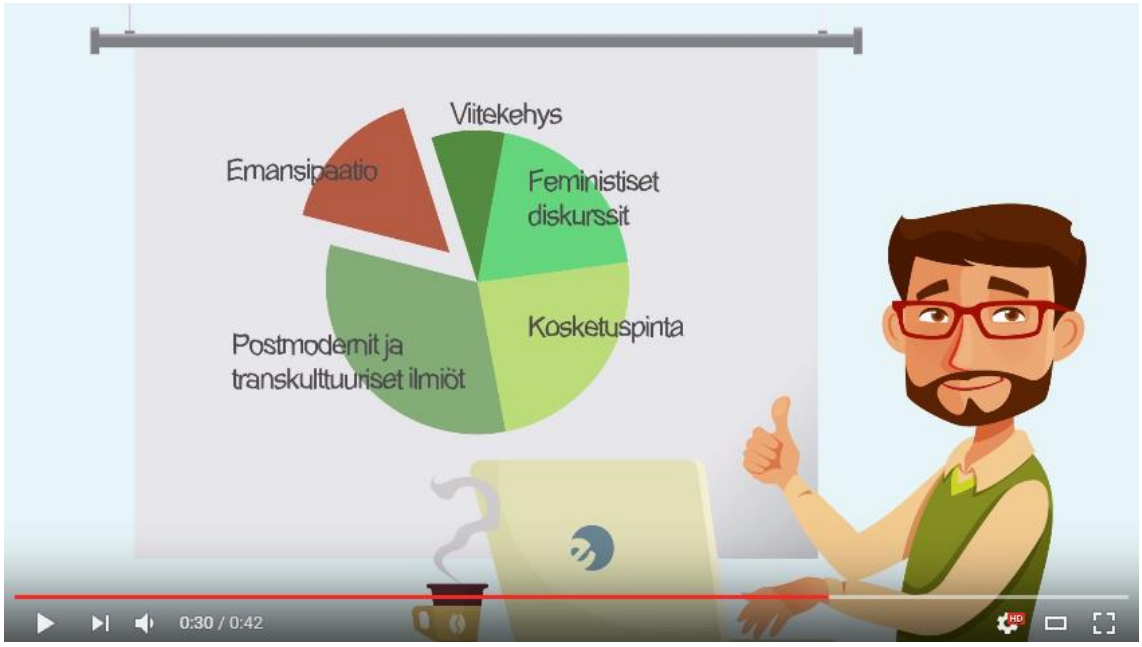
PICTURE 20. Same as picture 19, a lot was achieved with very little

The workload added to an infographic by animating it depends on many things. If the image includes speech, someone has to do the voiceover. Sounds are another thing. Picture 21 shows what the layers look like in the vector illustration software *Adobe Illustrator* before the footage can be imported into *After Effects*. All assets were placed on their own layers and named appropriately. Parts, like the eyebrows, that were going to be moved around in *After Effects*, were separated. Effects like the steam from the coffee mug and the texts on the slide could easily be animated with built-in effects in the software.



PICTURE 21. The preparation of a still image file for animation (The artboard should be 16:9 size, the company's 4:3 template was accidentally used here)

The animation comes together when the voiceover is added to the scene, the character moves his hands at appropriate intervals in the speech, and the small effects are added. The content could not have been explained as efficiently in text. A comic strip with speech bubbles could have been used instead of animation, but the voiceover gives emphasis on the choice of words and their effect. The decision to animate this information as well as the other infographics in this chapter was found beneficial. The animated infographics are more interesting and convey the information in a more understandable format.



PICTURE 22. Screenshot of the finished animation

6 DISCUSSION

The thesis examined the current trend of digital books and how they will transform the use of printed material. Also the state of present-day educational material is relevant to the case. The use of infographics in history and contemporary digital platforms was discussed briefly. The human brain was peeked at in the quest for understanding how it interprets visual data. Infographics or any visual support for learning helps students grasp the subject. Data visualizers can take advantage of the knowledge of *Gestalt laws* and how perception works in order to direct the viewer's attention and help them understand the information represented in the infographic.

The progress and significance of animation was followed from the simple gadgets of the early 19th century to the shape of the industry today. So far animation has been used in educational materials in a very different form. Full length films work differently than animated infographics. Animation is a new way of conveying information in the new learning platforms. It was not possible to include the kinds of animated infographics studied in this thesis to schoolbooks before the digitalization.

This background was applied to finding the benefits and disadvantages of using animated infographics instead of traditional ones. The problems can be summarized as production costs and possible distraction in some cases. Technological restrictions apply. The merits of animated visual aids include easier understanding on some subjects, attention value and the ability to pack a lot of information into an easy to read package. Animation is a good choice when the information and the story it tells has a linear direction. The decision whether to animate should be made individually in each situation.

The work included three practical examples of animated infographics made for a digital educational publishing company, e-Oppi Oy.

The first one included two simple parts for a physics book that already has a collection of other small animations lined up. The important part of animation for these clips was timing, so that the viewer has enough time to understand each part but does not get bored (and lose attention) between actions. The subjects are linearly progressing stories of physical phenomena and animation suits their representation well.

The second animation was a map of Europe with the plague advancing on it from the year 1346 to 1353. The company already had this map as an animated version but it needed to be updated to fit the current standards of the graphics in the books. The challenges on this task were to find the balance between too much and too little details in the map and to find the best colours to mark the advancement of the disease. It was important to make the viewer notice the year and that it changed at every level.

The third animation also included two scenes. It had a voiceover that played an important part in telling the story and representing the topic of language that was demonstrated. The teacher and professor who were giving lectures in the clips were not fully animated but have some parts like the eyes and hands moving occasionally throughout the speech. This shows how the benefits of animation can be achieved by very little effort.

If animated infographics prove to be invaluable tools for learning for the students and whether it is the one thing that makes e-Oppi's materials exceptional and an international success remains to be seen. The teachers have repeatedly requested for animations in the books when they have been interviewed about their ideas and wishes. The methods and advantages of going through the extra effort of production have not been clear because of the novelty of the field. This work will be beneficial when deciding if and when animation should be used in the books in the future.

Animation is decidedly a step to a new level in digital educational materials. This thesis was constricted to only one aspect of the digital realm and incorporating animated infographics in traditional digital media. This is, however, only one of the approaches. The rapid development of modern digital media, virtual reality for example, enables the use of completely new visual educational methods in new contexts and applications. The findings of this thesis can be expanded to new levels as technology advances.

REFERENCES

Beckerman, H. 2003. Animation, The Whole Story.
New York: Allworth Press.

Cairo, A. 2016. The Truthful Art: Data, Charts, and Maps for Communication.
San Francisco: New Riders.

Cairo, A. When animation lessens clarity. 16.6.2013. Read 25.5.2017.
http://www.thefunctionalart.com/2013/06/more-beautiful-static-information.html

Cairo, A. There's beauty in print graphics. 21.11.2012. Read 25.5.2017.
http://www.thefunctionalart.com/2012/11/theres-beauty-in-print-graphics.html

Digabi, Sähköisen ylioppilastutkinnon siirtymäaikataulu. Read 21.5.2017.
http://digabi.fi/doku.php?id=projekti:aikataulu

Harris, S. Beauty and Terror. Waking Up Podcast #70. 10.4.2017.
https://www.samharris.org/podcast/item/beauty-and-terror

Johnston, O. & Thomas, F. 1981. Illusion of Life
New York City: Abbeville Press

Kautto, J. & Peltoniemi, A. 2006. Selvää kärpännahkaa — Oppikirjan kuvituksen muutos ja käyttö opetuksessa. Tampere: Tampereen Yliopisto.

Kim, J. Motion Gestalt for Screen Design. 2007. Read 25.5.2017.
http://motiongestalt.com/

Meyer, K. How Chunking Helps Content Processing 20.3.2016. Read 25.5.2017.
https://www.nngroup.com/articles/chunking/

Newton, C. 2014. The Everything Book. Reading in the Age of Amazon. Read 31.5.2017. https://www.theverge.com/2014/12/17/7396525/amazon-kindle-design-lab-audible-hachette

Nielsen, J. How Little Do Users Read? 6.5.2008. Read 21.5.2017.
https://www.nngroup.com/articles/how-little-do-users-read/

O'Toole, J. 16.12.2013. Which Works Better: Static vs. Animated Ads. Read 31.5.2017.
https://www.webtrends.com/blog/2013/12/which-works-better-static-vs-animated-ads/

Paalasmaa, J. Lapsesta käsin. 2011. Kasvatuksen ja opetuksen vaihtoehtoja. Jyväskylä: PS-kustannus.

Pew Research Center. Book Reading 2016. Read 31.5.2017.
http://www.pewinternet.org/2016/09/01/book-reading-2016/pi_2016-09-01_book-reading_0-01/

Robinson, K. Changing education paradigms. RSA Animate. Oct 2010. Read 28.5.2017.
https://www.ted.com/talks/ken_robinson_changing_education_paradigms

Selby, A. Animation. 2013.
London: Laurence King Publishing.

Simmon, R. Is Animation an Effective Tool for Data Visualization? 14.3.2013. Read 25.5.2017. https://earthobservatory.nasa.gov/blogs/elegantfigures/2013/03/14/is-animation-an-effective-tool-for-data-visualization/

Smiciklas, M. The Power of Infographics. Using Pictures to Communicate and Connect with Your Audiences. 2012. Indiana: Que Publishing

Soegaard, M. Gestalt principles of form perception. 2002. Read 28.5.2017.
https://www.interaction-design.org/literature/book/the-glossary-of-human-computer-interaction/gestalt-principles-of-form-perception

Vilkko-Riihelä, A. 1999. Psyyke. Psykologian käsikirja. Porvoo: WSOY.

Weinberg, D. B Why Authors and Readers Still Want Print. 3.3.2015. Read 24.5.2017.
http://www.digitalbookworld.com/2015/why-authors-and-readers-still-want-print/